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EFFECT OF CYCLIC LED LIGHTING IN INCUBATOR ON HATCHING PERFORMANCE, CHICK QUALITY AND SEX RATIO OF BROILER CHICKS

M.I. El Sabry[1] and H.G.M. Essa[2]

1-Animal Production Department, Faculty of Agriculture, Cairo University, 12613, Giza Egypt, 2-Alwatania Poultry-Egypt, El Sadat City, Egypt

SUMMARY

Utilizing different colors of cool LED light during egg incubation process has shown positive effects on hatchability performance, however, the use of LED light still needs more investigation. This experiment was conducted to evaluate the effect of cyclical white LED light, during the first eighteen days of incubation period, on hatchability, chick quality and secondary sex ratio of broiler eggs. A total of 600 eggs from 34 wk old Cobb broiler breeders were divided into two groups, 300 eggs each. The treated group was incubated in 12-h light: 12 h dark (LD) regimen from day 0 to day 18 of incubation period, while the control group was incubated in complete darkness (DD). Egg weight loss %, chick weight, hatching performance (total incubation period, embryonic mortalities, hatchability rate, and hatching window), chick quality (chick weight, Tona score, sellable chick % and chick yield %) and secondary sex ratio were determined.

Using cyclical white LED light showed a positive influence on some economic parameters. The eggs of the LD group had higher hatchability of fertile eggs (91.05 %, P = 0.1) and sellable chicks % at hatch (89.6 %, P = 0.16) compared to those of DD treatment (86.99 % and 86.6%, respectively). In addition, the total incubation period of eggs (hours) of the LD group (495.7 hours) was shorter (P = 0.01) than that (498.1 hours) of the DD group. However, the results show that egg weight loss %, hatching window, chick weight and Tona score and secondary sex ratio of eggs exposed to LED light were similar to eggs hatched in darkness. The results indicate that providing cyclic LED light during incubation process improves hatchability and shorten the total incubation period with no deleterious effect on chick quality or significant changes in secondary sex ratio in broilers.

Keywords: LED light; incubation; hatchability; broiler eggs

INTRODUCTION

It is well known that incubation environment plays an important role in embryonic development. For example, temperature, humidity, ventilation, and egg turning can determine the success of incubation process. Fairchild and Christensen (2000) suggested light as a possible fifth environmental variable, which is not monitored during the incubation of avian eggs. The importance of light seems logical because under natural conditions, the hen leaves the nest periodically to feed and drink (Rogers, 1996), as well as the embryos can respond to light as early as 3 d of embryonic age (Erwin *et al*., 1971).

Shafey and Al-Mohsen (2002) and Hluchy *et al*. (2012) suggested that there are some factors which can impact the outcome of utilizing lighting in the incubators. These factors include: 1) source, color and intensity of light, 2) egg size and 3) eggshell characteristics. Moreover, both lighting hours and timing of light exposure are very important restrictions for the success of lighting during incubation. They have significant effects on the embryo's physiological traits, hatchability, chick quality and performance of post-hatch (Özkan *et al*., 2012 a,b; Archer and Mench. 2013; and Archer, 2015).

The contradictory reports about the influence of light on the embryonic mortality, hatchability rate and chick quality are probably the main reasons for ignoring it as an important environmental factor. For example, Archer (2015) found that there was no effect due to using light on the embryonic mortality, while Shafey and Al-Mohsen, (2002) found that light treatment significantly decreased early and late embryonic mortalities. In turkey, Kicka *et al*. (1982) and Fairchild and Christensen (2000) found that light treatment had no effect on hatchability rate, while Archer (2015) stated that hatchability rate was significantly increased due to light utilization (18 or 21 hours/ day) in the incubator during the first 18 of incubation or the entire 21days of incubation.

Because of the conflict about the importance of light in avian egg incubation process, this study was conducted to investigate the effect of LED light on egg weight loss, chick weight, embryonic hatching performance, chick quality and secondary sex ratio.

MATERIALS AND METHODS

Six hundred eggs from 34wk old commercial Cobb flock were used in this experiment. Two identical incubators and one hatcher were used; the front windows were covered with black plastic sheet to prevent light intrusion into the incubator. One incubator was operated with the common procedure of incubation at complete darkness (DD), while the other one was outfitted with (white LED light strip) on each level, with one strip running the length of the racks. Each LED strip was attached to metal frame of the upper rack. The light was controlled by a timer, with a 12hr L:12hrD light schedule (LD) at 300 lux at egg level. Two replicates of 50 eggs each were set on each rack, for a total of six replicates over three levels equaling 300 eggs per incubator. Eggs of both treatments received standard temperature and humidity levels of 37.5°C and 52% relative humidity (RH). The eggs were incubated for 18 d, and then they were moved into a hatcher. Each group was weighed at 0 time and re-weighed at d 18 to calculate egg weight loss % = (Initial egg weight at 0 time – egg weight at d 18)/ Initial egg weight at 0 time *100. During the last 3 days, eggs were incubated in the same hatcher at 36.5°C and 65% RH. Hatching window was considered from 1% hatch to complete hatch max at 500hours of incubation time. All the chicks were weighed and counted within 45 min after hatch. The chick yield was calculated = chick weight (g) / egg weight (g) *100.

Feather sexing was used for identification of males and females at one-day-old. In feather sexable broilers, slow- feathering chicks are male and fast-feathering chicks are female (Cobb-Vantress, 2008). The quality of the live chicks was assessed using Tona score, and they were categorized and counted as either sellable or cull chicks that are having any of the following: unhealed navel, leg abnormalities or too weak to stand, dirty or other abnormality. The unhatched eggs were broken out, the number of infertile, early death (0 to 7 d of incubation), middle death (8 to 14 d of incubation), and late death (15until hatch) eggs were recorded (Cobb-Vantress, 2008). Hatchability was calculated as a percentage of total eggs set, and was also calculated as a percentage of fertilized eggs. Sellable chicks were calculated as percentages of the total hatched chicks.

All of the assumptions of ANOVA were tested (Shapiro-Wilk test for normality). No transformations were needed to meet assumptions. All analyses were performed using JMP Pro 5 statistical analysis program. One-way ANOVA was used to investigate treatment effect on embryonic mortality, hatchability performance, chick quality traits and secondary sex ratio.

RESULTS AND DISCUSSION

Embryonic mortality

In the current study, the effects of white LED light from d1 to d 18 of incubation on embryonic mortality, hatching performance, chick quality and secondary sex ratio in broiler breeder eggs were studied. This procedure could be applicable in commercial hatcheries. Results in Table (1) show that there were no significant differences between LD and DD treatments in the early, mid or late embryonic mortality percentage as well as percentage of pipped chicks. Our finding agrees with those of Huth and Archer (2015), who found that lighting (12L: 12D) the incubator and hatcher did not affect embryonic mortality, in layer hens and broiler breeder. Whilst, Shafey and Al-Mohsen, (2002) found that using 20-watt green fluorescent light for 24h during the first 18 days significantly decreased the embryonic mortality, while light did not affect the percentage of pipped with dead embryos.

Both egg weight loss % and hatching window were not affected significantly by the LD light treatment (Table 2). These results may be due to similarity of the initial egg weight of the LD and DD groups were 59.7 g and 59 g, respectively. No information is available about the effect of light on egg weight loss % and hatching window.

Table 1. Comparison of embryonic mortality when eggs incubated in a 12:12 light cycle (LD) or 24-h darkness (DD)

	Light treatment			
Embryonic mortality (%)	LD	DD	p-Value	±SEM
Early	4.32	7.84	0.07	1.26
Middle	0.72	0.37	0.57	0.42
Late	3.19	1.84	0.19	0.68
Pipped	1.42	2.54	0.34	0.79

No significant differences were found between different treatments

Table 2.Egg weight Loss %, hatching window, total incubation period, chick weight and yield % and Tona score for eggs incubated in a 12:12 light cycle (LD) or 24-h darkness (DD)

	Light treatment			
Parameters	LD	DD	p-Value	±SEM
Egg weight loss (%)	12.31	12.11	0.72	0.38
Hatching window (hours)	23.37	23.41	0.96	0.57
Total incubation period (hours)	495.75[b]	498.16[a]	0.01	0.55
Chick weight (g)	42.63	42.35	0.43	0.24
Chick Yield (%)	71.39	71.77	0.49	0.38
Tona score	88.66	88.33	0.89	1.7

[a,b] Means, within a row, with different superscripts differ significantly.

The length of incubation period of LD group was significantly shorter compared to that of the DD group (Table 2). These results may be due to the changes in the physiological and metabolic activities of the embryos due to exposure to light. Cooper *et al*. (2011) incubated the eggs of house sparrow (*Passer domesticus*) under different photoperiods similar to those found at temperate (18L: 6D) and tropical (12L: 12D) latitudes. The results of metabolic rate of embryos showed that the mean metabolic rate during the dark phase (1.30 ± 0.57 µL CO_2 min^{-1} egg^{-1}) was lower than that of light phase (1.92 ± 0.73 µL CO_2 min^{-1} egg^{-1}). In addition, Cooper *et al*. (2011) postulated that eggs incubated under the longer photoperiod (18 L: 8D) hatched about 1 day earlier than eggs incubated under the shorter photoperiod (12L:12 D). Also, Fairchild and Christensen (2000) found that the length of incubation period of turkey eggs was shortened by photo stimulation of eggs during the incubation process. The present results indicate that the light passes through the shell may play a key role in accelerating the embryos' development and metabolic activates in chicken. More studies should be done to understand how lighting can affect the pathway of metabolic activity.

Both chick weight (g) and yield % of both LD and DD treatments were similar (Table 2). These results are compatible with our egg weight loss %, which were not affected by light treatment. These finding agree with those of Fairchild and Christensen (2000) in turkey. They found that chick weight was not affected by light treatment during incubation. While, Shafey and Al-Mohsen, (2002) found that chick weight (g) and yield % of the green light group were significantly lower than those of the dark group, in broiler breeders. This may be due to the different color light used in the experiments.

The differences between the overall hatchability, hatchability of fertile eggs and number of sellable chicks of LD and DD groups were not significant. However, it is noteworthy that the LD positively increased both overall hatchability percentage and hatchability of fertile eggs percentage by 5% as the most economic parameters that should be considered (Fig.1). These results are corresponded to findings by Hluchy *et al*. (2012), who tested different monochromatic lighting during incubation of broiler eggs and found that red light produced a higher hatchability than blue light, while the white light having the highest overall hatchability. In addition, Shafey (2004) found differences in hatchability among layer strains due to utilizing light during the incubation period. He suggested that the physical dimensions of eggs can allow different levels of light to pass through the eggshell. Archer *et al*. (2017) found a significant increase in the hatchability of chicken and Pekin duck eggs when they used a combination of white and red LED light during incubation. Moreover, our results partially agree with those of Shafey and Al-Mohsen, (2002), who found a significant increase in hatchability of fertile eggs percentage due to using green light throughout the incubation period. Huth and Archer (2015) found that both hatchability and percentage of chicks, with no defects, of the LED light group were significantly higher than those of un-treated group.

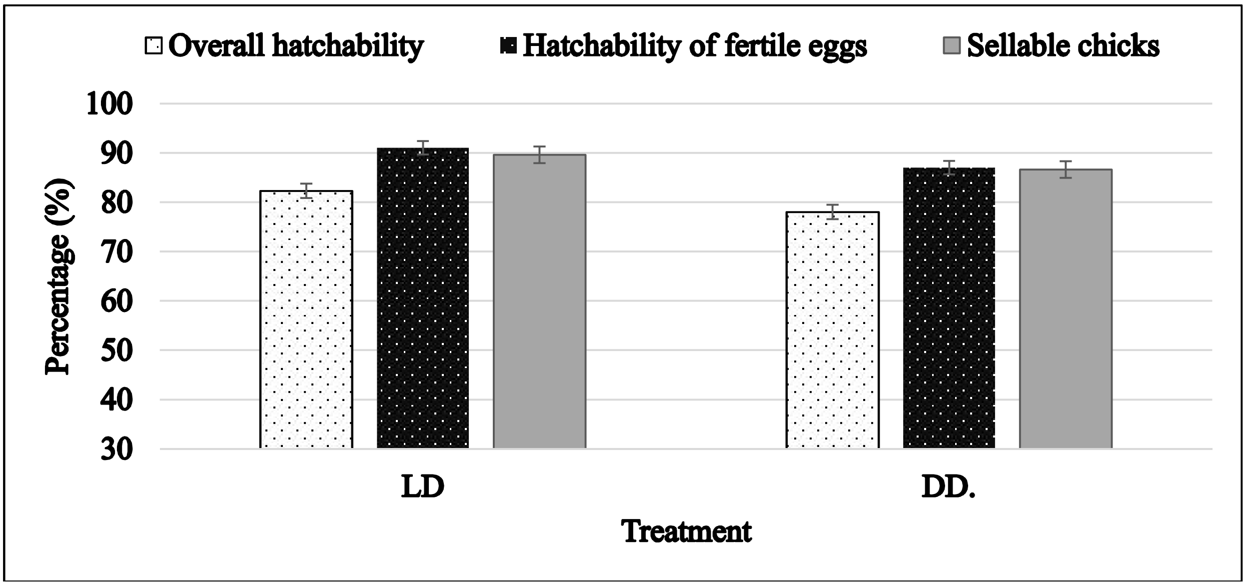

Fig.1. Comparison between overall hatchability, hatchability of fertile eggs and sellable chick of the treated (eggs incubated in a 12:12 light cycle, LD) or control group (24-h darkness, DD).
No significant differences were observed between the treated and control groups.

Tona score results show that there were no significant differences between LD and DD groups (Table 2). On the other hand, previous studies, indicated that different light treatments during incubation improved chick quality compared to darkness control in turkeys (Fairchild and Christensen, 2000), and broilers (Archer *et al*., 2009; and Archer *et al*., 2017). The largest difference in the chick quality was attributed to unhealed navels, that the dark treatments having greater number of navel scores compared to the lighted treatments, in broiler breeders (Archer *et al*., 2017). This reduced un-healed navels percentage could be attributed to the faster growth rate of embryos of the light treated groups (Cooper *et al*., 2011).

Göth and Booth (2005) indicated that the incubation temperature can change the sex ratio. Since environmental variable can significantly affect sex ratio, it was anticipated that exposing eggs to white LED light during incubation process may influence the secondary sex ratio. In the present study, there were no significant differences in secondary sex ratio due to using light in the incubator. However, the female to male percent of the LD group was slightly greater than this of DD group (Fig. 2). The differential mortality might have been happening during the embryonic development due to the presence of light.

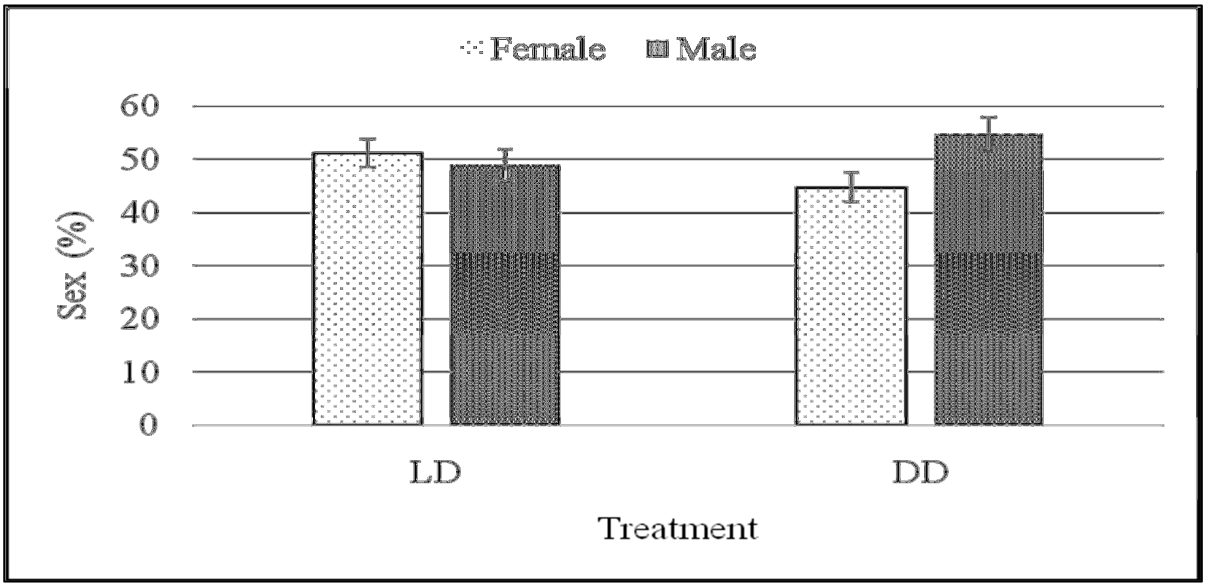

Fig.2. Comparison between secondary sex ratio of treated group (eggs incubated in a 12:12 light cycle, LD) or control group (24-h darkness, DD).

No significant differences were observed between the treated and control groups.

CONCLUSION

Providing cyclic white LED light during incubation of broiler eggs did slightly improve the measures of hatching and chick quality parameters. In addition, lighting did significantly shorten the incubation period. More benefits could be gained from this application after finding out the mechanism of light effects.

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تأثير استخدام الإضاءة (الليد) بصورة دورية في المفرخات على الفقس ، جودة الكتاكيت، والنسبة الجنسية لدجاج إنتاج اللحم

محمد إبراهيم الصبرى[1]، حسين جميل عيسى[2]

١-قسم الإنتاج الحيوانى، كلية الزراعة- جامعة القاهرة، ٢ - الشركة الوطنية للدواجن (معمل التفريخ)- مدينة السادات، المنوفية، مصر

إستخدام ألوان مختلفة من ضوء الليد البارد أثناء عملية التفريخ أظهرت نتائج إيجابية على معدلات الفقس، ومع ذلك فإن استخدام ضوء (الليد) لا يزال يحتاج إلى مزيد من التجارب. أجريت هذه التجربة لتقييم تأثير الإضاءة الليد البيضاء بصورة دورية خلال الـ ١٨ يوم الأولى من فترة التفريخ على كل من: الفقس، و جودة الكتكوت و النسبة الجنسية الثانوية للكتاكيت الناتجة من بيض أمهات دجاج اللحم. استخدمت في التجربة ٦٠٠ بيضة تفريخ من أمهات دجاج لحم سلالة (كوب)، قسمت إلى مجموعتين كل منها ٣٠٠ بيضة. تم تحضين المجموعة المعاملة في وجود الضوء بشكل دوري (١٢ ساعة إضاءة : ١٢ ساعة إظلام) من اليوم الأول إلى يوم الثامن عشر من فترة التفريخ، في حين تم تحضين بيض مجموعة المقارنة في إظلام كامل (٢٤ ساعة). تم تقدير كل من الفقد في وزن البيض %، وزن الكتكوت، أداء الفقس (مدة التفريخ الكلية، النفوق الجنيني، معدل الفقس، طول مدة الفقس)، جودة الكتكوت (وزن الكتكوت، مقياس(تونا) لتقييم جودة الكتكوت، الكتاكيت الصالحة للبيع %، ووزن الكتكوت منسوباً إلى وزن البيضة٪)، و تحديد النسبة الجنسية في الكتاكيت الفاقسة.

وأظهر استخدام ضوء الليد الأبيض بصورة دورية تأثير إيجابي على بعض الصفات الاقتصادية. وكانت نتائج مجموعة الليد أعلى في نسبة الفقس من البيض المخصب (٩١.٠٥٪، P = 0.1) و الكتاكيت الصالحة للبيع٪ (٨٩.٦٪، P = 0.16) مقارنة بنتائج مجموعة المقارنة (٨٦.٩٩٪ و ٨٦.٦٪ على التوالي). بالإضافة إلى ذلك، كان طول مدة التفريخ الكلية لبيض مجموعة الليد (٤٩٥.٧ ساعة) أقصر بصورة معنوية (P = 0.01) مقابل مجموعة المقارنة (٤٩٨.١ ساعة). بينما كانت نتائج الفقد في وزن البيض٪، طول مدة الفقس، وزن الكتكوت قيمة مقياس تونا لجودة الكتاكيت والنسبة الجنسية الثانوية للكتاكيت الناتجة لبيض المجموعة المعرضة للإضاءة متقاربة لنتائج البيض المفرخ في الظلام.

أشارت النتائج إلى أن توفير ضوء الليد بشكل دوري أثناء عملية التفريخ يمكن أن يحسن من الفقس% ويقصر من طول مدة التفريخ دون تأثير سلبي على جودة الكتكوت أو إحداث تغير معنوي في النسبة الجنسية الثانوية لكتاكيت إنتاج اللحم.