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(Original Article)

Response of Japanese Quail to Different LED Light Colors

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Abstract

The current study aimed to investigate the impact of raising Japanese quail on different light colors on growth performance and carcass traits. A total number of 132 one-week-old Japanese quail were reared in batteries and assigned to 4 groups (33 birds /each). Birds in the first group (C) were reared under white light produced by LED light bulbs, while those in the second, third and fourth groups were reared under blue, green and red LED light, respectively. Experimental birds were raised in batteries under similar environmental and managerial conditions. Growth performance parameters (body weight gain, feed consumption, and feed conversion) were recorded weekly from 7 to 42 days of age and carcass traits were recorded at the end of the experiment. Light color significantly influenced body weight and feed conversion. Birds exposed to green or blue light had heavier body weights than those exposed to red light at 5 and 6 weeks of age. While birds exposed to white light (control group) exhibited intermediate body weights. The dressed carcass weights and gizzard percentages were greater in green color compared to that in red light group. It can be concluded that the use of red light should be avoided in raising growing Japanese quail birds and that green and blue light can substitute white light.

Keywords: *Growth Performance, Light colors, Japanese quail.*

Introduction

Temperature, relative humidity, gaseous exchange and light are environmental factors that influence the development of the Japanese quail birds. As stated by Parvin *et al*. (2014), the wavelength of visible light in birds ranges from 380 nm to 740 nm lying between infrared and Ultraviolet light rays. Light is required for birds' eyesight, as it influences the vision sensitivity discrimination of color (Calvet *et al*., 2009). Moreover, the minimum illumination that should be provided in the chicken house is 20 lux, allowing for easy vision and complete inspection (RSPCA, 2013).

Using light-emitting diodes (LEDs) in poultry production compared to incandescent and fluorescent light has exhibited higher luminous efficiency, reduced consumption and longer service life (Cao *et al*., 2012). The spectral gap of LEDs approximates daylight more than the other illumination sources (El-

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Sabrout and Khalil, 2017). Recently with advanced technology of environmental lighting in poultry production, LED bulbs gradually replaced traditional light bulbs (Santana *et al*., 2014).

Valentine *et al*., (2010) found that 60W incandescent and 15W fluorescent light bulbs consumed electricity 12 and 5 times (respectively) higher than LED bulbs in the same luminance. The life span of LED bulbs was longer than fluorescent bulbs by 8 times and incandescent bulbs by 50 times (Liu *et al*., 2010). Mendes *et al*., (2013) indicated the beneficial effects of LED light on the growth performance of broiler. Most behavioral, physiological, and immunological pathway changes need the use of proper light color (Mohamed *et al.*, 2014).

Several outputs from various visible spectrum wavelengths were used to assess the color of the light (Riber, 2015). The effectiveness of lighting is to achieve maximum broiler production while simultaneously conserving welfare (Škrbić *et al*., 2012). The reddish orange light enhanced the reproduction while green light improved the production rate (Rozenboim *et al*., 2004). Young birds exposed to green light improved their growth rate, while the older ones were stimulated under the blue light (Classen *et al*., 2004). The objective of this experiment is to assess the impact of different LED light colors on growth performance and carcass parameters of Japanese quail birds.

Materials and Methods

The present experiment was carried out at the research poultry farm of Poultry Production Department, Faculty of Agriculture, Assiut University, Assiut, Egypt. A total number of 132 one-week-old Japanese quail (*Coturnix coturnix japonica*) were assigned to 4 groups (33 birds /each). The birds in the first group (C) were reared under white light produced by LED bulbs, while those in the second, third and fourth groups were reared under blue, green and red LED bulbs.

All chicks were brooded in batteries and weighed individually on weekly basis until 6 weeks of age. All experimented chicks were fed a diet containing 24% crude protein and metabolizable energy 2600 Kcal/kg of diet until 6 weeks of age. Birds were exposed to continuous light 24 hrs/day during the first 3 days of age and the photoperiod decreased gradually to be adjusted to 12 hrs (growing) lighting regimens with a light intensity of 10 Lux at birds' level. The experimental period took place between the months of 23 January and 6 March / 2019. During the first 3 d, the temperature was set to 34◦C then gradually decreased to 25◦C to the end of the experiment. Ventilation was secured by two fans (length: 50 cm; diameter: 50 cm) on the windows of the compartment. During the growth period (1-6 weeks of age), the body weight gain per day was calculated by subtracting the final and initial body weights and then dividing by the number of days. Daily feed conversion ratio per bird was calculated during the growth period by dividing the estimated feed intake (as g feed/ day) by the estimated body weight gain (as g/ day). At 6 weeks of age, 3 male and 3 female growing birds from each treatment group were randomly chosen, individually weighed and humanely killed by cutting the jugular vein then they were left to bleed for 5 minutes, then recorded dressed carcass weight, edible viscera weight (giblet = liver, heart and gizzard), weights of such organs were expressed relatively to live body weight.

Statistical analysis: The results obtained were submitted to ANOVA using the SAS software's General Linear Model (GLM) Procedure (SAS Institute, 2009). Duncan (1955) was used to determine differences in mean values among groups.

Results and Discussion

1. Body weight and body weight gain:

The effects of LED light color on live body weight (BW) from one to six weeks of age are presented in Table (1). The results showed that body weight of quails exposed to blue and green light color was higher than those of quails reared under red light at 5 weeks and 6 weeks of age, while body weights of quail in white group were intermediate. No significant differences were observed in BW among different treatment groups from 1 to 4 weeks of the growth period.

The effects of light emitting diode light color on daily body weight gain (BWG) from one to six weeks of age are presented in Table (2). From 1 to 4 and 5-6 weeks of age, no significant differences in daily BWG were observed between birds in all treatment groups. At 4-5 weeks of age, quails exposed to green light gained more weight than those exposed to red light. The daily BWG of birds in white and blue groups was intermediate. Afterward, no significant differences were observed in BWG among different treatments groups at other ages. Mohamed *et al*., (2015) found that rearing Japanese quail (JQ) under blue light ameliorates the effect of heat stress and the birds become calmer and reduce fear reaction. The growth rate increased by exposing birds to green color during the early period of growth, whilst it increased in the late period by exposing birds to blue color, and the body weight and weight gain of broilers were improved under blue and green color treatments attributed to higher skeletal muscle satellite cells during the early life period (Rozenboim *et al*., 2004).

Growth of quails is affected by light colors. BW is considered one of the important performance parameters. In this study, the results showed that the weight of the quail body increased significantly at 5 weeks of age under the blue and green colors. Cao *et al*., (2008) found that blue color affected positively on BW. Rozenboim *et al*. (2004) found that green light has a main effect on growth. However, Bala, (2020) indicated that the highest final BW of broiler was found under white color. Also, Elkomy *et al*., (2019) found that red light increased quail BW. Senaratna *et al*., (2011) reported insignificant differences in BW of broiler chickens and growth performance among artificial light color treatments. Moreover, broilers reared under red light increased BWG and preference higher than under other light colors (Senaratna *et al*., 2016).

Table 1. Effect of light color (LED) on body weight of Japanese quail

Groups / Age	Body weight (g/bird)				P-value
	White	Blue	Green	Red	
1 wk	38.9±1.1	37.7±1.4	37.5±1.1	39.1±1.2	0.1588
2 wk	65.5±2.4	69.8±2.1	67.8±2.3	65.2±1.6	0.4521
3 wk	108.5±3.4	112.9±3.1	109.2±2.5	105.3±3.1	0.3142
4 wk	145.0±2.1	151.73±3.6	149.12±3.9	139.9±3.2	0.7638
5 wk	200.5 ^{ab}±4.5	208.21 ^{a}±4.0	206.63^{a}±6.2	188.0 ^{b}±4.3	0.0261
6 wk	214.1 ^{ab}±6.2	225.13^{a}±4.9	223.9 ^{a}±5.7	201.2 ^{b}±4.4	0.0404

$^{a-b}$ Means in the same rows with different superscripts are significantly different (P≤0.05).

Table 2. Effect of light color (LED) on daily body weight gain of Japanese quail

Groups / Age	Body weight gain (g/bird/day)				P-value
	White	Blue	Green	Red	
1-2 wks	3.80±0.32	4.58±0.41	4.33±0.24	3.72±0.28	0.2541
2-3 wks	6.15±0.26	6.16±0.28	5.91±0.44	6.74±0.35	0.4125
3-4 wks	5.22±0.42	5.55±0.29	5.71±0.38	4.94±0.29	0.2546
4-5 wks	7.92^{ab}±0.21	8.07^{ab}±0.35	8.22^{a}±0.19	6.88^{b}±0.20	0.0311
5-6 wks	1.95±0.32	2.42±0.25	2.46±0.31	1.88±0.22	0.5503
Overall Mean	5.01 ±0.15	5.35 ±0.18	5.33 ±0.21	4.63 ±0.11	0.3144

$^{a\ and\ b}$ Means in the same rows with different superscripts are significantly different (P≤0.05)

2. Feed consumption and Fed conversion ratio

Table (3) presents the effects of LED light color on feed consumption (FC) from one to six weeks of age. No significant differences were observed in FC among different groups during the experimental period.

The effects of LED light color on feed conversion ratio (FCR) are presented in Table (4). At 5-6 weeks of age, quails reared under blue and green light colors have significantly better FCR than those reared under white and red light colors. No significant differences in FCR were observed among birds in red and blue groups. Although no significant changes were observed in FCR between different treatments groups at other ages, birds reared under blue and green light had better cumulative FCR compared to those in red light group.

Remonato-Franco *et al.*, (2022) showed that light could enhance FC, growth, and immunity in chickens. As well, Firouzi *et al.* (2014) indicated that birds exposed to yellow light had better FCR performance than green light.

Feed conversion efficiency at blue and green colors had improved significantly (p<0.05) as compared with white color, this result was agreed with (Firouzi *et al.*, 2014). Ibrahim *et al.*, (2023) found that the best FCR of (1.38) was recorded among broilers in red, followed by those in blue (1.40) and green (1.43). Broiler reared under green light increased feed intake (3.10kg) than those under red and white ((3.09 and 3.07 kg) treatments.

On the other hand, Classen *et al*., (2004) did not observe any differences (p<0.05) in final BW and FCR of birds exposed to blue, green, red and white color. Mousa-Balabel *et al*., (2017) reported that the highest FC was recorded in broilers reared under white light. Birds reared under blue light were recorded as the best FCR which agrees with the report of Cao *et al*., (2008). However, no significant differences were observed in FCR in the total rearing period of broiler chickens (Rozenboim *et al*., 1999).

During week 6 in our study, birds reared under white light decreased FCR likewise the findings of Cao *et al*., (2012) on Arbor acres broiler. While no significant differences were observed in FCR between Anak broiler chickens under light groups (Rozenboim *et al*., 2004). The reduced FC of the study's birds may be attributable to their improved intestinal feed retention, which led to higher nutritional absorption when they switched from either blue or green food. These findings are in agreement with those of Xie *et al*., (2011) who found that the growth of intestinal villi was improved in birds reared under blue and green light. Moreover, Kim *et al*., (2013) observed that light color is effective for feed utilization.

Table 3. Effect of light color (LED) on feed consumption of Japanese quail

Groups / Age	Feed consumption (g feed/day/bird)				P-value
	White	Blue	Green	Red	
1-2 wks	9.58±0.80	8.82±0.52	9.09±1.09	10.03±1.09	0.8587
2-3 wks	12.19±0.32	11.06±2.93	11.55±1.51	12.36±1.67	0.7744
3-4 wks	15.82±1.97	14.94±1.89	15.16±0.92	15.93±0.88	0.9739
4-5 wks	18.31±2.10	16.72±1.49	17.16±0.19	19.03±2.30	0.9348
5-6 wks	21.31±1.52	20.44±1.47	20.38±1.88	22.33±0.26	0.2751
Overall mean	15.43±1.12	14.40±0.621	14.67±1.01	15.94±0.722	0.1568

No significant differences were observed (P>0.05).

Table 4. Effect of light color (LED) on feed conversion ratio of Japanese quail

Groups / Age	Feed conversion ratio (g feed / g gain/ bird)				P-value
	White	Blue	Green	Red	
1-2 wks	2.52±0.07	1.92±0.21	2.10±0.15	2.70±0.12	0.7511
2-3 wks	1.98±0.11	1.80±0.09	1.95±0.21	2.15±0.19	0.9161
3-4 wks	3.03±0.31	2.69±0.40	2.65±0.18	3.23±0.32	0.8422
4-5 wks	2.31±0.31	2.07±0.25	2.09±0.19	2.77±0.41	0.5561
5-6 wks	10.89^{a}±0.25	8.46^{b}±0.14	8.27^{b}±0.15	11.86^{a}±0.21	0.0483
Overall Mean	3.08^{ab}±0.16	2.69^{b}±0.18	2.75^{b}±0.30	3.44^{a}±0.25	0.0258

$^{a\ and\ b}$ Means in the same rows with different superscript are significantly different (P≤0.05)

3. Carcass traits

The effects of LED light color on carcass characteristics are presented in Tables (5 and 6). It was observed that gizzard percentage of male Japanese quails reared under green and blue light were significantly higher than those of birds exposed to red light. The gizzard percentage of male Japanese quails in white groups was intermediate.

Dressed carcass of male JQ exposed to green light was significantly higher than those of quails exposed to red light. Dressed carcass weights of birds raised under white and blue light colors were intermediate. No significant differences were observed in other carcass characteristics among males in different treatments groups.

In females, dressed carcass of male JQ exposed to green light was significantly higher than those of quails exposed to red light. Dressed carcass weights of birds raised under white and blue light colors were intermediate value. No significant differences were observed in other carcass characteristics among different treatments groups. Soliman and Hassan (2019) found that carcass weight of birds in blue light treatment increased than those exposed conventional white lights.

In our present study, birds under different light colors improved breast muscle conforms with the findings of Liu *et al*., (2008) who showed that broilers reared under blue and green light increased breast muscle weight at market age, which can be explained by inducing myofiber growth of the birds (Velo and Ceular 2017).

Table 5. Effects of light color (LED) on dressed carcass and giblets of male Japanese quail

Traits / Groups		Light colors: White	Blue	Green	Red	p-value
Carcass traits						
Live body weight (g)		195.20±5.8	199.80±6.6	202.20±6.3	190.63±5.1	0.2654
Dressed carcass (%)		74.42^{ab}±0.98	75.18^{ab}±1.52	76.29^{a}±2.01	72.76^{b}±0.65	0.0428
Giblets,	**Liver (%)**	2.74±0.14	2.81±0.18	2.93±0.10	2.59±0.13	0.7521
	Heart (%)	0.88±0.05	0.86±0.03	0.89±0.04	0.84±0.04	0.1532
	Gizzard (%)	2.45^{ab}±0.18	2.62^{a}±0.12	2.67^{a}±0.09	2.17^{b}±0.15	0.0144

$^{a\ and\ b}$ Means in the same rows with different superscript are significantly different (P≤0.05)

Table 6. Effects of light color on carcass dressed and giblets of female Japanese quail

Traits / Groups		Light colors: White	Blue	Green	Red	p-value
Carcass traits:						
Live body weight (g)		215.20±7.0	218.43±8.8	219.10±7.6	212.6±4.5	0.6155
Dressed carcass (%)		72.94^{ab}±1.2	73.10^{ab}±2.2	74.40^{a}±1.4	71.49^{b}±0.7	0.0182
Giblets,	**Liver (%)**	2.69±0.31	2.72±0.43	2.80±0.16	2.58±0.24	0.741
	Heart (%)	0.73±0.03	0.80±0.07	0.84±0.04	0.75±0.01	0.8531
	Gizzard (%)	2.27±0.18	2.34±0.21	2.45±0.09	2.19±0.10	0.1782

$^{a\ and\ b}$ Means in the same rows with different superscript are significantly different (P≤0.05)

Conclusion

Quail production is a profitable project so monitoring the growth characteristics from the early period of age helps producers maximize profits. Light colors must be considered while breeding quail for greater development rates to maximize quail production earnings. LED lighting has proven to be more effective than other colors of lighting in terms of color diversity and homogenous distribution in improving the performance of meat quail. Our study presented that green and blue light had a favorable effect on growth, however, the productive problems of birds increased by red light, which had a negative effect on performance.

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إستجابة السمان الياباني لألوان الإضاءة الليد المختلفة

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الملخص

أجريت هذه الدراسة لتقييم تأثير تربية السمان الياباني تحت ألوان مختلفة لإضاءة الـ LED على معدل النمو وصفات الذبيحة. تم تربية 132 طائر من سمان ياباني بعمر أسبوع واحد وتم تقسيمها إلى 4 مجموعات (33 طائرا بكل مجموعة). تمت تربية الطيور في المجموعة الأولى (المجموعة الضابطة) تحت الضوء الأبيض الذي تنتجه مصابيح الليد، في حين تمت تربية الطيور في المجموعة الثانية والثالثة والرابعة تحت ضوء مصابيح الليد الأزرق والأخضر والأحمر، على التوالي. تمت تربية الطيور التجريبية في البطاريات في ظل ظروف بيئية وإدارية مماثلة. تم تسجيل معدلات النمو (زيادة وزن الجسم واستهلاك العلف والتحويل الغذائي) أسبوعياً من عمر 7 إلى 42 يوماً وتم تقييم بعض صفات الذبيحة في نهاية التجربة. أثر لون الإضاءة بشكل كبير على وزن الجسم وتحويل العلف، حيث كان وزن الجسم للطيور المعرضة للضوء الأخضر أو الأزرق أثقل من تلك التي تعرضت للضوء الأحمر في عمر 5 و6 أسابيع. بينما أظهرت الطيور المعرضة للضوء الأبيض (المجموعة الضابطة) أوزان جسم متوسطة. وكانت أوزان الذبيحة المجهزة والقونصة (%) أكبر في المجموعة المعرضة للون الأخضر مقارنة بتلك الموجودة في مجموعة الضوء الأحمر. أخيرا، يمكننا الاستنتاج أنه ينبغي تجنب استخدام الضوء الأحمر في تربية السمان الياباني النامي وأن الضوء الأخضر والأزرق يمكن أن يستبدل بالضوء الأبيض.