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Pre-hatch Performance of Japanese Quails and $Cobb_{500}$ Broiler Breeder Eggs Incubated Surrounded by Different Light Color Environments

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ABSTRACT

Light influences hatchability efficacy of poultry eggs as well as their productive and reproductive performance. Apparently fertile eggs of Japanese quail and $Cobb_{500}$ broiler breeder used in this study and incubated surrounded by dark, red and green light environments in order to investigate their effects on hatchability, embryonic mortalities and egg weight loss during incubation. Results revealed that, Red and Green light had significant increase ($P < 0.05$) on both scientific and commercial hatchability of Japanese quail and $Cobb_{500}$ eggs compared to those exposed to darkness during incubation. Moreover, Red light decreased ($P < 0.05$) early embryonic mortalities. Total egg weight loss of Japanese quail significantly decreased by application of green and red light color during incubation, Meanwhile, Green light decreased the total egg weight loss $Cobb_{500}$ broiler breeder eggs. These results suggested that Red or Green light is possibly the key spectrum to improve hatchability.

1. INTRODUCTION

The remarkable increasing in poultry production has renewed emphasis on essentially improvement of hatching efficiency to increase hatchability of fertile eggs (Farghly, 2015). Hatchery efficiency could be improved by optimizing relative humidity, temperature, egg turning and gaseous concentrations during incubation. Also, there is evidence that exposing embryos to light during incubation can have an effect on hatchability and embryo development (Shafey, 2004).

The earliest measurement of an embryo's ability to sense light is at 2 days of incubation, where light exposure stimulates mitosis in neural crest mesoderm (Cooper et al., 2011). This accelerates the closing of the neural tube, which in turn differentiates into the precursor of the central nervous system. Moreover, light affects embryonic developmental stages of birds through its stimulation of their pineal gland which forms at day 3 of incubation in chicken (Zeman et al., 1992). Photoperiodic lighting during incubation enhanced post hatch development of birds than those exposed to dark incubated eggs (Özkan et al. 2012), Increasing metabolic rate of embryos (Preda et al., 1962).

Different wavelengths of light can impact embryogenesis differentially (Hluchý et al., 2012), The spectral composition of light divided into two wavelength; long wavelength as Red light (618.4–620.8 nm) and yellow (587.9–589.1 nm), and short wavelength as Green (516.0–521.0 nm), blue (455.0–461.0 nm) and wide range of spectral output white light (400–760 nm) (Yang et al., 2016).

Light color in incubation had significant effects on hatchability of chicken eggs (Shafey, 2004 and Archer 2017) and also on quail eggs (Shafey and Al-Mohsen 2002). Moreover, light had significant reduction of early and late embryonic mortalities of chicken eggs (Shafey and Al-Mohsen (2002).

Little research has been done to determine the effect of different light colors on pre-hatch performance of Japanese quail eggs. The objective of this study was to investigate the effect of different light colors on pre hatch performance represented by hatchability and embryonic mortalities of Japanese quail and $Cobb_{500}$ broiler breeder eggs.

2. MATERIAL AND METHODS

This study was carried out at the Department of Animal Husbandry and Animal Wealth Development, Faculty of Veterinary Medicine, Alexandria University. A total of 1200 eggs of Japanese quails purchased from a commercial quail farm at Kafr EL-sheikh province, In addition, 170 $Cobb_{500}$ broiler breeder eggs were purchased from a commercial broiler farm at Rasheed city, Behera province.

2.1. Experimental design

Experimental design is presented in Table (1)

A sample from Japanese quail eggs (22 eggs) and a sample from $Cobb_{500}$ broiler breeder eggs (20 eggs) were numbered with marker and weighed individually before setting of eggs and then weighed every five days to estimate weight loss during incubation.

2.2. Pre- incubation management of eggs:

Incubator room was fumigated using formaldehyde gas by mixing of 40 ml formalin 40% and 20 g Potassium permanganate ($KMNO_4$) / three cubic meters of cabinet area for about 20 minutes then the gas expelled. Moreover, Eggs were disinfected by spraying of TH_4 solution diluted as (2ml/L) on eggs then let them dry for 15 minutes at room temperature.

2.3. Incubation Environment:

Eggs were set vertically with broad end up in the setting trays. Incubation temperature was adjusted at 37.5˚C and relative humidity 65% which kept all over the period for optimum hatchability. Eggs were turned automatically from second day of setting until the 14^{th} day of incubation for Japanese quail eggs and till 18^{th} day of incubation for $Cobb_{500}$ breeder eggs with turning angle ±45 degree from vertical position eight times daily using automatic turning timer. Eggs then were transferred to the hatcher at the last 3 days of incubation process where there was no turning occurs.

2.4. Lighting Environment:

Light treatments were allotted into three trials, first trials eggs were incubated in darkness (0 Light: 24 Dark) for 14 days then moved to hatcher at last three days in darkness. The other two trials eggs were incubated in Red LED light or Green LED light for 14 days then moved to hatcher at last three days in darkness. Incubator was outfitted with four bulbs. Two bulbs at each side of incubator located 10 cm above the eggs in the compartment of the lighted treatment. Light intensity was 12W/m2 at the top surface of the eggs with wave length 600–630 nm for Red light and 510–530 nm for Green light. Lighting managements (Red and Green) were operated by automatic timer to 12 hours light and 12 hours off (12 L: 12 D) light schedule (Archer 2015). The front windows of incubator were blacked out with cardboard to prevent light intrusion into the machine.

The eggs were moved to the hatcher before hatch by three days. The hatcher had no light and the eggs were in complete darkness. After complete hatching process, the non-hatched eggs were broken and examined for fertility, hatchability and embryonic mortality percentages.

2.5. Studied parameters:

Fertility percentage (No. of fertile eggs / Total number of eggs set)*100, scientific hatchability percentage (No. of hatched eggs / Total number of fertile eggs)*100, commercial hatchability percentage (No. of hatched eggs / Total number of eggs set)*100, embryonic mortalities of Japanese quail eggs (early embryonic mortality from 0 –7^{th} day of incubation, mid embryonic mortality from 8^{th} – 14^{th} day of incubation and late embryonic mortality from 15^{th} to 17^{th} days of incubation).

Table (1): Experimental groups, experimental birds, number of eggs and light treatment at incubator and hatcher level

Group	Birds	Number of eggs	Incubator light	Hatcher light
Control	Japanese quail	500	Dark (D)	Dark
	broiler $Cobb_{500}$	50		
Red Light	Japanese quail	350	Red (R)	Dark
	broiler $Cobb_{500}$	50		
Green Light	Japanese quail	350	Green (G)	Dark
	broiler $Cobb_{500}$	50		

Meanwhile, embryonic mortalities of Cobb500 broiler breeder eggs (early embryonic mortality from 0 –9th day of incubation, mid embryonic mortality from 9th – 18th day of incubation and late embryonic mortality from 18th to 21th days of incubation)

Weight loss (in grams and percentage): the differences between two successive weights of incubated eggs were estimated in grams to calculate the weight loss in grams then estimation of the relative weight loss.

2.6. Statistical analysis

Data of hatchability, fertility, embryonic mortality and egg weight loss were analyzed by analysis of variance (ANOVA) using SAS, 2004 and the significance between different group treatments were assessed using Duncan's test.

3. RESULTS AND DISCUSSION

3.1. Fertility and Hatchability

Fertility, scientific hatchability and commercial hatchability percentages of Japanese quail and $Cobb_{500}$ broiler breeder eggs incubated in different light colors are presented in Table 2 and 3.

It was clear that, scientific hatchability was significantly higher in Japanese quail eggs treated with Red and Green lights (91.53 and 89.90%) compared to those subjected to dark treatment (85.30 %). Moreover, there were higher significant differences for commercial hatchability of Japanese quail eggs treated with Red and Green lights (83.03 and 82.47%) than those subjected to dark treatment (78.77%).

Scientific hatchability for $Cobb_{500}$ broiler breeder eggs was significantly higher in Red and Green light treatments (92.40 and 90.77%) than those subjected to dark treatment (85.40%). Also, there were higher significant differences for commercial hatchability of $Cobb_{500}$ broiler breeder eggs treated with Red and Green lights (84.37and 82.37%) than those subjected to dark treatment (77.47%).

Previous works has shown that providing light during incubation could improve overall hatchability (Shafey, 2004; Archer and Mench, 2014). The same results was recorded by Shafey and Al-Mohsen (2002) who found that eggs incubated under the Green light condition had significantly higher hatchability than those incubated under the Dark treatment. In addition, Hluchý et al. (2012) had similar findings to this present study as Red light increasing hatchability.

Archer (2017) found that the Red and White light treatments had a higher hatch of fertile eggs than those of both Green and Dark treatments, but he found that Green light did not improve hatchability in his study suggesting that the wavelength of light responsible for increased hatchability. On the other hand, this result disagreed with Bowling et al. (1981) who reported a reduction in hatchability of White Leghorn eggs due to white lighted incubation. Moreover, Zakaria (1989) reported no improvement in hatchability of meat-type breeder eggs incubated under white fluorescent light.

Table (2): Means ± standard errors for fertility, scientific and commercial hatchability percentages of Japanese quail eggs incubated in different treatments of light color.

Light Treatment	Parameters		
	Fertility (%)	Scientific hatchability (%)	Commercial hatchability (%)
Dark	82.00±0.58 ^{a}	85.30±0.61 ^{b}	78.77±0.99 ^{b}
Green	81.80±0.96 ^{a}	89.90±0.78 ^{a}	82.47±0.74 ^{a}
Red	82.30±0.47 ^{a}	91.53±1.45 ^{a}	83.03±0.55 ^{a}

Means carrying different litters within the same column are significantly different ($P < 0.05$).

Table (3): Means ± standard errors for fertility, scientific and commercial hatchability percentages of $Cobb_{500}$ broiler breeder eggs incubated in different light colors.

Light Treatment	Parameters		
	Fertility (%)	Scientific hatchability (%)	Commercial hatchability (%)
Dark	86.13±0.49^{a}	85.40±0.55^{b}	77.47±0.55^{b}
Green	86.37±0.58^{a}	90.77±0.67^{a}	82.37±0.64^{a}
Red	86.40±0.70^{a}	92.40±0.61^{a}	84.37±0.70^{a}

Means carrying different litters within the same column are significantly different ($P < 0.05$).

3.2. Embryonic mortalities:

Early, mid and late embryonic mortalities percentages of Japanese quail and $Cobb_{500}$ broiler breeder eggs incubated in different light colors are presented in Tables 4 and 5.

Dark and Green light treatments showed higher significant differences for early embryonic mortality percentages for quail eggs (37.98 and 31.88 %) while Red light treatment expressed lowest significant difference for early embryonic mortality percentages for quail eggs (23.57%).

On the other hand non-significant differences were recorded for mid embryonic mortalities. Regarding late embryonic mortality recorded higher significant percentages for quail eggs incubated in Red and Green light treatment (55.26 and 52.06 %) than quail eggs incubated in Dark treatment (39.71%).

The same trend was reported for $Cobb_{500}$ broiler breeder eggs where D and G light treatments showed higher significant differences for early embryonic mortality percentages for $Cobb_{500}$ broiler breeder eggs (54.77 and 50.85%) while R light treatment expressed lowest significant difference for early embryonic mortality percentages for $Cobb_{500}$ broiler breeder eggs (26.07 %). On the other hand non-significant differences were recorded for mid embryonic mortalities. Regarding late embryonic mortality recorded higher significant percentages for $Cobb_{500}$ broiler breeder eggs incubated in R light treatment (66.85 %) than $Cobb_{500}$ broiler breeder eggs incubated in D and G light treatments (35.08 and 39.15%). Significant differences for early, mid and late embryonic mortality percentages among different light colors were recorded by (Shafey and Al-Mohsen, 2002). But non-significant differences among different light colors were recorded by (Archer 2017).

3.3. Egg weight loss during incubation period:

Table (6) shows that weight loss of Japanese quail eggs incubated under different light colors was recorded for three different periods (0-5, 5-10, 10-14 days of incubation) and the total weight loss from the first day till the end of 14 day of incubation. It was observed that during 0-5, 10-14 and 0-14 days of incubation, eggs incubated in Dark treatment recorded the highest egg weight loss (0.54, 0.43 and 1.41g; respectively) and percentage of weight loss (4.09, 3.26 and 10.75%; respectively).On the other hand, the lowest egg weight loss and percentage was recorded for eggs incubated in Green light recorded the lowest egg weight and percentage during 0-5, 10-14 and 0-14 days (0.40, 0.10 and 1.02 g) and (2.86, 0.70 and 7.21%), But eggs incubated in Red light recorded the lowest egg weight and percentage during and 5-10 days (0.34 g) and (2.56 %). The decrease in egg weight loss incubated under green light disagreed with the results obtained by Zhang et al. (2015) who found non-significant differences in weight loss rate of fertile eggs incubated under LED-based white light, green light or dark condition.

Table (4): Means ± standard errors for early embryonic mortality, mid embryonic mortality and late embryonic mortality percentages of Japanese quail eggs subjected to different treatments of light color.

Light Treatment	Parameters		
	Early embryonic mortality (%)	Mid embryonic mortality (%)	Late embryonic mortality (%)
Dark	37.98±3.66[a]	26.75±4.86[a]	39.71±1.28[b]
Green	31.88±4.38[ab]	22.96±1.54[a]	52.06±1.34[a]
Red	23.57±1.70[b]	22.59±3.27[a]	55.26±2.23[a]

Means carrying different litters within the same column are significantly different (P<0.05).

Table (5): Means ± standard errors for early embryonic mortality, mid embryonic mortality and late embryonic mortality percentages of $Cobb_{500}$ broiler eggs subjected to different treatments of light color.

Light Treatment	Parameters		
	Early embryonic mortality (%)	Mid embryonic mortality (%)	Late embryonic mortality (%)
Dark	50.85±3.40[a]	0.0	39.15±3.40[b]
Green	54.77±3.52[a]	0.0	35.08±3.57[b]
Red	26.07±4.27[b]	0.0	66.85±3.40[a]

Means carrying different litters within the same column are significantly different (P<0.05).

Table (6): Means ± standard errors of weight loss (gm. and %) of Japanese quail incubated eggs subjected to different treatments of light color.

Period per day		Color / Treatment		
		Dark	**Green**	**Red**
0:5	**(g)**	0.54 ± 0.03 ^{a}	0.40 ± 0.04 ^{b}	0.41 ± 0.02 ^{b}
	(%)	4.09 ± 0.24 ^{a}	2.86 ± 0.29 ^{b}	3.00 ± 0.17 ^{b}
5:10	**(g)**	0.45 ± 0.03 ^{a}	0.52 ± 0.05 ^{a}	0.34 ± 0.02 ^{b}
	(%)	3.41 ± 0.20 ^{a}	3.65 ± 0.32 ^{a}	2.56 ± 0.12 ^{b}
10:14	**(g)**	0.43±0.03 ^{a}	0.10±0.02 ^{c}	0.30±0.01 ^{b}
	(%)	3.26±0.21 ^{a}	0.70±0.12 ^{c}	2.25±0.09 ^{b}
Overall	**(g)**	1.41±0.08 ^{a}	1.02±0.07 ^{b}	1.04±0.04 ^{b}
0:14	**(%)**	10.75±0.59 ^{a}	7.21±0.50 ^{b}	7.80±0.30 ^{b}

Means carrying different litters within the same row are significantly different (P < 0.05).

Table (7): Means ± standard errors for weight loss of $Cobb_{500}$ broiler breeder incubated eggs subjected to different treatments of light color.

Period per day		Color / Treatment		
		Dark	Green	Red
0:5	(g)	1.96 ± 0.07 ^{b}	2.07 ± 0.06 ^{b}	2.70 ± 0.19 ^{a}
	(%)	2.96 ± 0.11 ^{b}	3.51 ± 0.11 ^{b}	4.22 ± 0.30 ^{a}
5:10	(g)	1.56 ± 0.06 ^{a}	1.07 ± 0.08 ^{b}	1.82 ± 0.14 ^{a}
	(%)	2.35 ± 0.09 ^{b}	1.80 ± 0.14 ^{c}	2.83 ± 0.22 ^{a}
10:14	(g)	1.32 ± 0.05 ^{b}	0.95 ± 0.05 ^{c}	1.94 ± 0.13 ^{a}
	(%)	2.00 ± 0.08 ^{b}	1.60 ± 0.08 ^{c}	3.02 ± 0.21 ^{a}
14:18	(g)	1.61 ± 0.05 ^{a}	1.05 ± 0.03 ^{b}	1.45 ± 0.12 ^{a}
	(%)	2.44 ± 0.09 ^{a}	1.78 ± 0.06 ^{b}	2.25 ± 0.18 ^{a}
Overall	(g)	6.44 ± 0.22 ^{b}	5.13 ± 0.16 ^{c}	7.90 ± 0.42 ^{a}
0:18	(%)	9.75 ± 0.34 ^{b}	8.69 ± 0.29 ^{b}	12.33 ± 0.66 ^{a}

Means carrying different litters within the same row are significantly different (P<0.05).

Table (7) shows egg weight loss of $cobb_{500}$ broiler breeder eggs incubated under different light colors for four different periods (0-5, 5-10, 10-14, 14-18 days of incubation) and the total weight loss from the first day till the end of 18 days of incubation. It was observed that during 0-5, 5-10, 10-14 and 0-18 days of incubation, eggs incubated in Red light recorded the highest egg weight loss (2.70, 1.82, 1.94 and 7.90 g; respectively) and percentage of weight loss (4.22, 2.83, 3.02 and 12.33 %; respectively), followed by eggs incubated in Dark treatment. On the other hand, the lowest egg weight loss and percentage was recorded for eggs incubated in Green light during 5-10, 10-14, 14-18 and 0-18days were (1.07, 0.95, 1.05 and 5.13 g) and (1.80, 1.60, 1.78 and 8.69 %; respectively), but eggs incubated in D treatment recorded the lowest egg weight and percentage during 0-5 days (1.96 g and 2.96 %).

The decrease in egg weight loss incubated under Green light disagreed with the results obtained by Zhang et al. (2015) who found non-significant differences in weight loss rate of fertile egg incubated under LED-based white light, Green light or dark condition.

CONCLUSION

It was concluded that using of the colored light (Red or Green) during incubation period of Japanese quail and $Cobb_{500}$ broiler breeder eggs improved hatchability performance.

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