Heat acclimation during incubation and breeder age influences on hatching performance of broilers

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Heat tolerance of broilers can be changed by exposing eggs to higher temperatures during incubation. The present study measured responses of the chicks, from eggs obtained from 3 different parental ages, to either standard or high incubation temperatures. A total of 1650 eggs were obtained from 3 broiler breeder flocks (Ross 308) that were 32 (younger), 42 (middle aged), and 65 (older) weeks of age. There were 2 flocks for each breeder age. Eggs were divided into 2 groups as 1). Control incubation temperature: eggs incubated at 37.8ºC from d 1 to 18 of incubation and 2). High incubation temperature: Eggs were heat acclimated at 38.5º C for 6 hours daily from d 10 to 18 of incubation. The timing of hatching was recorded every 2 h between 464 and 500 h of incubation. Hatchability was determined. At hatch, body weight, rectal temperature, length of beak and third right toe, blood HCO_3 level, and organ weights were measured for 10 male chicks/parent age/incubation temperature. Data were subjected to ANOVA.
Effects of high incubation temperature on traits measured did not interact with breeder age. As breeders aged from 32 to 65 wk, chick weight, residual yolk weight, yolk free chick weight, absolute liver and heart weights increased. Breeder age did not affect lung weight. An increase in residual yolk sac weight and rectal temperature, and a decrease in liver and heart weights were observed for the chicks from heat acclimated eggs. High incubation temperature had no effect on blood HCO_3 level of chicks at hatch. The results showed that although embryos could tolerate to 38.5°C 6h/d from 10 to 18d of incubation without reducing hatching success, there was a delay in hatching time.

Keywords: Breeder age; embryonic heat acclimation; hatchability; broiler chicks

Introduction

Optimum incubation temperature for avian embryos ranges from 37 to 37.5°C (Decuypere and Michels, 1992). Because the developing embryo reacts as a poikiloterm, any changes in incubation temperature may affect embryo size, organ growth, metabolic rate, physiological development, and hatching success (Tazawa et al., 2003; Yalçın and Siegel, 2003; Black and Burggren, 2004). Black and Burrgren (2004) reported that low incubation temperatures affect the timing of the onset of key physiological processes and their control that specifically influence growth and maturation of the respiratory system. Moraes et al. (2004) showed an increase in corticosterone, and blood pO_2 and pH levels in embryos after incubation at intermittent high temperatures.

Heat tolerance of broilers can be improved by exposing eggs to higher temperatures during incubation. Tzschentke and Basta (2002) reported that incubation at temperatures lower or higher than

standard resulted in changes in postnatal hypothalamic thermosensitivity. Thus, incubation temperatures may be of particular importance for improving the ability to adapt to an expected environment (Nichelmann et al., 2001). Moraes et al. (2003 and 2004) indicated that heat treatment of 39 °C on days 13-17 of incubation enhanced thermotolerance of broilers post–hatch. Yahav et al. (2004) concluded that thermal manipulation during incubation had a positive effect on thermoregulation without affecting body weight of chicks at hatch.

Breeder age-related changes in the development of embryos during incubation were reported by Peebles et al. (2001) and O'Dea et al. (2004). In a previous study, performance of broilers hatched from eggs originating from younger and older breeder flocks and conditioned at high incubation temperature to induce thermotolerance was evaluated and found that age of parent played a major role in their ability to thermoregulate (Weytjens et al., 1999; Yalçın et al., 2005). The present study measured responses of chicks, from eggs obtained at 3 different parental ages, to either standard or high incubation temperatures. Body and organ weights, blood HCO_3 and rectal temperatures were measured at hatch.

Materials and methods

A total of 1650 eggs were obtained from a broiler breeder stock (Ross 308) at 3 ages; 32 (younger), 42 (middle aged), and 65 wks (older). Breeders from the same farm with 2 flocks per age, were fed on the same diet, and maintained under similar environmental conditions. Eggs were divided into 2 groups as 1). Control incubation temperature: eggs incubated at 37.8ºC from d 1 to 18 of incubation and 2). High incubation temperature: Eggs were heat acclimated at 38.5º C for 6 hours daily from d 10 to 18 of incubation. From d 18 to hatch, temperature was 37.5ºC. All eggs were numbered prior to incubation. There were 3 replicate trays in each subgroup.

Eggs were individually checked every 2 h between 464 and 500 h of incubation and number of chicks hatched were recorded. Hatchability was defined as percentage of total number of eggs set. At hatch, after chicks dried, 10 male chicks from each group were sampled to measure body weights and rectal temperatures. Blood drawn into heparinized syringes from wing vein was immediately analysed for HCO_3 level by blood gas analysis. Chicks were killed by cervical dislocation and embryonic yolk sac, both lungs, heart, and livers were removed and weighed. Breast was dissected including cage plus muscles and weighed. Length of beak and third right toe was measured as an index of growth (Dzialowski et al., 2002).

Data for each flock/breeder age were analysed by two-way ANOVA with flock and incubation temperature as main effect and interaction between them. Because there was no flock and interaction effect on traits, then data were subjected to ANOVA with breeder age, incubation temperature, and the interaction between them as main effects using GLM procedure (SAS Inst., 1999). Significance was based on $P<0.05$.

Results

There was no interaction between incubation temperature and breeder age for the traits measured at hatch. Thus, main effects of incubation temperature and breeder age are presented in tables.

Exposure of eggs to 38.5°C from 10 to 18 d of incubation resulted in heavier chick and residual yolk weights but yolk free chick weights were similar to the controls (Table 1). Absolute and propotional weights of livers and hearts were lower for the high incubation temperature than control chicks. There was no incubation temperature effect on the weights of lung and breast. Beak length was not influenced by incubation temperature while at the high incubation temperature toe length was shorter.

As breeders aged from 32 to 65 wk, chick weight, residual yolk weight, and yolk free chick weight increased. Although relative weights of liver and heart were similar for chicks from different aged breeders, absolute liver and heart weights increased with breeder age. Breeder age did not affect lung weights. Breast weights were highest for the chicks from older breeders while similar for chicks from

Table 1. Effects of incubation temperature[1] and breeder age[2] on chick weight, absolute and relative liver, heart, lungs, and breast weights, beak length and length of right third toe on day hatch

Treatments		Chick weight g	Residual yolk weight g	Yolk free chick weight g	Liver weight g	Relative liver weight %	Heart weight g	Relative heart weight %	Lungs weight g	Relative lung weight %	Breast weight g	Relative breast weight %	Beak length mm	Length of right third toe mm
Incubation temperature		**0.034**	**0.002**	**0.213**	**<0.001**	**<0.001**	**0.003**	**<0.001**	**0.111**	**0.570**	**0.338**	**0.982**	**0.348**	**0.014**
	Control	44.6	5.77	38.8	0.98	2.25	0.32	0.73	0.26	0.58	0.76	1.71	7.45	16.2
	High	46.7	6.88	39.8	0.85	1.82	0.29	0.62	0.28	0.61	0.80	1.71	7.28	15.4
Breeder age		**<0.001**	**<0.001**	**<0.001**	**<0.001**	**0.746**	**<0.001**	**0.199**	**0.300**	**0.214**	**<0.001**	**0.384**	**0.008**	**0.125**
	Younger	40.8^{c}	4.93^{c}	35.8^{c}	0.80^{c}	1.98	0.27^{b}	0.67	0.26	0.63	0.72^{b}	1.76	7.25^{b}	15.3
	Middle	45.4^{b}	6.24^{b}	39.1^{b}	0.93^{b}	2.04	0.32^{a}	0.71	0.27	0.59	0.75^{b}	1.65	7.84^{a}	16.1
	Older	50.7^{a}	7.82^{a}	42.9^{a}	1.02^{a}	2.04	0.33^{a}	0.65	0.28	0.56	0.88^{a}	1.72	7.14^{b}	15.9

[1] Control: incubated at 37.8ºC throughout; High: exposed to heating at 38.5ºC 6 hours/day from 10 to 18days of incubation
[2] Younger: 32 wks old; Middle: 42 wks old; Older: 65 wk old breeders
[a,b] Means in the same column with no common superscript differ significantly (P values are in bold)

Table 2. Blood bicarbonate (HCO_3) concentration and rectal temperatures of chicks at hatch

Day	Treatments		HCO_3 Mmol/L	Rectal temperature ºC
21	Incubation temperature		**0.604**	**0.069**
		Control	18.98	37.86
		High	18.57	38.35
	Breeder age		**0.007**	**0.345**
		Younger	19.77^{a}	37.98
		Middle	19.58^{a}	38.38
		Older	16.98^{b}	37.95

[1] Control: incubated at 37.8ºC throughout; High: exposed to heating at 38.5ºC 6 hours/day from 10 to 18days of incubation
[2] Younger: 32 wks old; Middle: 42 wks old; Older: 65 wk old breeders
[a,b] Means in the same column with no common superscript differ significantly (P values are in bold)

middle aged and younger breeders. Beak length was longer for chicks from middle-aged broilers than those for chicks from younger and older breeders. Length of right third toe was similar among groups.

Incubation temperature did not influence blood bicarbonate concentration. The lowest blood HCO_3 concentration was observed in chicks from older breeders (Table 2). Rectal temperature was slightly but not significantly (P=0.069) higher in chicks from the high incubation temperature group.

Chicks from the control started to hatch almost 6 h earlier than those chicks from high incubation group; i.e., average 20, 55 and 90% of chicks from control completed hatching at 474, 478, and 484 h of incubation in contrast to 480, 484, and 490 h for the high incubation temperature group, respectively (Figure 1). High incubation temperature had no effect on hatchability. As expected, hatchability decreased gradually with breeder age (93.5, 87.3, 73.4%, for eggs from younger, middle and older aged breeders).

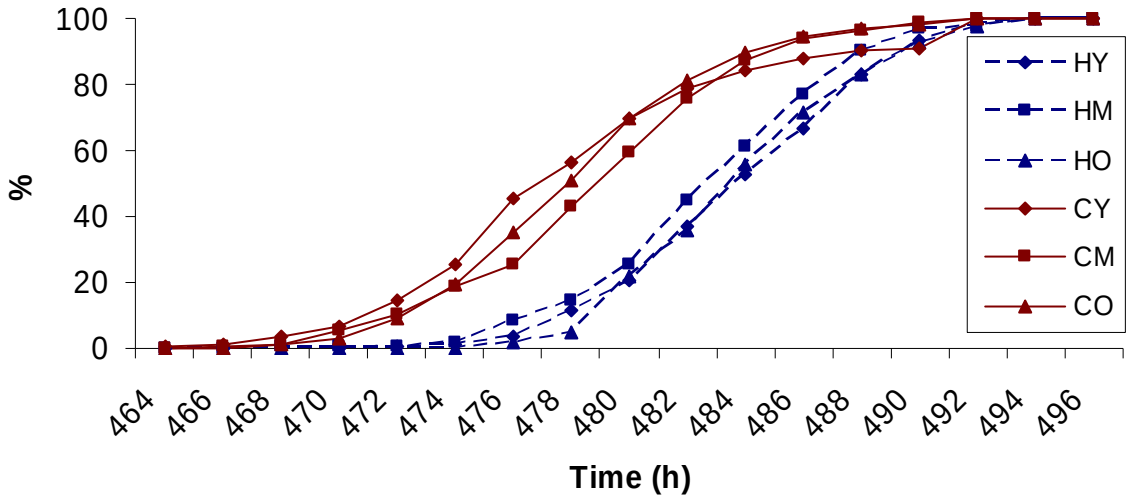


Figure 1. Hatching time of chicks from different aged breeders and incubated at control or high temperature
HY: High incubation temperature, eggs from younger breeders; HM: High incubation temperature, eggs from middle aged breeders; HO: High incubation temperature, eggs from older breeders; CY: Control incubation, eggs from younger breeders; CM: Control incubation, eggs from middle aged breeders; CO: Control incubation, eggs from older breeders

Discussion

A significant effect of breeder age on chick weight was expected because egg weight, which is positively associated with chick weight, increases with age of breeders (North and Bell, 1990). Heavier body weights of chicks from older breeders were associated with heavier heart, liver and breast muscle weights, which were consistent with the previous findings (Luquetti et al., 2004).

Higher incubation temperature did not affect yolk free chick weight, which is an indicator of the chick development. An increased residual yolk sac weight and decreased liver weight for the chicks from heat acclimated eggs may reflect physiological differences in yolk mobilization. However, effects of high temperature on lipid metabolism of developing embryos require further investigation. A decrease in heart weight obtained could be expected due to heat stress because cardiovascular changes; i.e., a decrease in heart rate and blood pressure, preceded respiratory adjustments during heat challenges to heat dissipation (Darre and Harrison, 1987). In the present study and our previous study (Yalçın et al., 2005), chick weight did not interacted with breeder age.

Conflicted results were reported on hatching time when eggs incubated at higher temperatures. Accelerated hatching time could be expected due to high incubation temperature (Iqbal et al., 1990), however a delay in hatching process was also reported (Moraes et al., 2004). The differences in studies

may probably due to the length of acclimation period, timing of acclimation, and incubation temperature, which may alter chronological time to complete development. In the present study, 38.5°C 6h/d from 10 to 18d of incubation delayed hatching time almost 6 h, however, total time spend for hatch was similar to control. The delay in hatching time with high incubation temperature was consistent across the breeder ages. The results also showed that embryos could tolerate the higher temperature without reducing hatching success. This observation is consistent with previous work (Yalçın and Siegel, 2003), suggesting that heat acclimation beginning on d 10 of incubation was not detrimental to the developing embryo. Acclimation depending on the timing and duration may have different effects on hatchability. Yahav et al. (2004) reported better hatching results when eggs were acclimated at 39C from 16 to 18 d of incubation compared to their control.

Tzschentke and Nichelmann (1999) suggested that lower deep temperature during the first days after hatching is caused by a lower thermoregulatory set-point. In the present study the increase in rectal temperature may be result of increased embryonic growth or increased thermoregulatory set point (Janke et al., 2002). Tullett and Burton (1985) reported that low porosity increased retention of carbondioxide within the egg, which leads to an increase in the level of blood HCO3. Therefore, lower blood HCO_3 levels obtained for the chicks from older breeders may be due to pore numbers of larger eggs.

In conclusion, our results showed that exposure of embryos to 38.5°C from 10 to 18 d of incubation lead to an increase in chick weight, residual yolk weight and a decrease in liver and heart weight. These traits did not interact with parental age of the chicks. The benefical effects of intermittent exposure to a slightly higher incubation temperature for later thermoregulatory ability remains to be proven however, as well as the physiological backgrounds of the observed changes by incubation temperature manipulation.

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