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Effect of Hatching Time on Yolk Sac Percentage and Broiler Live Performance

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ABSTRACT

This study investigated the effects of broiler chick hatching time on the percentage of the yolk sac and subsequent broiler live performance. Broiler hatching eggs were obtained from a commercial flock at 55 wk of age and were stored for 2 d at 18°C and 75% relative humidity (RH) prior to incubation. Chicks were identified as hatching Early (471-477 h), Middle (480-486 h), and Late (494-510 h). All chicks were removed from the trays at 510 h of incubation. Body weight (BW) and yolk weight (YW) were determined at emergence from the shell (initial hatch time) and at placement on feed. Chicks were permanently identified by hatch time with neck tags, feather sexed, weighed, and introduced to feed and water in litter floor pens. Broiler BW and feed consumption (FC) were then determined 7, 21, and 35 d of age. Mortality was recorded daily. Although the percentage of the yolk was similar at hatch time, it was less in Early compared to Middle and Late chicks at placement ($p \leq 0.05$). Broiler chick BW was greater at placement in Late chicks compared to Early and Middle chicks ($p \leq 0.05$) but this advantage disappeared by 7 d because Late chicks consumed less feed to 7 d ($p \leq 0.05$). Early hatched broilers exhibited greater BW than Late with Middle broilers intermediate at 35 d ($p \leq 0.05$). There were no significant differences in feed consumption and feed conversion ratio (FCR) at 35 d of age. Additionally, late hatch chicks exhibited greater mortality. Overall, live performance of Late hatching chicks, judged by mortality and BW at 35 d, was reduced compared to Early hatching chicks.

INTRODUCTION

There has always been a natural biological variation in the time that commercial broiler chicks emerged from their egg shells (hatch time) even under optimum conditions of artificial incubation. Thus, early hatching chicks have generally remained in the hatcher longer while awaiting removal of later hatching chicks from the machine (pull time) (Elibol *et al.,* 2011; Powell *et al.,* 2016). It has been reported that performance after placement was negatively associated with the time that chicks remained in the hatcher after hatching (Decuypere *et al.*, 2001; Halevy *et al.,* 2003) or that delayed access to feed depressed growth after access to feed (Careghi *et al.*, 2005), and increased mortality (Hamdy *et al.*, 1991). El Sabry *et al.* (2013) reported that early hatching chicks were not able to compensate for their post hatch BW loss and weighed less at 35 d of age. However, feed conversion ratio was little affected in these studies. Corless & Sell (1999) reported reduced BW associated with extended post-hatch holding, but these findings were not consistent with the data presented by Casteel *et al.* (1994), who weighed each group of birds 43 d following placement on feed and water and reported no differences. Work with respect to

hatch time and post-hatch holding has often differed in that chicks were placed as much or more than 24 h apart, but weighed on the same day subsequently in some experiments (Pinchasov *et al.*, 1993; Vieira & Moran, 1999) or on the basis of days on feed in other studies (Almeida *et al.*, 2006; Lamot *et al.*, 2014; Dişa *et al.*, 2015). Furthermore, holding chicks in the hatcher for 24 h has been reported to not clinically dehydrate chicks or affect live performance (Casteel *et al.*, 1994; Joseph & Moran, 2005; Almeida *et al.*, 2006; Lamot *et al.*, 2014). In fact, the percentage BW gain during the first 7 d was 76.6%, 76.2%, and 74.1% for early, middle, and late hatching groups, respectively, so that the differences in initial hatching BW disappeared and all groups exhibited a similar BW, feed intake, and mortality at 41 d of age (Almeida *et al.*, 2006). In yet another study, early, middle, and late hatched chicks had approximately 26, 19, and 13 h of no feed and water access after hatching, respectively, but early hatch chicks consumed more feed and had numerically greater BW gain to 18 d of age (Lamot *et al.*, 2014). Obviously, early hatching chicks have frequently exhibited a different developmental and growth pattern than did middle or late hatching chicks (Lamot *et al.*, 2014; Brake *et al.*, 2015), which may simply be related to differences in initial appetite. This may be related to having differences in residual yolk sac that may approximate 10% of total BW (Sklan *et al.*, 2000; Wolanski *et al.*, 2006). Residual yolk has been demonstrated to be important to the complex metabolic processes involved in early chick development (Noy & Sklan, 1998a; Noy *et al.*, 2001; Halevy *et al.*, 2003; Tona *et al.*, 2003; Careghi *et al.*, 2005) but required feed consumption to facilitate rapid absorption (Chamblee *et al.*, 1992; Henderson *et al.*, 2008), which has seemed to be greater in early hatching chicks. The objective of the present research was to determine the effects of hatch time on the percentage of the yolk sac at placement and subsequent broiler live performance.

MATERIAL AND METHODS

Hatching Eggs and Incubation

The experimental procedures and animal care employed in this experiment were approved by the University of Ankara Institutional Animal Care and Use Committee (Ankara, Turkey). Broiler hatching eggs were obtained from a commercial flock of Ross 308 at 55 wk of age. Hatching eggs were stored for 2 d at 18°C and 75% RH before incubation. A total of 2070 (69.0±4.9 g) eggs were set for incubation in three laboratory incubators (Cimuka Co., Turkey). A single-stage incubation program was used with a gradually decreasing machine set point temperature from 38.1°C at E1 of incubation to 37.5°C at E18. Hatchers had a dry bulb temperature of 37.2°C at E18 that was gradually decreased to 36.4°C at E21. Relative humidity was 53±2% from E1 to E18. The eggs were turned once every hour until E18 of incubation in all cases.

The hatching process was divided into three time periods with 471-477 h termed as Early, 480-486 h termed Middle, and 494-510 h termed Late. Chicks that hatched outside of these time periods were not used in the experiment.

All chicks that had completed the hatching process were removed from the hatching baskets (pulled) at 510 h. Chicks were deemed to be hatched when they exhibited healed navels and dryness about the head and neck. Early and Middle chicks were individually identified with neck tags and placed back inside their original hatcher tray where they awaited the final pull at 510 h. Average holding periods in the hatcher after emergence from the shell for Early, Middle and Late hatched chicks were 36, 27, and 8 h, respectively. The BW of chicks was initially determined at emergence from shell to calculate relative BW loss during the holding period.

Percentage of Yolk Sac at Placement

Ten randomly selected chicks from each hatch time were weighed and killed by cervical dislocation and residual yolk sac weight determined at time of emergence from the shell (initial hatch) and at time of placement into pens before introduction to feed and water.

Broiler Grow-Out Management

The chick processing time from final pull to placement was 8h during which the chicks were held at 24±1°C. During this period, chicks were feather sexed, counted, permanently identified with neck tags and weighed individually before being placed in a floor pen house on new wood shavings. The brooding facilities were preheated for 24 h before chick placement to achieve a stable and uniform litter temperature. At chick placement litter temperature was 33°C, which was gradually decreased to 20°C by 21 d of age and remained at that level until slaughter at 35 d of age. The chicks received continuous light (24L:0D) at a light intensity at pen level of 25 lux. Starter (3,000 kcal ME/

kg and 23.5% CP) and grower (3,200 kcal ME/kg and 22.0% CP) diets were fed for 0 to 10 and 11 to 28 d, respectively. The finisher (3,300 kcal ME/kg and 20.0 % CP) diet was fed 29 to 35 d. The feeds were in mash form. Chicks were provided ad libitum access to feed and water, and diets were formulated to meet or exceed NRC (1994) recommendations throughout the grow-out period.

Broiler Live Performance Measurements

From each hatch time chicks were assigned to 9 pens (1 x 1 m) with 9 male plus 9 female chicks each for a total of 486 chicks. Individual BW was recorded at 7, 21, and 35 d of age. Feed consumption was calculated by the difference in feed offered and feed remaining on a pen basis at these times. Mortality was recorded twice a day.

Statistical Analyses

Data on yolk sac, feed consumption, and feed conversion ratio were analyzed using the GLM procedure of SAS (version 9.1, SAS Institute, 2004) according to the following model: $Y_{ij} = \mu + HT_i + e_{ij}$, where μ was the overall mean, HT_i was the hatching time (Early, Middle, Late), and e_{ij} was the residual error term. Data concerning chick BW were analyzed according to the following model: $Y_{ijk} = \mu + HT_i + sex_j + (HT \times sex)_{ij} + e_{ijk}$, where sex_j was the sex of the chick, $(HT \times sex)_{ij}$ was the interaction between hatching time and sex, and e_{ijk} was the residual error term. When the means of the GLM were statistically different, means were compared using least squares or with DUNCAN for multiple comparisons. The mortality percentage was analyzed using the chi-square test via Minitab Version 14 (Minitab Inc., United Kingdom). Statements of statistical difference were based upon $p \leq 0.05$.

RESULTS AND DISCUSSION

Yolk Sac Percentage

The effect of hatch time on yolk percentage at the time of emergence from the shell (hatch time) and at placement on feed is shown in Table 1. Yolk sac percentage at emergence was not significantly different among the group's hatch time. However, Early chicks possessed less yolk percentage at placement ($p \leq 0.05$). Early chicks had less yolk sac weight compared to Late chicks in a manner similar to previous studies (Van de Ven *et al.*, 2013; Özlü *et al.*, 2015; Powell *et al.*, 2016). However, El Sabry *et al.* (2013) and Lamot *et al.* (2014) found no effect of hatch time on yolk sac weight. A smaller yolk sac percentage would suggest greater transfer of nutrients, immune bodies, and metabolic information to the hatchling as well as greater appetite as discussed below. The absorption of nutrients from the yolk sac has been reported to be essential to promote subsequent growth (Murakami *et al.*, 1992; Bigot *et al.*, 2001) and early hatching chicks may have had an advantageous developmental and growth pattern (Lamot *et al.*, 2014) due to earlier absorption of the yolk that has typically represented approximately 10% of total BW at initial hatching (Sklan *et al.*, 2000; Wolanski *et al.*, 2006). Early utilization of the yolk could have produced a metabolically more mature chick that was ready to consume feed and concurrently utilize the remaining residual yolk sac materials (Chamblee *et al.*, 1992; Noy & Sklan, 1998b; Halevy *et al.*, 2003; Tona *et al.*, 2003; Yang *et al.*, 2008; Careghi *et al.*, 2005; Bhanja *et al.*, 2009; Shinde *et al.*, 2015).

Table 1 – The effect of hatch time on yolk percentage at time of emergence from the shell (initial hatch) and at placement on feed.

		Yolk Sac	
Hatch Time[1]	n	Hatch	Placement[2]
		(g/100 g BW)	
Early	10	15.5	8.6[b]
Middle	10	15.6	12.4[a]
Late	10	13.4	12.9[a]
SE[3]		1.0	0.6

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

[1] Early hatch time was 471-477 h, Middle hatch time was 480-486 h, and Late hatch time was 494-510 h.

[2] Placement time was 518 h.

[3] SE for mean of 10 chicks.

Body Weight, Feed Consumption, and Feed Conversion Ratio

BW and BW loss between emergence from the shell and placement on feed are presented in Table 2. Chick BW was similar at all hatch times (477 h, 486 h, and 510 h) immediately upon emergence. However, Early and Middle chicks exhibited greater ($p \leq 0.05$) BW loss between hatch and placement and less BW ($p \leq 0.05$) at placement compared to Late chicks. However, this advantage was no longer evident 7 d after being introduced to feed and water. BW at 7 d and 21 d was similar for chicks from all hatch times, but Early chicks exhibited greater ($p \leq 0.05$) BW than Late chicks with Middle chicks intermediate at 35 d. The effect of hatch time on feed consumption, and feed conversion ratio from placement on feed to at 35 d of age are shown in Table 3. Late chicks consumed less feed ($p \leq 0.05$)

Table 2 – Body weight, BW loss of broiler chickens from hatch and placement on feed at 35 d of age as affected by hatch time.

	Age					
Hatching Time[1]	Hatch	Placement[2]	BW Loss (%)	7 d	21 d	35 d
			(BW, g)			
Early	49.7	43.6[b]	12.2[a]	162	899	2175[a]
Middle	49.6	44.6[b]	10.1[a]	160	880	2147[ab]
Late	49.1	47.9[a]	2.5[b]	159	878	2119[b]
SEM[3]	0.3	0.3	0.1	1.8	9.6	14.9

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

[1] Early hatch time was 471-477 h, Middle hatch time was 480-486 h, and Late hatch time was 494-510 h.

[2] Placement time was 518h.

[3]SEM for mean of 9 pens of 9 male plus 9 female chicks at placement.

at 7 d compared to Early and Middle chicks but the effect was not apparent thereafter. These data were consistent with the BW data. The present data clearly demonstrated a negative effect of late hatching, which was obviously related to poor feed consumption at 7 d. Early hatch groups have been reported to consume more feed at 4 d as compared to middle and late hatch groups (Lamot *et al.*, 2014). Additionally, Løtvedt & Jensen (2014) reported that early male hatched chicks displayed a higher response to novelty, as well as a tendency of lower passivity. In this study for the overall period at 35 d, there were no significant differences in feed consumption in a manner similar to previous studies (Casteel *et al.*, 1994; Joseph & Moran, 2005; El Sabry *et al.*, 2013; Lamot *et al.*, 2014). Further, the Early chicks exhibited an improved ($p \leq 0.05$) FCR at 21 d of age but not thereafter (Table 3). Effects on FCR due to hatch time have also not been apparent at market age in other studies (Casteel *et al.*, 1994; Joseph & Moran, 2005; El Sabry *et al.*, 2013).

Table 3 – Feed consumption, and feed conversion ratio of broiler chickens from placement on feed at 35 d of age as affected by hatch time.

	Age		
Hatching Time[1]	7 d	21 d	35 d
	(Feed Consumption, g/chick)		
Early	155[a]	1227	3282
Middle	156[a]	1242	3239
Late	148[b]	1210	3205
SEM[2]	1.3	14.6	31.5
	(Feed Conversion Ratio, g:g)		
Early	0.92	1.34[b]	1.50
Middle	0.93	1.39[a]	1.52
Late	0.94	1.37[a]	1.51
SEM[2]	0.012	0.014	0.110

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

[1] Early hatch time was 471-477 h, Middle hatch time was 480-486 h, and Late hatch time was 494-510 h.

[2]SEM for mean of 9 pens.

Joseph & Moran (2005) reported that the mean incubation length of early hatching chicks was 497 h (480-504 h) compared with 509 h (506-512 h) for late hatching chicks resulting in an average post-emergent holding duration of 15 h versus 3 h in the hatcher, respectively. At 512 h of incubation, all of the chicks were removed, weighed, and kept in the hatchery for an additional 9 h before placement. Although greater BW and yolk sac weight at hatch time were associated with late emergence, decreased holding time in the hatcher had no effect on live performance or carcass yield at 42 d of age. In another study, chicks that hatched early (480 h), or in the middle of the hatching period (492 h), and were held in the hatcher for 12 to 24 h lost 11.5% and 6.7% of their BW, respectively, and exhibited lower initial BW as compared to chicks that hatched during late incubation (504 h). However, the percentage BW gain during the first 7 d was 76.6%, 76.2%, and 74.1% for the early, middle, and late hatching groups, respectively, so that differences in initial hatching BW disappeared. All hatch time groups exhibited a similar BW, feed intake, and mortality at 41 d of age (Almeida *et al.*, 2006).

Pinchasov & Noy (1993) and Tong *et al.* (2015) found that BW loss and yolk sac utilization were increased when chicks had extended holding period. Therefore, posthatch BW loss may not be exclusively the result of dehydration. Dehydration as a result of extended post-hatch holding has been associated with poor post-hatch performance (Joseph & Moran 2005; Almeida *et al.*, 2008). It has been reported that chick BW at pull time was significantly influenced by time of emergence from the shell as chicks that hatched early lost BW while waiting to be pulled and subsequently weighed less than later hatching chicks at pull time (Reis *et al.*, 1997; Sklan *et al.*, 2000; Joseph & Moran, 2005; El Sabry *et al.*, 2013).

Using a different experimental protocol, Casteel *et al.* (1994) divided chicks after 528 h of incubation into two groups that were either placed in floor pens or returned to the hatcher for an additional 24 h. Chick BW was reduced after holding for 24 h as chicks lost approximately 5% of their BW compared with initial hatch BW. At 21 d post-placement the broilers held were significantly heavier than their controls but were similar by 43 d of age when birds were weighed at the same age relative to placement on feed and water. Obviously, hatched chicks underwent complex metabolic processes as they decreased in BW at a rate of about 4 g per 24 h due in part to moisture loss as well as utilization of reserves available from the yolk and pectoral muscle (Noy & Sklan, 1998b; Halevy *et al.*, 2003; Tona *et al.*, 2003; Careghi *et al.*, 2005). This process appeared to be necessary to prepare the chick to consume feed and complete the absorption of the yolk sac (Chamblee *et al.*, 1992) as late hatching chicks that had not undergone this BW loss did not consume feed as well as did the early hatching chicks. The present data clearly demonstrated a positive effect of early hatching, which was obviously related to BW loss and yolk sac utilization while being held under optimum conditions in the hatcher.

Some authors have found chick weight to be an accurate predictor of final BW (Sklan *et al.*, 2003) while others have not (Ulmer-Franco *et al.*, 2010). The current study showed no positive relationship between day old chick BW and final BW at 35 d. As expected, males exhibited greater BW than females after 7 d post-hatch (data not shown; $p \leq 0.05$).

Mortality

The effect of hatch time on mortality is presented in Table 4. First week mortality was 0.7%, 0.5%, and 2.2% in Early, Middle, and Late chicks, respectively. The difference was only numerically greater for Late chicks but Late chicks experienced greater mortality to 35 d of age ($p \leq 0.05$). Mortality was not affected by hatch time in the previous studies (Blake *et al.*, 2013; Dişa *et al.*, 2015). In some previous studies extended holding in the hatcher increased early rearing mortality (Hamdy *et al.*, 1991; Pinchasov & Noy, 1993). On the contrary, Early hatched chicks exhibited lower mortality even when their holding period was longer than late hatched chicks in the present study. Similarly, a trend was seen in the previous report by Brake *et al.*(2015).

Table 4 – Effect of hatch time on mortality.

	Hatch Time[1]		
Period	Early	Middle	Late
(d)	——————(%)——————		
0-7	0.7	0.5	2.2
0-21	1.5	1.9	3.9
0-35	2.3[B]	1.9[B]	7.1[A]

[A,B] Means in a row with different superscripts differ significantly (χ^2=7,997; DF=2; $p \leq 0.02$).

[1] Early hatch time was 471-477 h, Middle hatch time was 480-486 h, and Late hatch time was 494-510 h.

CONCLUSIONS

This study demonstrated that Late hatching chicks had a greater yolk sac percentage and BW at placement but that was followed by poorer feed consumption at 7 d, decreased BW at 35 d, and increased mortality compared to Early and Middle hatching chicks. Overall, live performance of Late hatching chicks, judged by mortality and BW at 35 d, was reduced compared to Early hatching chicks. Under optimum hatcher conditions, chicks could be held approximately 30 h without detrimental effect on subsequent broiler performance.

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