Effects of preincubation heating of broiler hatching eggs during storage, flock age, and length of storage period on hatchability[1]

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ABSTRACT The effects of heating of eggs during storage, broiler breeder age, and length of egg storage on hatchability of fertile eggs were examined in this study. Eggs were collected from Ross 344 male × Ross 308 broiler breeders on paper flats, held overnight (1 d) at 18°C and 75% RH, and then transferred to plastic trays. In experiment 1, eggs were obtained at 28, 38, and 53 wk of flock age. During a further 10 d of storage, eggs either remained in the storage room (control) or were subjected to a heat treatment regimen of 26°C for 2 h, 37.8°C for 3 h, and 26°C for 2 h in a setter at d 5 of storage. In experiment 2, eggs from a flock at 28 wk of age were heated for 1 d of a 6-d storage period. Eggs from a 29-wk-old flock were either heated at d 1 or 5 of an 11-d storage period in experiment 3. In experiment 4, 27-wk-old flock eggs were heated twice at d 1 and 5 of an 11-d storage period. Control eggs stored for 6 or 11 d were coincubated as appropriate in each experiment. Heating eggs at d 5 of an 11-d storage period increased hatchability in experiment 1. Although no benefit of heating 28-wk-old flock eggs during 6 d of storage in experiment 2 was observed, heating eggs from a 29-wk-old flock at d 1 or 5 of an 11-d storage period increased hatchability in experiment 3. Further, heating eggs from a 27-wk-old flock twice during 11 d of storage increased hatchability in experiment 4. These effects were probably due to the fact that eggs from younger flocks had been reported to have many embryos at a stage of development where the hypoblast had not yet fully developed (less than EG-K12 to EG-K13), such that heating during extended storage advanced these embryos to a more resistant stage.

Key words: egg storage incubation, flock age, storage period, hatchability

2013 Poultry Science 92:3310–3313
http://dx.doi.org/10.3382/ps.2013-03133

INTRODUCTION

Preincubation of hatching eggs before or during storage has been reported to reduce the detrimental effects of periods of storage greater than 7 d (Becker and Bearse, 1958; Kan et al., 1962; Proudfoot and Hulan, 1982; Fasenko et al., 2001a,b; Reijrink et al., 2009). The effect of preincubation on hatchability has been found to be influenced by the length of egg storage period and the developmental stage of the embryo before (Meir and Ar, 1998; Reijrink et al., 2009) or after (Kosin, 1956; Fasenko et al., 2001a) the heating treatment. Several recent practical studies with eggs stored for very long periods in primary breeder facilities have examined this process in greater depth (French et al., 2011; Nicholson et al., 2011; Dymond et al., 2012; Nicholson, 2012; Nicholson et al., 2012) and reported beneficial effects on hatchability. Another recent positive preliminary report involving broiler hatching eggs from commercial parent stocks flocks stored for less than 12 d was published (Brake et al., 2010). The hypothesis of the present study was based on the findings that embryos before hypoblast formation [before EG-K12 to EG-K13, as defined by Eyal-Giladi and Kochav (1976)] were more adversely affected by longer storage compared with embryos that were in a later stage of development at the start of storage (Coleman and Siegel, 1966; Fasenko et al., 2001b), and that preincubation heating would advance the stage of development (Meir and Ar, 1998; Reijrink et al., 2009, 2010). Further, less advanced stages of embryo development would be expected to be more frequently observed in younger breeder flocks (Reijrink et al., 2009), probably due to the thicker albumen that retards early embryonic development [for review, see Brake et al. (1997)]. Hatching eggs from younger flocks have also been most often subjected to extended storage on a routine basis due to the combined effects of low egg production and less than minimum hatching egg weight, such that extra time was required to accumulate sufficient numbers for setting.The objective of the present research was to

Received February 21, 2013.
Accepted August 31, 2013.

[1]The use of trade names in this publication does not imply endorsement of the products mentioned nor criticism of similar products not mentioned.

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determine the effects of breeder flock age, egg storage period, and heating broiler hatching eggs during storage on hatchability.

MATERIALS AND METHODS

Commercial flocks of Ross 308 feather-sexable strain females mated to Ross 344 males that were subjected to similar management and nutrition within the same commercial company were used as the source of broiler hatching eggs in all experiments. In general, freshly collected eggs were stored overnight in a hatchery egg storage room at 18°C and 75% RH in paper egg flats that had been used to gather and then transport the eggs from the farms on the day of collection. Eggs were allowed to cool while they were graded initially in the egg collection room at the farm and secondarily when preliminarily sorted into treatment groups at the hatchery. Eggs were then transferred to plastic setter trays and either remained at 18°C in the storage room (control) or were subjected to a preincubation heat treatment regimen of 26°C for 2 h, 37.8°C for 3 h, and 26°C for 2 h in a Petersime setter either 1 or 2 times during storage before being returned to the 18°C storage room.

In experiment 1, hatching eggs were obtained from broiler breeders at 28, 38, and 53 wk of age. Eggs were heated after 5 d of storage and then stored for 6 d more before incubation. Thus, eggs from younger (28 wk), prime (38 wk), and older (53 wk) broiler breeder flocks were initially studied. A tray of 150 eggs constituted a replicate and 10 replicate trays (1,500 eggs in total) were set per preincubation heating treatment at each flock age in experiment 1. Eggs from a 28-wk-old flock were heated when transferred to setter trays during a 6-d storage period in experiment 2. In experiment 3, a portion of the eggs from a 29-wk-old flock were heated at transfer to setter trays and then stored for 10 d more, whereas another group of eggs was heated after 5 d of storage and then stored 6 d more before incubation. In experiments 2 and 3, 12 and 6 replicate trays of 150 eggs were used per heating treatment for a total of 1,800 and 900 eggs, respectively. In experiment 4, eggs that came from a breeder flock at 27 wk of age were heated twice at d 1 and 5 of an 11-d storage period; 13 replicate trays of 150 eggs were used per preincubation heating treatment in experiment 4 for a total of 1,950 eggs.

All eggs were incubated together in a single incubator and hatcher in each experiment. Control eggs stored for either 6 or 11 d were coincubated as appropriate. The incubators used were a Petersime model 576 setter and a model 192 hatcher (Petersime, n.v., Zulte, Belgium). Machines were monitored by computer 6 times daily for proper operation. Trays representing each preincubation heat treatment were distributed throughout all positions in the setter and hatcher to distribute possible minor machine position effects across treatments, which could be due to small differences in air flow. Infertile and early deads (0–6 d) were identified by candling and removed at 14 d, followed by macroscopic examination of opened eggs by a single experienced individual. At the time of removal for chicks from the hatchers, all unhatched eggs were opened and examined macroscopically by the same experienced individual to determine remaining late embryonic mortality and percentage hatchability of fertile eggs was calculated as the number of chicks hatched per 100 fertile eggs set. The results for the incubation variables were analyzed by ANOVA with a general linear model procedure (SAS Institute Inc., 2004). Between-tray variation (residual) was the source of the error term; flock age and preincubation heat treatment were the main effects. Statements of statistical significance were based upon $P \leq 0.05$ unless otherwise indicated.

RESULTS AND DISCUSSION

In experiment 1, the effect of flock age and preincubation heat treatment on hatchability of fertile eggs and embryonic mortality of 28-, 38-, and 53-wk-old flocks is shown in Table 1. Hatchability of fertile eggs was greater in the 38-wk-old flocks compared with 28- and 53-wk-old flocks, which reflected lower early and late dead mortality in the 38-wk-old flock. Hatchability of fertile eggs was increased by heating eggs during the 11 d of storage, which was related to significantly reduced late embryonic mortality and numerically reduced early embryonic mortality.

In experiment 2, no benefit of heating eggs was observed during the 6 d of storage (Table 2) in a manner similar to previous studies with chicken eggs (Meir and Ar, 1998; Fasenko et al., 2001b; Reijrink et al., 2009). Hatchability of fertile eggs from a 29-wk-old flock stored for 11 d was increased by heating at either d 1 or 5 of storage, with an accompanying significant decrease in early dead and numerical decrease in late dead as compared with the control in experiment 3 (Table 3). These results agreed with those of Fasenko et al. (2001b) and Reijrink et al. (2009), both of whom used younger flock eggs in their experiments. In experiment 4, eggs from a 27-wk-old breeder flock were heated at both d 1 and 5 of an 11-d storage period, as shown in Table 4. Hatchability of fertile eggs was increased and early embryonic mortality decreased. Although eggs were heated twice (d 1 and 5) during the 11-d storage of 27-wk-old flock eggs in experiment 4, results were somewhat similar to those found with the single heating in experiments 1 and 3. This suggested that the stage of embryo development of eggs from younger broiler breeder flocks required only a single incubation episode to become sufficiently advanced to survive 11 d of preincubation storage. The delayed embryonic development of hatching eggs from young broiler breeder flocks observed by Reijrink et al. (2009) may be related to the thicker albumen possessed by those eggs, as discussed previously (Brake et al., 1997).

Reijrink et al. (2009) found that, in eggs from an older flock, most embryos had progressed to hypoblast

Table 1. The effect of flock age and preincubation heat treatment during 11 d of storage on hatchability of fertile eggs and early and late embryonic mortality in experiment 1

Item	Preincubation treatment[1]	n[2]	Hatchability of fertile eggs (%)	Early dead (%)	Late dead (%)
28 wk of age	Control	10	82.8	9.8	5.4
	Heat 5–11 d	10	87.5	7.4	3.4
	Overall	20	85.2[b]	8.6[a]	4.4[a]
38 wk of age	Control	10	89.4	6.1	2.7
	Heat 5–11 d	10	89.5	6.8	2.4
	Overall	20	89.4[a]	6.4[b]	2.6[b]
53 wk of age	Control	10	83.7	8.6	5.0
	Heat 5–11 d	10	85.1	8.1	3.5
	Overall	20	84.4[b]	8.3[a]	4.2[a]
SEM			0.7	0.5	0.4
	Control	30	85.3[b]	8.2	4.4[a]
	Heat 5–11 d	30	87.4[a]	7.4	3.1[b]
	SEM		0.6	0.4	0.3

[a,b]Means with different superscripts differ significantly ($P \leq 0.05$).

[1]Control eggs remained at 18°C throughout the storage period. For the heat treatment, air temperature was increased or decreased incrementally to 26, 37.8, and 26°C for 2, 3, and 2 h, respectively, at d 1 or 5 of the 11-d egg storage period.

[2]There were 10 replicate trays of 150 eggs (1,500 eggs) set per preincubation heat treatment at each flock age.

Table 2. The effect of heat treatment during 6 d of storage on hatchability of fertile eggs and early and late embryonic mortality in experiment 2

Flock age (wk)	Preincubation treatment[1]	n[2]	Hatchability of fertile eggs (%)	Early dead (%)	Late dead (%)
28	Control	12	91.5	5.3	2.0
	Heat 1–6 d	12	91.1	5.3	2.4
	SEM		0.5	0.4	0.2

[1]Control eggs remained at 18°C throughout the storage period. For the heat treatment, air temperature was increased or decreased incrementally to 26, 37.8, and 26°C for 2, 3, and 2 h, respectively, at d 1 of the 6-d egg storage period.

[2]There were 12 replicate trays of 150 eggs (1,800 eggs) set per preincubation heat treatment.

Table 3. The effect of storage period, flock age, and preincubation heat treatment during 11 d of storage on hatchability of fertile eggs and early and late embryonic mortality in experiment 3

Flock age (wk)	Preincubation treatment[1]	n[2]	Hatchability of fertile eggs (%)	Early dead (%)	Late dead (%)
29	Control	6	84.9[b]	11.1[a]	3.2
	Heat 1–11 d	6	89.6[a]	6.6[b]	2.7
	Heat 5–11 d	6	91.9[a]	5.0[b]	2.3
	SEM		0.7	0.6	0.3

[a,b]Means with different superscripts differ significantly ($P \leq 0.05$).

[1]Control eggs remained at 18°C throughout the storage period. For the heat treatment, air temperature was increased or decreased incrementally to 26, 37.8, and 26°C for 2, 3, and 2 h, respectively, at d 1 or 5 of the 11-d egg storage period.

[2]There were 6 replicate trays of 150 eggs (900 eggs) set per preincubation heat treatment.

Table 4. The effect of preincubation heat treatment during 11 d of storage on hatchability of fertile eggs and early and late embryonic mortality in experiment 4

Flock age (wk)	Preincubation treatment[1]	n[2]	Hatchability of fertile eggs (%)	Early dead (%)	Late dead (%)
27	Control	13	81.9[b]	12.0[a]	4.4
	Heat 1 + 5–11 d	13	85.9[a]	7.6[b]	4.3
	SEM		1.2	0.7	0.6

[a,b]Means with different superscripts differ significantly ($P \leq 0.05$).

[1]Control eggs remained at 18°C throughout the storage period. For the heat treatment, air temperature was increased or decreased incrementally to 26, 37.8, and 26°C for 2, 3, and 2 h, respectively, at 1 and 5 d of the 11-d egg storage period.

[2]There were 13 replicate trays of 150 eggs (1,950 eggs) set per preincubation heat treatment.

formation (EG-K12 or EG-K13) of development at oviposition, whereas embyos from a young flock were distributed from EG-K stage 9.22 to 12.63. Embryos at the earlier stage at oviposition have been reported to be less able to successfully withstand prolonged storage as compared with embryos where the hypoblast had formed (Coleman and Siegel, 1966; Fasenko et al., 2001a; Reijrink et al., 2009); therefore, it was hypothesized that preincubation would be most beneficial when embryos were produced by a younger breeder flock. Thus, in experiment 1, the control group from the younger flock exhibited a lower hatchability of fertile eggs than prime and older flocks following 11 d of storage, as reported by Yassin et al. (2008) and Reijrink et al. (2010), and responded more favorably to preincubation heating, as hypothesized. In experiment 1, preincubation heating had no positive or detrimental effect on hatchability of fertile eggs produced by prime and older flock eggs stored for 11 d under the conditions of this study.

In the study of Elibol (1997), eggs from an older commercial layer breeder flock were heated for 3 h at 38.8°C following oviposition and then stored 11 or 18 d. The heating treatment decreased early embryonic mortality and increased hatchability of fertile eggs stored for 18 d, but not 11 d, as compared with nonheated controls. It was conceivable that a longer egg storage period in experiment 1 could have yielded different results. However, a longer heat treatment period could also be harmful to chicken embryos, as the stage of embryonic development might be further advanced than the optimal stage for prolonged egg storage (Fasenko et al., 2001b; Silva et al., 2008; Reijrink et al., 2009). Nevertheless, a longer heating period has been reported to improve the hatchability of turkey eggs (Fasenko et al., 2001a).

The effect of preincubation on hatchability in each species may depend upon the specifics of flock age, hatching egg management, breeder nutrition, storage period, and heat treatment period. Nevertheless, these data demonstrated clearly that heating eggs during storage for 11 d consistently increased fertile hatchability of eggs from younger broiler breeder flocks. In the case of younger breeder flocks stored 11 d, as might be expected frequently in the case of young commercial parent stock flocks used in the present study, the mechanism of action may be logically ascribed to a simple advancement of embryonic development to the formation of a resistant hypoblast stage. However, the beneficial effects in older flocks subjected to extended periods of storage under primary breeder conditions (Nicholson et al., 2011; Dymond et al., 2012; Nicholson, 2012; Nicholson et al., 2012) may be due to presently undefinced additional or other mechanism(s).

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