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Effects of Short-Term Storage or Pre-Storage Heating of Hatching Eggs from Young Broiler Breeder Flock before Incubation on Hatching Parameters and Chick Quality

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Abstract

This study was conducted to evaluate the effects of short-term storage (four days) or pre-storage heating of hatching eggs from young Ross broiler breeding flocks (28 week old) on hatching parameters and chick quality. In total, 1350 hatching eggs of 1 d and 4 d of laid were individually numbered and distributed three treatments, named as NS (eggs that were not stored), S (eggs that were stored for four days before incubation) and HS (eggs that were heated at 37.7 °C and a relative humidity of 60% for 24 h and then stored for three days before incubation). The HS treatment increased the hatchabilities of set and fertil eggs compared to the NS and S treatments, whereas the S decreased the these variables compared to the NS treatment. The embrionic mortality in the HS eggs was lower than those in the NS and S eggs. The rate of discarded chicks was higher in the S group than in the HS group. The chick weight in the NS treatment was higher than those in the S and HS treatments. In conclusion, the pre-storage heating of hatching eggs from young broiler breeder flock positively affected hatchability without chick weight and quality.

Keywords: Broiler, Chick weight, Hatchability, Chick quality, Heating

1. Introduction

Egg storage is a common practice for coordinating hatchery activities in grandparents and breeding enterprises in broiler breeding (Dymond et al., 2013). The storage time depends on the supply of hatching eggs, the maximum hatchery capacity and the variable market demand of one-day-old chicks in the poultry industry. However, storage of the hatching eggs affects both the embryo and the internal quality of the egg by increasing the albumen pH, decreasing the albumen height (Gharib, 2013) and the membrane flexibility of the egg yolk sac (Jones and Musgrove, 2005). In addition, depending on storage time, the hatching window period and the rate of discarded chicks increase and hatchability decreases (Yassin et al., 2008). Nowadays, the poultry industry usually stores eggs for three or four days to ensure that the hatching results are not negatively affected. However, the storage of the young breeding flocks eggs reduces the hatchability of the eggs (Yassin et al., 2008) which is inevitable in order to collect sufficient numbers for minimum hatching capacity because of the small number of eggs produced in young breeding flocks.

A number of methods have been investigated to increase the hatchability of eggs depending on storage time (Rocha et al., 2013). One of these is heating hatching eggs before or during storage (Fasenko et al., 2001a, b; Reijrink et al., 2009). Pre-storage heating of the chicken eggs for six hours (Fasenko ve ark., 2001a), the turkey eggs for 12 hours (Fasenko ve ark., 2001b) and the quail eggs for 8 hours (Petek ve Dikmen, 2004) ensures complete formation of the hypoplast. When the hypoplast stage occurs before storage (Fasenko et al., 2001a; Reijrink et al., 2009), shorter incubation time, higher embryo viability and hatchability are observed. Therefore, pre-storage heating may improve the incubation results (Fasenko et al., 2001a, b; Renema et al., 2006; Silva et al., 2008). During storage, the eggs stop growing, below physiological zero (20-21 °C), at a stage characterized by complete formation of zona pellucid. However, as the temperature increases during incubation, embryo development continues (Fasenko et al., 2001a). There is evidence that strategically applied heat treatments during storage advance developmental stage of the embryo and thereby increase the viability in storage.

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Compared to unheated eggs, it has been reported that heating eggs before storage leads to less embryonic death (Petek and Dikmen, 2004; Gharib, 2013). In addition, less developed embryo stages in eggs obtained from young breeding flocks are observed more frequently due to thicker albumen, which delays early embryonic development (Reijrink et al., 2009).

The effects of long-term storage (more than 7 days) and/or heating hatching eggs before or during storage on hatchability have been investigated in many studies (Fasenko et al., 2001a, b; Renema et al., 2006; Reijrink et al., 2009). Research has concluded that the hatching results can be improved by pre-incubation heating of eggs, especially from older than 30 weeks of age broiler breeding flocks. In addition, there is little information about the benefits of pre-storage heating of eggs from young breeding flocks when stored for a short period of time. Therefore, the aim of this study was to determine whether pre-storage heating would improve hatchability and chick quality in young broiler breeding eggs under four-day storage conditions.

2. Materials and Methods

In this study, a commercial broiler breeder flock, Ross 308 strain (at 28 weeks of age), located in Eskisehir territory, Turkey was selected. All the eggs laid during 4–8 hour of light periods on 1 d and 4 d of laid were collected. During the collection of eggs, because all substandard eggs like misshapen, cracked, dirty, blood-stained, toe-punched and elongated were eliminated, only oval shape and good quality intact eggs were selected for hatching. Thus, the 1350 hatching eggs (55.2 ± 0.05 g) of 1 d and 4 d of laid were individually numbered and distributed three treatments, named as NS (eggs that were not stored), S (eggs that were stored for four days before incubation) and HS (eggs that were stored for three days before incubation and then heated at 37.7 °C and a relative humidity of 60% for 24 h). The eggs were stored at 17 °C and 75% relative humidity for the time corresponding to the treatments.

To set all eggs at the same time to avoid additional variables into the study, 450 eggs of 1 d of laid were set into five trays (replicates) selected for the NS treatment whereas 900 eggs of 4 d of laid were set into five trays selected for the each of S and HS treatments. To account for possible environmental difference caused by position in incubator, these five replicated trays of the each treatment were randomly placed to the top, middle and lower part of the setter of chick master machine The setter conditions were operated at a temperature of 37.5 °C and a relative humidity of 60% during the first 18 day and eggs were turned after every hour. On 19th day of incubation, 90 eggs in the each replicated tray were transferred to separate hatch baskets and placed in a hatcher operated at a temperature of 37.2 °C and a relative humidity of 75%. The setter and hatcher (model CIMUKA) were automatically controlled. After 21 days of incubation, all hatched chicks from each treantment were taken out of hatcher, counted, weighed and transferred to brooding room. All eggs that were not hatched were broken open to examine whether eggs are fertile and to assess the approximate day of embryonic death (Iqbal et al., 2016). The eggs that there was no embryonic development was considered as infertile. The embryonic mortality that classified as early- (7 days after set), mid- (8 d to 18 d after set) and late- (19 d to 21 d after set) dead was assessed according to stages of embryo development.

The hatchability parameters (hatchabilities of set eggs and fertile eggs), embryonic mortality (early-, mid- and late-dead) rate of discarded chick that had physical abnormalities (weak, unhealed navels or red hocks, etc.) studied in this study were calculated using the following equations (1-5).

Hatchability of set eggs (%) = Number of chicks hatched/number of total eggs set × 100 (1)

Hatchability of fertile eggs (%) = Number of chicks hatched/number of fertile eggs set × 100 (2)

Unhatched egg rate (%) = Number of unhatched egg/number of total eggs set × 100 (3)

Discarded chick rate (%) = Number of discarded chick/number of total eggs set × 100 (4)

Early-, mid- or late- embryonic mortality (%) = Number of embryos that died between corresponding days of incubation/number of fertilized eggs × 100 (5)

Tona score (TS), and relative asymmetry (RA), which is an indicator of chick quality (Tona et al., 2003) and developmental stability (Yalçin et al., 2005), respectively were determined using randomly selected five chicks per repetition. For TS, different criteria such as umbilical region, legs, yolk sac and activity of these five chicks were evaluated (Tona et al., 2003). To calculated RA there right and left leg lengths were measured using a digital caliper (Stainless Hardened) and the following equation was used (6).

$$RA = [\,|L - R|\, / \{(L + R) / 2\}] \times 100 \quad (6)$$

Where L: left shank length, R: right shank length.

Statistical analyses

Normal distribution of the data obtained from the study was previously evaluated by Kolmogorrov-Smirnov test, homogeneity of variance was tested by Levene test. Then, the data Data were compared by one-way analysis of variance (ANOVA) with the Duncan option and statements of statistical significance were based upon P<0.05. (SPSS v21.0; IBM SPSS Statistics, Version 21.0. Armonk, NY: IBM Corp.).

3. Results

The HS treatment increased the hatchabilities of set and fertil eggs compared to the NS and S treatments, whereas the S decreased the these variables compared to the NS treatment (Table 1, P <0.001). The embrionic mortality in the HS eggs was lower than those in the NS and S eggs (P <0.001). Early embryo deaths were lower in the NS eggs (P <0.001), whereas mid-term embryo deaths were lower in the HS eggs (P <0.05). The late deaths were lower in the HS group than the NS eggs (P <0.001). In this study, number of pipped-not-hatched were not observed. The rate of discarded chicks was higher in the S group than in the HS group (P <0.05).

As shown in Table 2, the chick weight in the NS treatment was higher than those in the S and HS treatments (P <0.001) whereas chick quality parameters were not affected (P > 0.05). In conclusion, the pre-storage heating of hatching eggs from young broiler breeder flock positively affected hatchability without chick weight and quality.

Table 1. Effects of short-term storage or pre-storage heating of hatching eggs from young broiler breeder flock before incubation on hatching parameters

Paramater	NS	S	HS	SEM	P
Hatchability of					
Set eggs	71.33^{b}	68.44^{c}	74.44^{a}	0.672	<0.001
Fertile eggs	77.91^{b}	74.94^{c}	81.71^{a}	0.753	<0.001
Embrionic mortality	19.65^{a}	21.42^{a}	16.33^{b}	0.684	<0.001
Early-dead	4.61^{b}	8.77^{a}	9.76^{a}	0.173	<0.001
Mid-dead	4.12^{a}	3.89^{a}	1.95^{b}	0.600	0.006
Late-dead	10.92^{a}	8.76^{ab}	4.63^{b}	0.041	<0.001
Discarded chick	3.11^{ab}	3.89^{a}	2.38^{b}	0.234	0.017

NS, eggs that were not stored; S, eggs that were stored for four days before incubation; HS, eggs that were heated at 37.7 °C and a relative humidity of 60% for 24 h and then stored for three days before incubation; SEM, Standard error of the mean.

^{a,b} Means in the same row not sharing a common letter are significantly different (P < 0.05).

4. Discussion and Conclusion

The present results showed that short-term storage of eggs obtained from young breeding flocks significantly affected the hatching results. The hatchability and fertile hatchability were increased by heating the eggs pre-storage, which may be due to a significant reduction in late embryonic mortality. Thus, the fact that late and total embryonic deaths are approximately 3-5 units less in the HS group proves this situation. Less developed embryo stages in eggs obtained from young breeding flocks are observed more frequently due to thicker albumen which delays early embryonic development (Reijrink et al., 2009). This may explain the cause of embryo deaths in NS and S eggs. Therefore, this decrease in the fertile hatchability of eggs obtained from young breeding flocks can be prevented by pre-storage heating process.

Table 2. Effects of short-term storage or pre-storage heating of hatching eggs from young broiler breeder flock before incubation on chick weight and chick quality traits

	NS	S	HS	SEM	P
Chick weight (g)	36.44^{a}	35.49^{b}	35.50^{b}	0.119	<0.001
Chick quality					
Tona score	75.96	75.56	77.03	0.314	0.143
Relative assimetry	4.87	4.28	4.41	0.228	0.548

NS, eggs that were not stored; S, eggs that were stored for four days before incubation; HS, eggs that were heated at 37.7 °C and a relative humidity of 60% for 24 h and then stored for three days before incubation; SEM, Standard error of the mean.

^{a,b} Means in the same row not sharing a common letter are significantly different (P < 0.05).

In the present study, the developmental hypoplastic stage of the embryos was maintained by heating the eggs pre-storage, maintaining them during the storage period. Fasenko et al. (1992) reported that the condition of the embryo not change during the storage period below the physiological zero (20 - 21 ° C) for embryo development. Embryos in which hypoplasts are formed are more resistant to long-term storage (Fasenko et al., 2001a; Reijrink et al., 2009); therefore, heating in the eggs of young breeding flocks may be more beneficial.

The negative effect of storage on hatching results may be due to the embryos of stored eggs may not start to develop immediately after normal incubation temperatures have been achieved or may have developed at a slower rate (Fasenko et al., 2001a). It may also have affected the changes in the circulatory system during embryogenesis depending on the storage time, as well as the lower metabolic rate, slower growth in the heart and liver (Haque et al., 1996; Christensen et al., 2001).

Heating the hatching eggs before or during storage has been reported to reduce the harmful effects of storage periods greater than 7 days (Fasenko et al., 2001a, b; Reijrink et al., 2009). It has been found that the effect of heating on the hatchability is influenced by the egg storage time and the heating process before (Reijrink et al., 2009) or after the embryo development stage (Fasenko ve ark., 2001a). The last few practical studies with long-term stored eggs have examined this process in more depth and have reported beneficial effects on hatchability (Nicholson et al., 2011, 2012). In the present study, although the storage time is short, the positive effects of heating have been proved. Unlike Fasenko et al. (2001b), the hatchability results improved with short-term storage and pre-storage heating. This may be due to differences in the age of the breeder flock, heating conditions and heating time. Thus, embryo viability decreases during egg storage due to cell death, even if eggs are stored at a temperature below 20 °C (Bloom et al., 1998). However, in contrast to studies reporting that a longer heat treatment time may also be harmful to chicken embryos (Fasenko et al., 2001b; Silva et al., 2008; Reijrink et al., 2009), positive effects were found in the present study. This may be due to the fact that the breeder flock is young and the storage period is short. Therefore, it can be recommended for the hatcheries to apply heating even in short-term storage of eggs obtained from young breeding flocks. However, it should be noted that in this study, eggs were stored for only 4 days. The effect of heating on the hatchability may depend on the characteristics of the age of flock, hatching egg management, breeder feeding, storage time and heat treatment time. Nevertheless, the findings clearly show that the heating of the eggs obtained from young breeding flocks before short-term storage increases the hatching capacity.

Tona et al. (2003) and Willemsen et al. (2008) reported that long-term storage of eggs adversely affects chick quality. In addition to the physical parameters used in determining the chick quality score, it is also possible to determine chick quality by a quantitative method such as asymmetry measurements (Molenaar et al. 2008). The fact that the QS and RA were not affected in the present study may be due to the storage period is short. Nevertheless, the reduction of discarded chicks may provide an economic advantage.

Based on the present findings, it can be said that pre-storage heating the eggs which is one of the strategies that ensures that eggs can be stored without hatchability and chick quality deterioration, will increase the efficiency of hatcheries by increasing the hatchability and fertile hatchability and decreasing the rate of mortality and discarded chicks. It is seen that the heating of the eggs before storage may be beneficial not only for eggs requiring long-term storage but also for short-term storage. As a result, heating commercial broiler hatching eggs before storage can be used as a method for increasing the hatchability of hatching eggs obtained from young breeding flocks by the industry and stored for a short period of time. However, it should be kept in mind that pre-storage heating should be evaluated in terms of economic cost and labor force with its beneficial effects.

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