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Original article

The Effects of Monochromatic Lighting on Hatch Window and Hatching Performance in Broiler Breeder Eggs

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Abstract

In this study, the effects of monochromatic lighting on egg weight loss, embryonic mortality, hatch window and hatching performance were investigated. The number of eggs used in the experiment was a total of 780 (Ross-308 genotype). Eggs were randomly assigned to 3 groups. 1) Control group: Eggs were incubated in dark, 2) Green light group: 560 nm (wavelength from 535 to 585 nm), 3) Red light group: 670 nm (wavelength from 640 to 690 nm). During the first 18 days of the incubation period, continuous illumination of 0.1-0.2 lx intensity was provided with LEDs placed on both sides of the trays. The light transmission was prevented by blank trays coated with greenhouse covering material which has 75% shading feature placed among experiment groups. In this way, light transmission to other trays and any possible hitches of air circulation was prevented. There was no difference between examined egg weights of the treatment groups in the experiment, but it's found that significant difference in egg weight loss for both colours of light. Red light and control groups (15.00% and 11.92%) show a similar embryonic mortality rate, while the green light group has a lower embryonic mortality rate (5.00%) than these groups. The effects of monochromatic lighting on the hatching time were significant (Chi-square<0.05). Although there was no significant difference between hatching performance parameters of the control and red light treatment groups in the experiment, the green light group had better hatching efficiency than the other groups. The findings of this research were carried out with two different light wavelengths are remarkable for showing that the significant effects of the monochromatic illumination on hatching results.

Keywords: Hatchery, Monochromatic lighting, Hatching performance, Hatch window.

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INTRODUCTION

In commercial hatcheries, eggs are usually hatched in the dark. However, some studies have been shown that light stimulation accelerates embryonic development. Also, it has been reported that light stimulation applied to breeder eggs stored in the dark before hatching increases hatching weight in different species of poultry embryos, including broilers, laying hens, turkeys, and quails. (Shutze et al., 1960; Siegel et al., 1969; Cooper, 1972; Walter and Voitle, 1972; Coleman and McNabb, 1975).

Hatchability is affected by many factors such as breeder age, egg quality, storage conditions and duration, and hatching conditions (Altan et al., 2002). Rozenboim et al. (2004) reported that lighting in incubation has crucial importance as like temperature, humidity and ventilation for embryonic development. When the lighting applies during incubation, embryonic development accelerates this improves hatching performance (Fairchild and Christensen, 2000; Rozenboim et al., 2004; Shafey, 2004; Archer, 2015; Archer et al., 2017). However, there is not enough database on the source of this positive effect (heat and/or light) and the mechanism of action.

Siegel et al. (1969) have found that exposure to light for the first two weeks in incubation shortened the incubation period, while the hatchability and incubation performance did not change. This phenomenon is term as photo-acceleration by some researchers. Demircioğlu (1994), Walter and Voitle (1972) reported that hatching weights of broiler chicks, is hatched in the dark were lower than those of the illuminated group, and lighting did not affect embryonic deaths or hatchability, however, embryonic development was accelerated, and the incubation period was shortened. Coleman (1979) has determined that the application of lighting to White Leghorn eggs from the first day they were incubated significantly reduced early-term embryonic deaths. Shafey (2004) on the other hand, determined that continuous constant lighting for 5-18 days in incubation accelerates embryo development, but the effect on hatchability varies depending on the physical characteristics of the egg.

The light environment has a decisive influence on bird performance. Effects of light on birds are determined by five basic parameters, these are: illumination duration, light intensity, light source, light color and light wavelength (Keskavarz, 2000; Mashkov et al., 2015). New developments in today's lighting technologies have brought up the new generation of light sources called LEDs (light-emitting diots), which are emitted in a certain wavelength of light (monochromatic lighting) use for the incubation enterprises. In recent years, studies have focused on monochromatic lighting. According to the latest studies have shown that monochromatic lighting has a more positive effect on hatching performance than white light. Hluchy et al. (2012) stated that light excitation of different wavelengths could affect hatchability at different levels.

Light is an important environmental stimulus during incubation as the avian embryo has evolved to respond to light stimulation. It has been reported that the hatchability of broiler breeder eggs hatched

in white, red and green light is significantly higher (Archer et al., 2017). Hluchy et al. (2012) stated that embryonic development accelerated in broiler breeder eggs to which monochromatic lighting was applied for 24 hours between 14-21 days of incubation, they were also more sensitive to green light compared to red light and hatching began earlier.

The objective of this study was to determine how the green and red light affected broiler breeder eggs in respect to embryo mortality, hatch window, hatchability and hatching performance.

MATERIALS and METHODS

The study (experiment) was conducted using 780 eggs obtained from a commercial hatchery. The trial was conducted using white eggshell (Ross-308). Standard incubation conditions were provided in a trial (Eggs incubated at 37.7±0.1 ºC, 60±5% relative humidity during the first 18 days and 37.2±0.1 ºC, 75±5% relative humidity for last 3 days) and the eggs were turned every hour.

In the experiment, a total of 840 eggs were candled and 780 eggs with hatching characteristics were selected. Eggs were randomly assigned to 3 groups (n=260); 1) Control group: Eggs were incubated in dark, 2) Green light group: 560 nm (wavelength from 535 to 585 nm), 3) Red light group: 670 nm (wavelength from 640 to 690 nm). During the first 18 days of the incubation period, continuous illumination of 0.1-0.2 lx intensity was provided with LEDs placed on both sides of trays. The light transmission was prevented by blank trays coated with greenhouse covering material which has 75% shading feature placed among experiment groups. In this way, light transmission to other trays and any possible hitches of air circulation was prevented.

All eggs were weighed and candled at d 18 of incubation. Infertile eggs, early dead (0-7 d) and mid-dead (8-14 d) eggs were identified and recorded after the remaining eggs were transferred to the hatcher. On d 21 unhatched eggs were broken out and late dead (15-21 d), dead in shell, pip deads were recorded and total embryonic deads, infertility, hatchability (hatchability of fertile eggs), hatching performance (hatchability of set eggs) were calculated (%). Between 471-501 hours of incubation, the incubator opened every 3 hours, hatched chicks in groups were counted and removed from the hatcher.

Data were recorded by ms excel and they were analyzed with JMP statistical software when comparing the differences of means it was deemed to be significant at $P<0.05$. ANOVA procedures were used for balanced data percentage data was conducted using chi-square tests.

RESULTS and DISCUSSION

The egg weight, egg weight loss, hatchability and hatching performance were presented in Table 1. Although no differences were observed in egg weight, egg weight loss was significantly different between treatment groups (Chi-sq=0.0236). The egg starts to lose water after oviposition. For optimum hatchability, egg weight loss is expected to be around 6.5-12.0% (Hays and Spear, 1951; Ar, 2004). Egg

water loss is also an indicator of embryo metabolic rate and a high metabolic rate accelerates water loss (Christensen et al., 1996). The early start of hatching in the green light group, which showed higher egg weight loss than the control group, was supported this information. Stating that the egg weight loss will increase with the warming effect caused by the LEDs, Zhang et al. (2016) stated that the lighting intensity of 30 lux, they applied did not cause such an effect. In the light of that information, it can be said that the illumination intensity level of 0.1-0.2 lux was no associated with egg weight loss in our study.

The green light group had a higher (Chi-sq=0.0013) hatchability than the red-light treatment and control groups. In this present study, the improved hatchability with green light treatment disagrees with previous findings (Zhang et al., 2012; Archer, 2017). On the other hand, Archer (2016) observed no differences in hatchability in broiler eggs exposed to red light during incubation although Hluchý et al. (2012) found that the red light increasing hatchability. As can be seen, many studies have been conducted to determine the negative or positive effects of light of different wavelengths on hatchability. Regardless of the color (wavelength) of light, studies investigating light intensity and retinal photoreceptors and hormones related to embryonic development and therefore increased hatchability have gained momentum (Rozenboim et al., 2013; Tong et al., 2015; Zhang et al., 2016).

Table 1. Effects of monochromatic lighting on egg weight loss and hatching performance.

Parameters	Control	Red light	Green light	Chi-sq
Egg weight (g)	61.72±0.25	61.85±0.26	62.33±0.25	0.2099 *(P)*
Egg weight loss (d 10, %)	8.30±0.27^{ab}	7.42±0.27^{b}	8.89±0.27^{a}	0.0236
Hatchability (%)	84.62±2.97^{b}	82.31±2.97^{b}	92.69±2.97^{a}	0.0013
Hatching performance (%)	63.85±4.04^{b}	64.23±4.04^{b}	77.69±4.04^{a}	0.0006

a, b: Means within rows with no common superscript differ significantly (Chi-sq<0.0001).

Early, mid and late-term embryonic deaths were evaluated during the 21-day incubation period and no differences were found between the treatment groups (Chi-sq>0.05) (Table 2). The red light group had the highest total embryonic mortality (%15), followed by the control (%11.92) and, green light (%5.00) was the lowest (Chi-sq=0.0007). Likewise, red light group (%6.53) had the highest death in shell embryos, followed by the control (%3.46), and green light (%0.76) was the lowest (Chi-sq=0.0019). On the other hand, results in Table 2 show that there were no pipped with death embryos in the green light group. Generally, in the late-term period (including deaths in shell and piping embryo deaths) the highest embryonic mortality was recorded in the control and red light groups. In agreement with our findings, Shafey and Al-mohsen (2002) showed that the green light incubation of eggs reduced dead embryos. On the other hand, Archer (2017) observed no differences overall dead embryos between treatments although red light had higher total dead embryos and he found that the dark treatment group had the lowest pip death rate.

Table 2. Effects of monochromatic lighting on embryonic deaths.

Embryonic Mortality	Control	Red light	Green light	Chi-sq
Infertility rate (%)	20.38±2.38	18.46±2.38	15.00±2.38	0.2691 *(P)*
Total embryonic mortality (%)	11.92±1.89^{a}	15.00±1.89^{a}	5.00±1.89^{b}	0.0007
Early embryo deaths (%)	3.46±0.93	1.53±0.93	1.92±0.93	0.3038
Mid-term embryo deaths (%)	1.15±0.66	1.54±0.66	0.78±0.66	0.7146
Late embryo deaths (%)	1.92±0.88	2.69±0.88	1.53±0.88	0.6407
Deaths in shell (%)	3.46±1.14^{ab}	6.53±1.14^{a}	0.76±1.14^{b}	0.0019
Pipping embryo deaths (%)	1.92±1.07^{ab}	2.69±1.07^{a}	0.00±1.07^{b}	0.0368

a, b: Means within rows with no common superscript differ significantly (Chi-sq<0.0001).

Table 3 shows a comparison of the hatching time mean and hatch window in each treatment from 471 h to 501 h. At the 471st hour when hatching started, 6 chicks from the control group and 15 chicks from the green light group hatched, while there was no hatching in the red light group. Consistent with the findings in the Yu et el. (2018), Shafey and Al-mohsen (2002) and Archer (2017), green light stimulation during the first 18 days of incubation decreased the mean of hatching time (481.33 h) in this study.

Table 3. Effects of monochromatic lighting on hatch window

Hour	Control		Red light		Green light		Total	
	n	%	n	%	n	%	n	%
471	6	1.16	0	0.00	15	2.89	21	4.05
474	8	1.54	1	0.19	26	5.01	35	6.74
477	14	2.70	2	0.39	27	5.20	43	8.29
480	45*	8.67	4	0.77	27	5.20	76	14.64
483	38	7.32	23	4.43	29*	5.59	90	17.34
486	27	5.20	29	5.59	26	5.01	82	15.80
489	16	3.08	37	7.13	13	2.50	66	12.71
492	11	2.12	39*	7.51	8	1.54	58	11.17
495	4	0.78	18	3.47	5	0.97	27	5.22
498	1	0.19	8	1.54	1	0.19	10	1.92
501	1	0.19	7	1.35	3	0.58	11	2.12
Total	171	32.95	168	32.37	180	34.68	519	100
Chi-Kare=0.0001								
Hatching time mean	482.96^{b}		489.48^{a}		481.33^{b}		*Chi-square 0.0001*	

*: Proportionally the hour of the hatching

CONCLUSIONS

In this study, effects of lighting with different wavelengths in broiler breeder eggs during incubation have been investigated and egg weight loss, hatchability, hatching performance, hatch

window, and embryo mortality were determined. Our results indicated that monochromatic green light during the first 18 days of incubation enhanced the hatchability and reduced mortality compared with the red light treatment and control groups. Generally, in the late-term period, there were no pipping deaths were recorded in green light treatment. When the number of chicks hatched and their ratios were evaluated cumulatively, it was seen that the most positive results were obtained from the green light group.

The findings obtained from this study, which was carried out with two different light wavelengths, are remarkable in terms of showing that monochromatic lighting applied in hatching has significant effects on both hatchability performance and embryonic development characteristics.

It would be beneficial to evaluate with further studies of these positive effects of light on hatching and embryonic development the impacts on post-hatch performance. Transferring the results to be obtained from this and similar studies to the field will provide a significant economic contribution to the sector by providing an increase in performance along with chick quality as well.

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