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Durability of Induced Heat Tolerance by Short Term Heat Challenge at Broilers Marketing Age

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Abstract: A trial was conducted to determine the influence of short term exposure to high ambient temperature at 28 and 35 days of age on deep body temperatures (Tb) and subsequent growth of birds until 42 days of age. A total of 90 day old chicks were reared in stainless steel battery cages and were assigned at random into 18 pens of 5 birds each, with 9 pens containing males and another 9 pens containing females. Three treatment groups, each represented by 3 male and 3 female pens, were represented by T_1 without any heat exposure, T_2 with heat exposure starting at day 28 and T_3 with heat exposure starting at day 35. Heat stress was defined as 180 min exposure to 35±1°C. Tb and body weights were measured at 35, 37 and 39 days of age immediately following heat exposure. Heat stress resulted in higher Tb and Onset of heat stress at 28 days resulted in significantly lower Tb than onset of heat stress at 35 days. Lower Tb in T_2 than T_3 permitted recovery in body weight at 42 days. Sexes responded similarly to heat stress.

Key words: Acclimation, heat stress, body temperature, broiler, sex

INTRODUCTION

Practical means to alleviate heat stress include improving ventilation, pelleting diet, reducing stock density, fogging, evaporative cooling, usage of feed additives and feed restriction (Liew *et al.*, 2003; Dozier *et al.*, 2005). The thermoregulatory system and behavioral thermoregulation matures during first 2-3 weeks post hatch in chicken (Dawson and Whittow, 2000). Chickens are homoeothermic animals and able to maintain constant deep body temperature within a thermoneutral zone through various mechanisms. The Tb of unstressed domestic fowls normally varies between 41.0 and 41.5°C and is essentially constant to an ambient temperature of 27°C (Van Kampen, 1981), but rises with higher ambient temperatures.

Tb is a useful and reliable indicator of stress in poultry (Teeter *et al.*, 1992; De Basilio *et al.*, 2003). Heat challenges at 3-5 days post hatch has two positive effects at 6th week of age indicating acclimation: increased growth rate and increased thermotolerance (Yahav and Hurwitz, 1996; Yahav and McMurtry, 2001). Similar results from various heat challenges were reported at older ages (May *et al.*, 1987; Lott, 1991; Teeter *et al.*, 1992). But, there is no information regarding the persistency of acclimation after thermoregulatory system maturation. Chickens that have become acclimated exhibit larger combs and wattles, less fat and feather cover than controls (Van Kampen, 1981; Meltzer, 1987). Generally, acclimation is associated with increased heat loss and decreased heat production.

To date, the persistency of acclimation of male and female broilers has not been reported. The objective of this study was to measure the persistency of heat acclimation on deep body temperature and growth performance of male and female broilers after exposure to high environmental temperature.

MATERIALS AND METHODS

Ninety day-old commercial broilers (Arbor Acres Plus) were obtained from a government accredited commercial hatchery and housed at poultry unit of Department of Animal Science. The breeder age was 45 weeks old. Males and females were reared separately in stainless steel wire meshed floor battery cages in an environmentally controlled chamber where temperature and ventilation were controlled. Ambient temperature of the chamber was initially set at 32±1°C, reduced to 29±1°C on day 4 and then gradually decreased to 24±1°C by day 21 and thereafter. On day 27, birds were individually weighed and sorted into 4 weight classes between

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850-1050 g for females and between 950-1150 g for males (each class with a 50 g interval). Then one chick from each class was assigned to each pen. The three treatment groups consist of T_1 as control without heat stress exposure, T_2 with heat stress from day 28 onwards and T_3 with heat stress from day 35 onwards. Each treatment consisted of 30 birds. Provided diets (Gold Coin Sdn. Bhd.) were 22% CP, 2950 kcal ME kg^{-1} as crumble from day 1 to day 21 and 20.6% CP, 3100 kcal ME kg^{-1} as pellet form thereafter. Water and feed were available *ad libitum* and continuous fluorescent illumination was provided.

From day 28 to 42, birds from T_2 were removed from their pens daily, placed in plastic crates and transferred to another environmentally controlled chamber with ambient temperature of 35±1°C for 3 h and 65-75% relative humidity. From day 35-42, birds from T_3 were also subjected to the same physical movement and heat challenge. T_1 (control) broilers were not subjected to heat challenge. However, they catch and placed in plastic crates to avoid the confounding effect of being removed and placed in plastic crates from day 28-42. Feed and water were not available during the heat challenge.

Tb was recorded for 8 males and 8 females from each treatment groups using digital thermometer (RS stock No. 612849) on day 35, 37 and 39. Temperature was recorded after 1 min probe insertion (3 cm depth) into the bird's rectum. Tb was recorded within the last 15 min of heat stress period. After the treatment period, birds were transferred from the crates back to the battery cages. Mortality after commencement of treatment (28 days onward) was recorded.

Statistical analysis: Body weight and relative weight gain data were subjected to analyses of variance in a 3×2 factorial arrangement. The three heat challenge treatments and sex of birds were considered as factors. Tb data were analyzed by GLM procedure under split plot design and trend analysis to investigate the effect of time (at 35, 37 and 39 days) on Tb and to find any possible linear or quadratic regression between time and Tb. All data were analysed by computational package (SAS® Institute, 1996). Means were separated by Duncan multiple range test when appropriate by using SAS. The significance levels were reported at $p<0.05$. Mortality data were analysed by Chi square test.

RESULTS

The effect of sex and onset of heat challenge on body weights and relative weight gains of broiler chickens at 35 to 42 days of age are presented in Table 1. Birds that were exposed to heat challenge weighed less ($p<0.01$) and had lower relative weight gains ($p<0.01$) than their controls. There was no interaction between onset of heat challenge and sex ($p>0.05$). There was no difference in relative weight gains between T_2 and control (T_1). At day 42, T_2 showed 63% improvement in relative weight gains compared to T_3. These results showed that birds which received heat challenge at day 28 were able to recover their body weight by improvement in relative weight gain. Birds from T_2 showed lower mortality ($p<0.01$) than T_3 from 35-42 days. Among the T_3, females had higher mortality (37%) than males (12.5%) (Table 2). As shown in Table 3, T_2 (heat acclimated) chickens could maintain their Tb at a lower level than T_3 (non-heat acclimated) chickens. However, it was not very long and heat acclimated birds lose their ability to maintain lower Tb and gradually their Tb reached to the point of non-heat acclimated group. Tb of T_2 birds were lower ($p<0.01$) than those of T_3 at day 35 and 37 (Table 3). All treatments showed increase in Tb at day 39 which was not significantly different between treatment groups.

There was no interaction between sex and heat challenge duration on Tb for both T_2 and T_3. Trend analysis was carried out to investigate the regression

Table 1: ANOVA and means for sex and onset of heat challenge on body weight and relative weight gain of broiler chickens at 35 to 42 days of age

	Body weight (g)		Relative weight
Treatment groups	(35 days)	(42 days)	gain (%)
Sex			
Male	1706^a	2334^a	37.8^a
Female	1577^b	2072^b	34.2^b
Heat challenge duration			
T_1[1]	1688^b	2306^b	41.7^a
T_2	1527^a	2171^a	40.7^a
T_3	1709^b	2132^a	25.6^b
SEM	18.5	37.8	1.9
ANOVA			
Sex	**	**	**
Heat challenge duration	**	**	**
Sex×heat challenge duration	NS	NS	NS

NS- Not significant; * $p<0.05$; ** $p<0.01$, a, b Means with no common superscripts within a column-subgroup differ significantly, [1]T_1: Control; T_2: Heat stress from day 28 onwards; T_3: Heat stress from day 35 onwards

Table 2: Mean mortality rate (%) of broiler chickens[1] by sex and onset of heat challenge at different age period

	(28-35) days		(35-42) days		(28-42) days	
Heat challenge duration	Male	Female	Male	Female	Male	Female
T_1 (control)	0.0	0.0	0.0	0.0	0.0	0.0
T_2	8.3^x	4.2^y	0.0	0.0	8.3^{ax}	4.2^{ay}
T_3	0.0	0.0	12.5^x	25^y	12.5^{bx}	25^{by}

[1]Equal number of birds from each heat challenge duration and sex treatment groups (3 replicate pens, 4 birds per pen) were exposed to heat stress (35°C) or No-heat stress (21°C), x,yMeans for sex within each period with no common superscript in a same row differ significantly ($p<0.05$), a,bMeans for treatments with no common superscript in a column differ significantly ($p<0.05$)

Table 3: ANOVA and means of sex and heat challenge duration on deep body temperature (°C) of broiler chickens at 35-39 days of age

	Age (day)		
Treatment groups	35	37	39
Sex			
Male	44.38	44.02	44.27
Female	44.42	44.14	44.37
Heat challenge duration			
T_1	41.05^c	41.05^c	41.05^b
T_2	43.94^a	43.64^a	44.21^a
T_3	44.86^b	44.51^b	44.44^a
SEM	0.12	0.12	0.09
ANOVA			
Sex	NS	NS	NS
Heat challenge duration	**	**	**
Sex×heat challenge duration	NS	NS	NS

NS: Not Significant; *p<0.05; **p<0.01, ^{a,b}Means with no common superscripts within a column-subgroup differ significantly

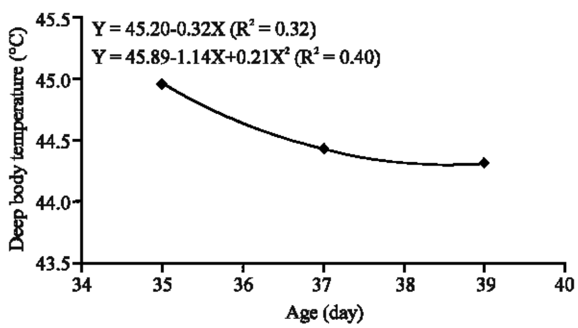

Fig. 1: Quadratic regression curve and equation between time (age) and Tb for T_3 male birds during 35-39 days of age

between time and Tb; it was revealed that except for male birds of T_3, there were no significant regressions during 35-39 days of age (Fig. 1).

The significant linear and quadratic regression equations ($p<0.01$) of Tb with time in T_3 male birds are shown in Fig. 1. Mean Tb was recorded as 41.05°C for control group in both male and female birds.

DISCUSSION

Acclimation is a more extensive adaptation than thermal conditioning, which involves hypothalamic thermoregulatory threshold changes that enable chickens, within certain limits, to cope with acute exposure to unanticipated high ambient temperature. The obstacle of thermal conditioning lies in its inefficiency to raise thermotolerance close to the level achieved through acclimation (Yahav, 2001). The present study showed that subjecting birds to acclimation (T_2) reduced Tb, suggesting better ability to cope with heat stress. This result confirmed earlier findings that acclimated chickens were better able to maintain body temperatures at a point which was lower than that of non-heat acclimated chickens following heat exposure (May *et al*., 1987; Teeter *et al*., 1992; Yahav and Hurwitz, 1996; Yahav and Plavnik, 1999). After 3 h of heat stress the non-heat acclimated chickens (T_3) exhibited a significant rise in Tb by almost 3.5°C, while the response in heat acclimated group (T_2) was only 2.7°C. In the present study, heat acclimated birds did not exhibit a greater reduction of Tb at day 39 than the non-heat acclimated chickens. However, May *et al*. (1987) practiced acclimation at an older age and observed reduction in the Tb of acclimated chickens during heat challenge.

Guerreiro *et al*. (2004) reported that broilers raised at high temperature showed steep colonic temperatures increase during the first 2 h of heat challenge (1.06°C h^{-1}) and more slowly thereafter (0.59°C h^{-1}). Broilers reared at thermoneutral temperature showed a small increase in the first 4 h of heat stress (0.18°C h^{-1}) and then colonic temperature increased sharply (0.72°C h^{-1}). Nevertheless, both groups presented similar final colonic temperature by the end of the heat challenge period. This inconsistency may be due to procedural difference for acclimation and heat challenge duration. Guerreiro *et al*. (2004) used a 420 min heat challenge period and gradually increased temperature from 28 to 42°C while May *et al*. (1987) exposed the birds to 41°C during a 210 min time. The rate of increase in colonic temperature during the heat challenge period in the heat-acclimated birds might be associated with the process of reducing water loss in order to prevent dehydration.

Previously Yahav and Hurwitz (1996) demonstrated that as the phase of thermal conditioning being extended, the compensatory growth response deteriorated. This development of positive gain in Tb maybe occurred because of the ongoing trend of bird's metabolic rate and subsequent heat production. Cooper and Washburn (1998) indicated that broiler chickens lose their ability to thermoregulate efficiently under extreme conditions because of their dramatically increased growth rate. Therefore, it seems that metabolic rate follows the same developmental pattern like dramatic growth rate during 6th week of age. However, the data on relative weight gain indicated that although heat acclimated chickens lost their ability to keep low Tb, they succeeded to recover their productive potential to the level of control birds. Moreover, significant differences in mortality rate of heat acclimated and non-heat acclimated birds confirmed the above explanation.

It was suggested that the feed consumed by the acclimated birds created a delay in nutrient metabolism or carryover of nutrients for utilization during the next hours of heat stress or thermoneutral period (Wiernusz and Teeter, 1996). Thus, it may be concluded that decreased feed intake not only allows the birds to reduce heat production but, also enables maximum acclimation expressions such as increased respiration efficiency and therefore lower relative weight gain in acclimated birds than non-heat acclimated birds.

CONCLUSION

In conclusion, both male and female broilers could acclimate to heat stress during last two weeks before marketing age, but this adaptation was not stable and long lasting, however they compensated for relative weight gain at the end of 6th week of age. In another word, acclimation after thermoregulatory system maturation during within first two weeks of life is not seems to be persistent throughout the life.

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