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Manipulation of Broiler Growth Performance, Physiological and Fear Responses Using Three Monochromatic LED lights

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ABSTRACT

The present study aimed to investigate the effect of rearing avian broiler under different monochromatic LED light color on their growth performance, physiological and fear responses. One hundred and thirty five unsexed day-old avian 48 chicks were randomly allocated into three light treatment (n=45 bird) each treatment 3 replicates (n=15 bird). The treatments were white, green, and blue light. The obtained results demonstrated that, broilers reared under blue and green light had higher body weight, weight gain, feed intake, carcass weight, carcass percent, hemoglobin, red blood cells, packed cell volume, total leucocytes count, lymphocytes, total protein, albumin, globulin and lower feed conversion ratio, bursa, liver, spleen relative weight, heterophils: lymphocytes ratio, glutamic oxaloacetic transaminase, glutamic pyruvic transaminase compared with white light. Moreover, blue and green lights reared birds showed short tonic immobility duration and high levels of exploration in the open field test. In conclusion, rearing broilers under blue and green light for 23 h per day improve growth performance, physiological response, welfare, reduce stress and fear responses.

1. INTRODUCTION

Many light sources are used in the field of poultry production as incandescent light, fluorescent light and light-emitted dioxide (LED). LED is a special unique light source of semiconductor diode which characterized by a very significantly longer life that may reach 100,000 h compared to other conventional light sources. Furthermore, monochromatic LEDs have small size, adjustable light intensity, specific wavelength, low thermal output and high photoelectric conversion efficiency, these benefits make LEDs very preferable light source in modern poultry management (Yang et al., 2016).

Light considered as an important environmental factor for bird vision and modulation of physiological condition, growth performance, behavior and immune response (Rozenboim et al., 2004; Xie et al., 2008). Light duration, intensity, color and wavelength are very crucial factors in the growth performance of domestic fowl (Prayitno et al., 1997; Rozenboim et al., 2004).

Varity of previous conducted studies demonstrate the effects of light criteria on bird health and immunity with special references to light color and spectrum, Rozenboim et al. (1999) found that maximization of monochromatic light effect on growth and welfare in broiler chickens is achieved by age of birds, also, Karakaya et al. (2009) found that rearing broiler under green light at an early age and blue light in older one could improve growth performance and meat quality properties, while, Rozenboim et al. (2004) stated that switching light from blue to green at 20 day age could improve growth performance of male broiler chickens. Moreover, Xie et al. (2008) found that immune response of broilers was enhanced under green and blue light.

The present study aimed to investigate the effect of rearing broiler chickens under continuous monochromatic light color (blue, green light and white light) on growth performance, physiological and fear responses.

2. MATERIALS AND METHODS

This study was carried out in a private poultry farm in Garbia governorate under the approval of animal ethics committee, Faculty of Veterinary Medicine, Kafr El-Sheikh University, Egypt.

2.1. Birds and management:

One hundred and thirty five unsexed day-old avian 48 chicks were used in this study. The chicks were randomly allocated into three light treatment (n=45 birds). Each treatment was three replicates (n=15 birds). The treatments were distributed according to LED light color into, white light (400–770 nm), green light (560) and blue light (460 nm). The light program was set as 24 h continuous white light during the first 3 days and 23 h LED light of previous mentioned colors and 1 h dark (23L/1D) and the light intensity was 1 watt/ m^2 till the end of the experiment.

Chicks in all groups were brooded on deep litter system and received the same standard management conditions along the rearing cycle (40 day) with stocking density 10 birds/m^2.

Feed and water were provided ad libitum. Ration was formulated in El-Nour and El-Baraka for poultry fodder, starter ration (19% crude protein, 2900Kcal/ kg gross energy) for 20 days and finishing ration (21 % crude protein, 3100 Kcal/ kg gross energy) till end of finishing period to meet the nutrient requirements for broilers according to NRC (1994).

2.2. Estimation of productive performance

From day 0 to 40, chicks were individually weighed every week. Initial body weight, Average live body weight and average live body weight gain was calculated. Moreover, feed intake was daily estimated for each light treatment then feed conversion ratio was calculated according to according to (Wanger et al., 1983; EL Saidy et al., 2015).

2.3. Evaluation of carcass trait and some internal organs weight

At day 40, 15 birds from each light group (5 from each replicate) were euthanized carefully using sharp knife. The birds were kept for 5 minutes for bleeding and then dipped in a hot water bath for 2 minutes to facilitate the process of defeathering. Manual evisceration was done to obtain carcass, liver, thymus, spleen and bursa weight. Absolute weight, relative weight of carcass and relative internal organs weight to final body weight was calculated according to Mohamed et al. (2014).

2.4. Evaluation of physiological response:

From each light treatment, 15 blood samples (5 from each replicate) were collected during euthanize at 40 day. Each sample was taken in 2 separate tubes; one ml whole blood in EDTA tubes for estimation of hemoglobin, red blood cells (RBCs), packed cell volume (PCV), total and differential leucocytes count and estimation of heterophil / lymphocyte (H/L) ratio according to Dein, (1984).

The second samples (2 ml blood) were left for 30 minute till blood clotting then serum separation by centrifugation at 3000 rpm for 10 minutes. Serum samples were stored at -40 ^{o}C until assaying of:

- Liver function indicators: Serum Glutamic oxaloacetic transaminase (SGOT) and Serum Glutamic pyruvic transaminase (SGPT) enzymes according to Reitman and Frankel (1957).
- Serum total proteins (TP), albumin (AL), globulin (GL) and A/G ratio according to Armstrong and Carr (1964).
- Serum glucose level according to Trinder (1969).

2.5. Estimation of fear response:

2.5.1. Tonic immobility (TI) test

At 40 day, a tonic immobility test was carried out on 15 birds from each light treatment. Each bird was carefully handled and transported to a separate room, placed in a wooden U-shaped cradle on their backs, held for 10 s to induce tonic immobility and then released. After this time, if tonic immobility lasted less than 10 s, the process was repeated immediately, with a maximum of 5 attempts.

The number of attempts required to induce tonic immobility was recorded (induction number). When tonic immobility lasted more than10 s, the total duration of tonic immobility was recorded, with a maximum duration of 600 s according to Jones (1996).

2.5.2. Open field (OF) test

Each bird was tested individually in an OF arena with dimensions of 1×1.5 m. Individual bird was always placed at the arena and the behaviors were recorded over 3 min testing time.

The following behavioral patterns were observed and recorded using a video camera: latency to first step, immobility duration (sitting and standing duration), walking duration, pecks directed to the floor or the walls of the arena and frequency of elimination (dropping) were measured according to Mohamed et al., 2016).

2.6. Statistical analysis

Data was tested for distribution normality and homogeneity of variance. Data was reported as mean ± SEM and analyzed by ANOVA using Graph pad Prism 5™ by SAS (2002). The significance of difference among different treatments was evaluated by Tukey's test.

3. RESULTS AND DISCUSSION

3.5. Growth performance

Our results showed that growth performance of broiler was influenced by LED light color (Table 1), where broiler reared under blue and green light showed significantly higher ($P<0.05$) final body weight, weight gain and feed intake compared to white light group.

Rearing avian 48 broilers under white light birds significantly ($P<0.05$) increased FCR followed by green light while, blue light treatment showed the lowest FCR. These findings are in agreement with previous studies conducted by Rozenboim et al., (2004); Cao et al., (2008) and Mohamed et al., 2014.

The improvement of final body weight and weight gain in broilers reared under blue and green light may be attributed to higher proliferation of skeletal muscle satellite cells (Halevy et al., 2006). While, much feed intake and inferior FCR in broiler reared under blue light and green light compared to white light treatment may be attributed to calming effect of blue and green light where, birds become less active (Mohamed et al. 2014) and less stressful (Mohamed et al., 2016).

3.2.Carcass traits and weight of internal organs

Rearing broilers under different LED light colors significantly ($P<0.05$) affected their carcass weight, carcass percent, and liver percent. For blue and green light, there was no significant ($P<0.05$) difference in between but they were significantly ($P<0.05$) differed from white light group (Table 2).

There were no significant ($P<0.05$) differences in abdominal fat, spleen, thymus and bursa percent among LED light treatments. Our results were in close accordance with previous findings (Mohamed et al., 2014; Olanrewaju et al., 2015).

Rearing broiler chickens under blue light and green light showed higher carcass weight, carcass percent, and lower liver percent compared to white light group this may be attributed to improved quality and antioxidation process of muscles (Ke et al., 2011) and increased proliferation of skeletal muscle satellite cells (Halevy et al., 2006).

The enhancement of broilers' growth under green and blue light may be due to elevation of plasma androgens that increased protein synthesis, consequently maintaining myofibrils and muscle growth (Cao et al., 2008). For the relative weight of internal organs, broiler chickens reared under blue and green light showed lower liver, spleen and bursa percent compared to white light with exception of thymus percent. These results may be attributed to calming effect of blue and green light and so birds become less active (Mohamed et al., 2014) and less stressful (Mohamed et al., 2016).

3.3. Physiological response:

The obtained results showed that, light treatment had significant ($P<0.05$) effect for all physiological response either hematological and or biochemical traits except for globulin and albumin/ globulin ratio (Table, 3). For hemoglobin, red blood cells, packed cell volume, total protein and albumin there was no significant ($P<0.05$) difference between white and green light while they were differed significantly ($P<0.05$) from blue light group that recorded the highest values. For TLC, H/L ratio, GOT, GPT and glucose there was no significant ($P<0.05$) difference between green and blue light but they differed significantly ($P<0.05$) from white light group that had the highest values. These findings are in agreement with Mohamed et al. (2016) and Xie et al. (2008).

Broiler chickens reared under blue and green light showed lower physiological changes to stress than those reared in white light. This was evident by low levels of TLC, H/ L ratio, glucose, GPT and GOT and high values for RBCs, hemoglobin, PCV, total protein, albumin and globulin. It can be stated that the blue light and green light influenced the hematological measures that ultimately reflected in better growth response. The lower stress responses exhibited by broilers reared in blue light and green light could be attributed to the calming effect of these light colors (Prayitno et al. 1997). Broilers reared under both blue and green light appeared to be less fearful than those reared under white light. This reduced level of fear could be due to reduced level of general activity and aggression (Mohamed et al. 2016).

3.4. Fear responses:

a. Tonic immobility (TI) test:

The results of TI test showed that number of inductions required to induce TI did not significantly differ between light treatments (Table 4). The duration of TI was significantly affected by light treatments. Broilers reared under blue and green light displayed shorter durations of TI compared with those of white light group (P<0.05). The shortest TI duration was recorded in blue light followed by green light which differed significantly (P<0.05) from the longest duration that recorded in white light group. These findings are in agreement with Mohamed et al. (2014). Shorter duration of IT in broilers reared under blue and green light may be due to calming effect of these light colors (Prayitno et al. 1997) and birds become less active and less aggressive (Mohamed et al. 2016).

b. Open field (OF) test

Rearing broilers under different LED colors light affected their behavior in OF test (table 4). Broilers reared in white light recorded the highest values in latency to first step, immobility duration, setting phase of immobility duration and incidence of defecation and the lowest values were recorded in green and blue light respectively. On the other hand, broilers reared in blue light had the highest values in standing phase of immobility duration, walking duration and incidence of wall and ground pecking in the OF arena followed by green light and the lowest value was recorded in white light group respectively. There was a significance (P<0.05) difference between different light color groups. However, there was no significance (P<0.05) difference between green and blue light but they are differed significantly (P<0.05) from white light group. These findings are in agreement with Mohamed et al. (2016). These findings could be attributed to motivation of broilers reared under green and blue light to much standing, walking and pecking activity to floor or walls of arenas and could reflect high levels of exploration in the novel environments (Suarez and Gallup 1980).

The high level of exploratory behavior in novel environments has been interpreted as denoting lower levels of fear (Arnaud et al. 2008). Similar findings of higher fear-indicating behaviors (prolonged latency to first step, higher immobility duration and defecation incidence) in birds reared under white light have been reported in broilers (Faure et al. 1983) and Mulard ducks (Mohamed et al. 2016).

c. CONCLUSIONS

The obtained results suggest that, blue and green monochromatic light has a beneficial impact on growth performance of broilers and direct impact on broiler fear reaction and stress response that improved their welfare and production. Moreover, monochromatic blue or green light could be a potential replacement for other light colors and sources for sustainable commercial broiler production.

Table 1. Mean (± SEM) broiler performance reared under monochromatic white, green and blue light.

Item	White light	Green light	Blue light	P-value
Initial weight (g)	36.52±0.2634	36.14±0.2874	36.10±0.3225	0.5495
Final body weight (g)	1971±69.18^{a}	2284±52.29^{b}	2334±63.29^{b}	0.0027
Weight gain (g)	1934±69.01^{a}	2248±52.22^{b}	2408±93.21^{b}	0.0021
Feed intake (g)	4316±151.5^{a}	4827±44.57^{b}	4840±85.04^{b}	0.0054
Feed conversion ratio	2.232±0.001^{a}	2.062±0.012^{b}	2.010±0.001^{c}	0.0001

Means within each raw having different superscript letters differ significantly.

Table 2. Mean (± SEM) carcass characteristics and weight of internal organs as a percent of final body weight of broiler reared under monochromatic white, green and blue light.

Item	White light	Green light	Blue light	P-value
Carcass weight (g)	1400±15.02^{a}	1723±10.38^{b}	1767±86.32^{b}	0.015
Carcass %	71.30±0.374^{a}	75.10±0.557^{b}	75.90±1.145^{b}	0.001
Abdominal fat %	0.934±0.011	0.939±0.044	1.022±0.032	0.136
Liver%	1.245±0.057^{a}	0.960±0.021^{b}	0.958±0.029^{b}	0.0002
Spleen %	0.126±0.005	0.118±0.010	0.115±0.011	0.683
Thymus %	0.635±0.034	0.741±0.050	0.733±0.038	0.167
Bursa %	0.227±0.031	0.207±0.048	0.204±0.048	0.920

Means within each raw having different superscript letters differ significantly.

Table 3. Mean (± SEM) hematological and biochemical parameters of broiler reared under monochromatic white, green and blue light.

Item	White light	Green light	Blue light	P-value
Hemoglobin (g/dl)	10.50±0.036[a]	10.60±0.037[a]	11.67±0.211[b]	0.001
RBCs(×10^6/µl)	2.327±0.013[a]	2.367±0.021[a]	2.800±0.063[b]	0.001
PCV %	31.33±0.211[a]	31.33±0.558[a]	35.33±0.212[b]	0.001
TLC / cu mm	62733±4465[a]	41850±624.5[b]	41833±628.6[b]	0.001
H/L ratio	0.253±0.015[a]	0.131±0.010[b]	0.119±0.008[b]	0.001
GOT(U/L)	198.8±8.864[a]	175.5±9.854[b]	167.8±7.305[b]	0.001
GPT(U/L)	5.017±0.140[a]	4.333±0.109[b]	4.152±0.092[b]	0.0002
Glucose (mg/dl)	248.7±1.926[a]	237.0±1.528[b]	234.7±2.390[b]	0.0003
Total protein (g/dl)	2.778±0.030[a]	2.798±0.006[a]	2.882±0.010[b]	0.0026
Albumin (g/dl)	1.345±0.004[a]	1.340±0.006[a]	1.402±0.010[b]	0.0001
Globulin (g/dl)	1.433±0.028	1.458±0.011	1.490±0.018	0.1752
A/G ratio	0.940±0.018	0.919±0.011	0.935±0.017	0.6241

Means within each raw having different superscript letters differ significantly.
RBCs: Red blood cells, PCV: Packed cell volume, TLC: Total leucocytes count, H/L: heterophils/ lymphocytes ratio, GOT: Glutamic oxaloacetic transaminase, GPT: Glutamic pyruvic transaminase, A/G Albumin/Globulin ratio.

Table 4. Mean (± SEM) fear responses of broiler reared under monochromatic white, green and blue light.

Item	White light	Green light	Blue light	P-value
Tonic immobility .a				
Number of inductions	1.000	1.200±0.447	1.200±0.447	0.6186
Duration (s)	370.0±30.33[a]	253.8±16.93[b]	217.2±30.66[b]	0.0043
Open field test .b				
Latency to first step(s)	4.200±0.800[a]	1.600±0.245[b]	1.200±0.200[b]	0.0021
Immobility duration (s)	166.0±6.116[a]	153.4±3.140[b]	146.8±2.596[b]	0.0226
Sitting duration (s)	65.20±2.818[a]	11.80±1.594[b]	6.000±1.817[b]	0.0001
Standing duration (s)	100.8±6.880[a]	141.6±3.945[b]	140.8±3.878[b]	0.0001
Walking duration (s)	14.00±1.183[a]	26.60±3.140[b]	33.20±2.596[b]	0.0004
Pecking	0.200±0.200[a]	1.400±0.245[b]	1.600±0.245[b]	0.0021
Defecation	1.400±0.245[a]	0.400±0.244[b]	0.400±0.245[b]	0.0196

Means within each raw having different superscript letters differ significantly.

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