Effect of short-term pre-hatch heat shock of incubating eggs on subsequent broiler performance

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Abstract

The aim of this study was to investigate the effect of thermal conditioning of broiler chickens during embryonic development on subsequent performance under standard rearing conditions. During incubation eggs from 32-, 45- and 56-week old Ross 308 broiler parent stock were subjected to a 2 h heat shock of 39 °C on days 14 and 15 of incubation. Eggs in the control were incubated throughout incubation at 37 °C. Chicks were feather sexed and equal numbers of each sex were placed in each pen per treatment, and reared for 42 days. Live weight, mortality and feed conversion ratio (FCR) were used as measures of performance. The final (six-week) live weights of broilers from young, mid and older parents for the treatment and control groups were 2113 ± 13.8 *vs.* 2159 ± 20.0, 2084 ± 29.2 *vs.* 2139 ± 20.0 and 2096 ± 17.6 *vs.* 2131 ± 24.3 g, respectively. The six-week live weight of the heat-treated group (2098 ± 12.0 g) was significantly lower than that of the control (2143 ± 12.2 g). The 1-6 week mortality figure was significantly lower in the heat-treated group of chickens from the young (83) and mid parent (77) groups compared to their controls (130 and 119), respectively. However, in the treatment group the incidence of mortality in broilers from the older parent group was significantly higher (105) than that of the control (79). The overall mortality without considering the parent age group was significantly lower in the treatment group (265) than in the control group (328). Mean FCR (g feed/g gain) of the chickens of the three parent groups was 1.79 ± 0.02 *vs.* 1.75 ± 0.03, 1.85 ± 0.03 *vs.* 1.77 ± 0.02 and 1.80 ± 0.03 *vs.* 1.77 ± 0.03 for the treatment *vs.* control groups, respectively, but the difference was significant only in the mid age parent group. These results suggest that prenatal thermal conditioning is not detrimental to broiler growth under standard rearing conditions in the absence of thermal stress. However, survival rate was improved but live weight and FCR were in some cases significantly poorer.

Keywords: Heat stress, incubation, parent age, live weight, mortality
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Introduction

The physiology of poultry under heat stress has been investigated extensively (McCormick *et al.*, 1979; 1980 a; b; Edens *et al.*, 1992; Ait-Boulahsen *et al.*, 1989; 1993; 1995), and consequently many approaches have been developed to increase thermotolerance, leading to the minimizing of heat-related mortality while maintaining productivity.

In many regions of the world heat stress, usually in summer months, is one of the major problems in poultry production. Heat stress is an abnormal condition for birds and is caused by hot and humid weather, but is usually minimized through the control of environmental factors such as temperature and ventilation in poultry houses. However, sophisticated housing designs are not always available because of economic and other constraints.

Epigenetic thermal conditioning prior to hatching involves changes in some physiological characteristics and probably serves as a method for epigenetic temperature adaptation since the same mechanisms are employed for coping with heat stress during post-embryonic growth. Previous research suggested that days 14–15 of incubation might be the optimal and most sensitive time for evoking this mechanism during embryonic development (Moraes *et al.*, 2004).

Improved thermotolerance by acclimation could be a valuable tool to maintain the productivity of the broiler industry in tropical and subtropical regions during hot seasons. In broiler chickens, exposure to heat stress at an early post-hatch age could precondition the chickens to improved thermotolerance later in life. Many studies have shown that heat tolerance can be improved by acclimation. Several reports covering several species have documented the use of postnatal heat treatment to induce thermotolerance later in life, including poultry. The effect of early-age thermal conditioning on the performance of poultry under heat stress later in life is well documented in the literature (Arjona *et al.*, 1988; Yahav & Hurwitz, 1996; Yahav, 2000). On the other hand, not much research has been conducted to improve thermotolerance at later ages using prenatal but not postnatal heat conditioning (Moraes *et al.*, 2003; 2004; Yalçin *et al.*, 2005). In fact, the consequences of prenatal heat conditioning without secondary environmental heat stress conditions in later life have not been studied. Additionally, postnatal heat treatment is a burdensome process for farmers to apply under field conditions and would be almost impossible to implement.

The purpose of the present study was to investigate the effect of thermal conditioning of broiler chicks originating from breeder flocks of three different ages, using heat stress during embryonic development on the performance of broilers reared under standard conditions without heat stress.

Materials and Methods

Eggs collected from 32-, 45- and 56-week old Ross-308 broiler parent stocks were used in this study. These eggs were classified as young, middle aged and older parents, and further classified as control and treatment. Eggs in the control groups were subjected to the normal incubation temperature (37 °C) while those in the treatment groups were incubated at 37 °C but were subjected to two hours of heat treatment of 39 °C on days 14 and 15 of incubation.

Once hatched 2 200 chickens subjected to the heat treatment during incubation and 2 200 from the control were selected for each parent group. Consequently the study consisted of six treatments and a total of 13 200 chickens. The experimental house contained 60 identical pens, and 10 pens were allocated to each experimental treatment. Each pen was stocked with 220 birds at 17 chicks per m², and contained equal numbers of males and females. Heating, humidity and ventilation in the house were applied according to commercial standards. In the hatchery the chicks were vaccinated against New Castle disease (ND) and infectious bronchitis-H120, and again on days 12 and 26 against ND. On days 14 and 20 they were vaccinated with the Gumboro vaccine via their drinking water. The chicks were fed a standard broiler feed prepared according to the Ross 308 management guide.

Live weight gain, feed consumption and mortality were recorded daily during the 42 days of the experimental period, using an automatic in-house built weighing device that recorded daily average live weight of a pen at the end of the each day. Therefore the means and standard error of means were the means within a pen. Birds were weighed at the slaughterhouse before slaughter.

Data for live weight and feed conversion ratio (FCR, g feed/g gain) for the heat-treated and control groups were analyzed using the Student's t-test. The comparisons between the three parent age groups for live weight and FCR were made by analysis of variance (ANOVA) in a completely random design. A least significant difference (LSD) test was carried out to determine the significance of the differences among the groups at the 5% level of significance. Data on the incidences of mortality in the heat-treated and control groups were analyzed using the Chi-Square test. A SPSS-10 (1998) Package Program for Windows was used for the statistical analysis. Since the sex ratios of the pens were equal, no statistical analyses were done on a sex basis.

Results and Discussion

The live weights of the six-week old broilers originating from young, middle aged and older parents for the treatment and control groups are presented in Table 1. The live weight of the broilers in the heat treatments was not affected by the age of the parents that produced the eggs.

The six-week live weights of birds for the treatment and control groups without considering parent age are shown in Table 2. Regardless of parent age, weekly live weights of broilers were almost identical for the control and treatment groups except at week 6 when the control group was heavier ($P < 0.05$) than the heat-treated group.

Yalcin *et al.* (2005) studied the effects of pre- and postnatal conditioning to induce thermotolerance in broilers obtained from eggs originating from younger and older breeder flocks. As prenatal treatment eggs were subjected to 39.6 °C for six hours per day from days 10 to 18 of incubation. The broilers were reared under standard (control), conditioned (treatment-1) and high ambient (treatment-2) temperatures. Contrary to the present findings Yalcin *et al.* (2005) found differences (P <0.05) in body weight at seven and 28 days between chicks from the different parent age groups. The 49-day body weight was higher (P <0.05) in the standard incubated group compared to the high temperature incubated group for both parent groups. This result is in accordance with our finding for final (42 day) body weight without considering parent age.

Table 1 Comparison of mean live weights (g) of birds according to parent age groups during the different weeks of the experiment (n = 13 200) between the heat-treated and control groups

Groups		Treatment ± s.e.	Control ± s.e.	P
From Young Aged Parents	1^{st} week	153 ± 1.7	151 ± 1.7	0.616
	2^{nd} week	396 ± 4.3	394 ± 4.7	0.723
	3^{rd} week	783 ± 6.7	783 ± 7.9	0.977
	4^{th} week	1291 ± 10.3	1276 ± 10.4	0.313
	5^{th} week	1829 ± 13.3	1821 ± 17.8	0.746
	6^{th} week	2113 ± 13.8	2159 ± 20.0	0.074
From Middle Aged Parents	1^{st} week	161 ± 2	159 ± 0.8	0.580
	2^{nd} week	409 ± 4.6	410 ± 2.9	0.942
	3^{rd} week	794 ± 10.2	805 ± 9.0	0.439
	4^{th} week	1293 ± 17.8	1321 ± 14.2	0.231
	5^{th} week	1846 ± 32.8	1865 ± 22.6	0.632
	6^{th} week	2084 ± 29.2	2139 ± 20.0	0.139
From Older Aged Parents	1^{st} week	166 ± 1.4	167 ± 2.3	0.774
	2^{nd} week	417 ± 3.2	420 ± 6.2	0.624
	3^{rd} week	812 ± 6.9	813 ± 11.3	0.911
	4^{th} week	1323 ± 11.0	1323 ± 15.4	1.00
	5^{th} week	1864 ± 18.8	1879 ± 16.8	0.551
	6^{th} week	2096 ± 17.6	2131 ± 24.3	0.264

Differences not significant; P – Student's t-test

Table 2 Mean live weights (g) of the birds at the end of each week, without considering parent age groups (n = 13 200) between the heat-treated and control groups

	Treatment ± s.e.	Control ± s.e.	P
1^{st} week	160 ± 1.4	159 ± 1.5	0.798
2^{nd} week	407 ± 2.8	408 ± 3.4	0.903
3^{rd} week	796 ± 5.0	800 ± 5.8	0.604
4^{th} week	1303 ± 8.0	1307 ± 8.5	0.712
5^{th} week	1846 ± 13.2	1855 ± 11.6	0.605
6^{th} week	2098 ± 12.0	2143 ± 12.2	0.011*

*P < 0.05; P – Student's t-test

However, in an investigation at North Carolina State University (NCSU) it was found that seven- and 28-day body weights of broilers incubated under high and standard incubation temperatures did not differ (P >0.05) (Leksrisompong, 2005). This finding is in accordance with our results up to five weeks, but contrary to the body weights at 42 days of age, when body weights in the present study differed significantly (P <0.05) between treatments.

Mean body weights of broilers at all ages, except at six weeks, originating from the old breeder flocks, were higher (P >0.05) compared to those from the younger flocks. At six weeks of age broilers from the younger parents performed better compared to the older and middle aged parents (P >0.05). Weytjens *et al.* (1999) studied thermoregulation in chicks from breeder flocks of two different ages and reported that chicks from young breeders had lower (P <0.05) body weights than those from older breeders. This report was only contrary to our findings for the six-week body weights.

Mortality figures up to six weeks from the three parent groups are presented in Table 3. Mortality of broilers in the treatment groups during the first week and for the 1-6 week period from young parents and during the second, third and 1-6 weeks from middle aged parents was lower (P <0.05) than that of the birds in the control. Conversely, over the six week period mortality among chicks from the older parents in the treatment group was higher (P <0.05) than in those from the other heat-treated groups.

Table 3 Comparison of incidence of broiler mortality according to parent age group between the heat-treated and control groups (n = 13200)

Groups		Treatment	Control	X^2	P*
From Young Aged Parents	1st week	17	56	21.187	0.000*
	2nd week	13	19	1.245	0.264
	3rd week	10	13	0.459	0.498
	4th week	3	3	0.001	0.978
	5th week	7	8	0.091	0.762
	6th week	33	31	0.025	0.875
	1-6 week	83	130	10.898	0.001*
From Middle Aged Parents	1st week	18	27	1.819	0.177
	2nd week	8	21	5.921	0.015*
	3rd week	12	24	4.158	0.041*
	4th week	5	9	1.211	0.271
	5th week	10	5	1.585	0.208
	6th week	24	33	1.585	0.208
	1-6 week	77	119	9.420	0.002*
From Older Aged Parents	1st week	33	24	1.440	0.230
	2nd week	13	6	2.620	0.106
	3rd week	7	9	0.236	0.627
	4th week	6	5	0.098	0.755
	5th week	16	16	0.000	0.984
	6th week	30	19	2.577	0.108
	1-6 week	105	79	3.834	0.050*

*P < 0.05; P – Chi-Square test (X^2)

Incidence of mortality in the treatment and control groups, without considering parent age, is shown in Table 4. Mortality in the first (P <0.05), third and over the 1-6 week period was lower in the treatment than in the control group (Table 4). Birds in the heat-treated group therefore appeared to be less prone to postnatal mortality under normal environmental rearing conditions that those incubated under standard temperature conditions.

Table 4 Incidence of mortality between the heat-treated and control groups during different weeks of the study, without considering parent age groups (n = 13 200)

	Treatment	Control	X^2	P*
1st week	68	107	8.808	0.003*
2nd week	34	46	1.884	0.170
3rd week	29	46	4.012	0.045*
4th week	14	17	0.324	0.569
5th week	33	29	0.217	0.642
6th week	87	83	0.058	0.810
1-6 week	265	328	7.008	0.008*

*P < 0.05; P – Chi-Square test (X^2)

Moraes *et al*. (2003) reported thermotolerance of broilers from conditioned embryos, compared with broilers from untreated embryos, and suggested that these birds might have less difficulty in coping with adverse environmental conditions than the controls. The authors additionally suggested that thermal conditioning during embryonic life might offer an additional practical method for easing heat stress in broilers especially under tropical conditions. In our experiment the prenatally heat-treated birds survived better than the control birds during the rearing period, although they were not exposed to extra postnatal heat stress. Leksrisompong (2005) conducted a study to determine the effect of temperature during incubation and

Table 5 Comparison of mean broiler feed conversion ratios (FCR) (g feed/g gain) according to parent age groups between the heat-treated and control groups (n = 13200)

Groups		Treatment ± s.e.	Control ± s.e.	P
From Young Aged Parents	1st week	0.98 ± 0.01	0.99 ± 0.01	0.316
	2nd week	1.18 ± 0.01	1.17 ± 0.01	0.519
	3rd week	1.34 ± 0.01	1.32 ± 0.01	0.180
	4th week	1.41 ± 0.02	1.41 ± 0.02	0.840
	5th week	1.55 ± 0.02	1.53 ± 0.03	0.547
	6th week	1.79 ± 0.02	1.72 ± 0.03	0.079
From Middle Aged Parents	1st week	0.93 ± 0.01	0.94 ± 0.00	0.471
	2nd week	1.15 ± 0.01	1.14 ± 0.01	0.861
	3rd week	1.33 ± 0.02	1.29 ± 0.02	0.186
	4th week	1.45 ± 0.02	1.39 ± 0.02	0.062
	5th week	1.57 ± 0.03	1.52 ± 0.03	0.259
	6th week	1.85 ± 0.03	1.77 ± 0.02	0.025*
From Older Aged Parents	1st week	0.88 ± 0.03	0.90 ± 0.01	0.499
	2nd week	1.11 ± 0.01	1.11 ± 0.02	0.948
	3rd week	1.29 ± 0.01	1.30 ± 0.02	0.768
	4th week	1.39 ± 0.02	1.37 ± 0.03	0.723
	5th week	1.53 ± 0.02	1.51 ± 0.02	0.550
	6th week	1.80 ± 0.03	1.77 ± 0.03	0.445

*P < 0.05; P - Student's t-test

rearing on broiler performance and found no significant differences between the mortality of broilers incubated under high and standard incubation conditions for the ages of 0 - 14, 0 - 21 and 0 - 28 days. This result is contrary to our findings where high incubation temperature appeared to reduce the postnatal mortality compared to control (P <0.05).

The FCR of six-week old broiler birds obtained from the three parent groups for the treatment and control groups is presented in Table 5. The FCR of birds for the treatment and control groups without considering parent age is presented in Table 6.

Overall FCR of birds from the three parent groups in the heat-treated groups was higher (poorer) than that of the control groups (Table 5) but the FCR of only the middle aged parent group differed significantly (P <0.05). Without considering parent age, FCR of broilers was numerically higher (poorer) in the treatment compared to the control (Table 6); this difference being significant (P <0.05) in week 6. Leksrisompong (2005) found that the difference in FCR for birds hatched under high incubation temperatures was lower (P <0.05) than that under standard incubation temperatures for the periods 0 - 7, 0 - 14 and 0 - 21 days but differences over the 0 - 28 days were not significant (P >0.05).

Feed intake, weight gain and FCR for broilers from the three parent age groups for the heat-treated and control groups are shown in Table 7.

Table 6 Comparison of mean feed conversion ratios (FCR) (g feed/g gain) of broilers (n = 13 200) without considering parent age between the heat-treated and control groups

	Treatment ± s.e.	Control ± s.e.	P
1st week	0.93 ± 0.01	0.95 ± 0.01	0.328
2nd week	1.15 ± 0.01	1.14 ± 0.01	0.674
3rd week	1.32 ± 0.01	1.30 ± 0.01	0.187
4th week	1.42 ± 0.01	1.39 ± 0.01	0.154
5th week	1.55 ± 0.01	1.52 ± 0.01	0.155
6th week	1.81 ± 0.01	1.75 ± 0.02	0.006*

* P <0.05; P – Student's t-test

Table 7 Cumulative values over 42 days for feed intake (g/bird) and weight gain (g) and mean feed conversion ratio (FCR) (g feed/g gain) of birds (n = 13 200) in the heat-treated and control groups

	Weeks 1-6	Young age	Middle age	Older age	F	P
Treatment	Feed Intake	3774 ± 38.2	3858 ± 13.8	3776 ± 35.9	2.334	0.116
	Weight gain	2069 ± 13.4	2037 ± 29.3	2047 ± 17.4	0.603	0.555
	FCR	1.82 ± 0.02	1.90 ± 0.03	1.85 ± 0.03	2.175	0.133
Control	Feed Intake	3708 ± 44.5	3781 ± 26.0	3771 ± 23.1	1.472	0.247
	Weight gain	2117 ± 19.9	2092 ± 19.6	2082 ± 24.6	0.712	0.500
	FCR	1.75 ± 0.03	1.81 ± 0.02	1.81 ± 0.03	1.443	0.254

P = ANOVA

In terms of feed intake, weight gain and FCR, no differences were observed (P >0.05) between the parent age groups.

Conclusions

The results of this study suggest that prenatal thermal conditioning is not detrimental to broiler growth under standard rearing conditions in the absence of postnatal heat stress.

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