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# Effects of incubation temperature on hatching and carcass performance of broilers

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**In the past 20 years, broiler production has increased in hot climate countries, due to a greater potential for further growth. Thus, there is a necessity to improve thermotolerance of broilers produced in hot climates. Incubation period will become increasingly important in enhancing thermotolerance, because higher temperatures during incubation may lead to an elevation of the thermoregulatory set-point after hatch. Two recent experiments, conducted to determine the effect of high incubation temperature ($INC_{HIGH}$) from d 10 to 18 on hatching performance and carcass characteristics of broilers, have been compared with broilers from incubated at control temperatures ($INC_{CONT}$). $INC_{HIGH}$ resulted in a delay in external pipping and hatching times compared with $INC_{CONT}$. There was no incubation temperature effect on the weights of bursa of fabricius, spleen and lungs, and moisture content of chicks but lowered heart and liver weights. When broilers exposed to daily cyclic high temperature from 21 to 42 d, slaughter weight of broilers from $INC_{CONT}$ reduced while heavier body weight and breast yield were obtained in broilers from $INC_{HIGH}$. It was concluded that higher incubation temperature from d 10 to 18 for 6 h/d had no effect on chick weights and minimized the negative effect of heat stress on slaughter weight and breast meat yield.**

**Keywords:** broilers; incubation temperature; hatching performance; carcass performance

## Introduction

Chickens maintain a constant body temperature over a wide range of ambient temperature. However, the ability to maintain body temperature depends on balance between the internally produced heat and the rate of heat dissipation. Fast growing

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broilers have difficulties in dissipating heat production and to maintain body temperature at high environmental temperatures (Chwalibog and Eggum, 1989). Indeed, 0.57-0.85°C higher body temperatures were reported in broilers reared at higher temperatures compared to broilers reared at control (Yalçın *et al.,* 1997). Although respiratory evaporative heat loss is an effective mechanism for heat dissipation, increased the ventilation is based on the upper respiratory track results an increase in panting (respiratory rate), blood pH, and decrease in blood $Na^+$, $K^+$, $pCO_2$, and $HCO_3^-$ characterizing a status of respiratory alkalosis in broilers exposed to higher temperatures (Borges *et al.*, 2003). Thus, high ambient temperature from 3 to 7 weeks induces major economic losses by increasing mortality and decreasing growth rate of broilers. On the other hand, there is strong evidence that climate change is already occurring, and global temperatures will rise by between 1.4 and 5.8ºC during this century. This makes it necessary to improve strategies to alleviate the negative effects of high ambient temperatures on broilers.

Early thermal conditioning, exposure to 36°C for 24h at 5d of age, seems to be one of the most promising methods in increasing resistance of broilers to heat stress (Yahav and Hurwitz, 1996; Yahav and Plavnik, 1999). Our previous studies (Yalçın *et al.,* 2003 and 2004) showed that when broilers exposed to heat stress, conditioned broilers gained 3.2% more body weight than heat stressed broilers and had similar feed conversion to control from 21 to 42 d. Increases in body temperatures were average 0.57 *vs.* 0.76ºC in conditioning and control broilers, respectively, after exposure to 34°C for 8 h (Yalçın *et al.,* 2005).

Incubation period is of particular importance in thermoregulation of poultry. Exposure to higher incubation temperatures during the critical periods can improve broilers capability for thermotolerance at later post-hatch age (Moraes *et al.,* 2003; Yahav *et al.,* 2004; Yalçın *et al.,* 2005). Yahav *et al.* (2004) concluded that exposing embryos to higher incubation temperature (38.5°C) for 3 h from 16 to 18 d had a positive effect on thermoregulation of broilers without affecting hatchability. It was demonstrated that 39ºC incubation temperature from either 11 to 20 d of incubation for 6 h/d (Iqbal *et al.,* 1990) or from 13 to 17 d of incubation for 2 h/d improved broilers capability to combat with heat stress at later ages (Moraes *et al.,* 2003 and 2004). Because thermal conditioning during incubation may become a practical tool to prevent the detrimental effect of heat stress, more information is needed to determine its effect on hatching performance and slaughter weight and carcass performance. The objective of the present study was to evaluate the effects of higher incubation temperature from 10 to 18 d of incubation on hatching and carcass performance in broilers reared at daily higher temperature from 21 to 42 d.

## Recent research

In the first recent experiment conducted in our own laboratories, a total of 1700 eggs were used. Eggs were weighed individually and numbered before setting for incubation. Eggs were divided into two groups and set to either a high ($INC_{HIGH}$, 39.6°C/6h/d from d 10 to 18) or control ($INC_{CONT}$ 37.8°C) temperature incubator. Using a thermometer (Braun Thermoscan) eggshell temperature was recorded on d 14 and 18 of incubation on 25 eggs/incubation temperatures. Between 464 and 510h of incubation, the number of embryos pipped externally and chicks hatched were recorded every 2 h. All unhatched eggs were broken to macroscopically determine fertility or stage of development at death. Total embryonic mortality was calculated as total of early, mid and late deaths and pipped but unhatched eggs. Malpositions were classified. Chicks hatched from fertile eggs (H/F)



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were also determined. On day of hatch, ten chicks from each incubation temperature were weighed, sacrificed by cervical dislocation, dissected, and residual yolk sac weight and weights of liver, heart, bursa of fabricius, spleen, and lungs were measured. Chick moisture was determined after chicks were dried at 110ºC for 24 h.

In a second trial, a total of 552 eggs were used and the same incubation process was repeated, except for temperature that was 38.5°C/6h/d from d 10 to 18 in the $INC_{HIGH}$ group. A total of 300 chicks (150 from each incubation temperature) were allotted to 12 floor pens. Room temperature was 33ºC at 1 d of age and decreased gradually 3°C/week until they reached 24°C at 21 d. From d 21 to 42, half of broilers from each incubation temperature were exposed to daily cyclic high temperature of 32 to 35°C from 10:00 to 17:00 h, while the other half was reared at optimum temperature (24°C, control). Birds had ad libitum access to diet and water. At 42 d, all birds were weighed and body temperatures of 12 male broilers during the daily cyclic high temperature were recorded. Twelve male broilers/incubation temperature/rearing temperatures were slaughtered after 8 h feed withdrawal. Weights of breast (with and without bone and skin), drumsticks, and wings were measured and yield was expressed as a percentage of carcass weight.

## Hatching performance

Significantly higher shell temperature was obtained for eggs from $INC_{HIGH}$ at both 14 and 18 d of incubation (*Table 1*). This higher eggshell temperature could be a prerequisite for a higher thermoregulatory set-point during the post-hatch period (Tzschentke, 2008). The higher incubation temperature may increase incubation weight loss and affect chick moisture. Indeed, Lourens (2008) found 11.5 and 12.4% weight loss between setting and transfer at 19 d of eggs that incubated at constant 37.8 and 38.9 ºC eggshell temperature from 9 to 19 d of incubation. However, in the present study, similar chick moisture levels were obtained (*Table 1*). This result could indicate similar weight loss between two incubation temperatures. This difference between studies may be due to duration and degree of higher incubation temperature.

There was no effect of incubation temperature on H/F. Hatchability was 79.9 and 80.2% for $INC_{CONT}$ and $INC_{HIGH}$, respectively, being insignificant between groups (*Table 1*). Embryos incubated at $INC_{HIGH}$ pipped 7.2 h later compared to $INC_{CONT}$ embryos. Higher daily cyclic temperature treatment during incubation increased the duration of total incubation time as was previously demonstrated by Yalçın *et al.* (2006). Duration of total incubation was 495.5 h and 500.5 h for $INC_{CONT}$ and $INC_{HIGH}$ chicks, respectively.

Embryonic mortalities were not influenced by incubation temperature. Although the incidence of the malpositions was 0.47%, all was belong to the embryos from $INC_{HIGH}$. Head under left wing constituted almost 62.5% of the malpositions, followed by head in the small end of egg with a frequency of 25.0% and feet overhead with a frequency of 12.5%. The incidence of blind embryos was 0.8% (data not shown in tables).

There was no effect of higher incubation temperature on chick weight (*Table 2*). Yolk absorption was greater for control chicks. Higher residual egg yolk content found in late-hatched $INC_{HIGH}$ chicks was consistent with the finding of Joseph and Moran (2005) who reported that late-hatched chicks had a greater residual yolk sac weight. Higher residual egg yolk content suggested that $INC_{HIGH}$ chicks were not efficiently utilising yolk reserves before hatching. On the other hand, higher residual yolk sac after hatch may be critical to growth and development (Turro *et al.,* 1994).

However, chicks had similar yolk-free chick weights. There were no differences between incubation temperature groups for relative weights of bursa of fabricius,



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spleen, and lungs. Relative weights of liver and heart were higher in chicks from $INC_{CONT}$ than those from $INC_{HIGH}$ chicks. Sklan *et al.* (2003) reported that greater growth rate birds had larger liver weight which may reflect the level of metabolic activity. The lower liver weight of $INC_{HIGH}$ chicks may be related to the lowered metabolic activity of the $INC_{HIGH}$ chicks. The findings of a reduction in plasma $T_3$ concentration in chicks from $INC_{HIGH}$ (Yahav *et al.,* 2004) also support this result. A negative association between incubation temperature and cardiac cell division was reported by Leksrisompong *et al.* (2007). Thus, lower heart weight in $INC_{HIGH}$ chicks might be expected due to lower number of mitotically active myocytes of the heart under higher incubation temperatures. Wineland *et al.* (2000) also found lower heart weight when embryos incubated at higher temperatures.

**Table 2 Weights of chick (g) and relative weights (%) of yolk sac, bursa of fabricious, spleen, liver, and lungs of chicks from control ($INC_{CONT}$) and higher incubation ($INC_{HIGH}$)[1].**

| Incubation | Chick weight g | Yolk sac % | Yolk free chick weight g | Bursa of fabricius % | Spleen% | Liver% | Heart% | Lungs% |
|---|---|---|---|---|---|---|---|---|
| $INC_{CONT}$ | 41.8 | 11.8[b] | 36.8 | 0.117 | 0.023 | 2.07[a] | 0.70[a] | 0.71 |
| $INC_{HIGH}$ | 40.8 | 14.2[a] | 35.1 | 0.104 | 0.016 | 1.82[b] | 0.63[b] | 0.72 |
| SE | 0.8 | 0.7 | 0.6 | 0.008 | 0.003 | 0.06 | 0.01 | 0.04 |
| P (significance) | 0.504 | 0.033 | 0.071 | 0.289 | 0.141 | 0.012 | 0.013 | 0.841 |

$INC_{HIGH}$: 39.6°C from 10 to 18 d of incubation
[a,b]Means in columns not sharing a letter differ significantly

## Body temperatures under daily cyclic high ambient temperature and carcass performance of heat acclimated broilers during incubation

In the present study, if cyclic higher incubation temperature from 10 to 18 d of incubation induces long-term acquisition of thermotolerance was also investigated. The increased thermotolerance of $INC_{HIGH}$ broilers was reflected in their body weight when exposed to daily cyclic high temperatures from 21 to 42 d. Although, broilers from $INC_{HIGH}$ exhibited significantly lower body weight when reared at control temperatures from 21 to 42 d, $INC_{HIGH}$ broilers were heavier than $INC_{CONT}$ when reared at daily cyclic high temperature (*Table 3*). Under daily high temperature, slaughter weight of $INC_{CONT}$ broilers was lower about 6.5% whereas $INC_{HIGH}$ broilers gained 135 g more (relative advantage was 5.2%) body weight than $INC_{CONT}$. On the other hand, the lower body weight of $INC_{HIGH}$ broilers at control ambient temperature was associated with lower body temperature. The $INC_{HIGH}$ broilers had lower body temperatures than $INC_{CONT}$ broilers at both control and daily higher rearing temperatures (*Table 3*). This result suggested that higher incubation temperature from 10 to 18 d of incubation appears to induce long-term thermal adaptation to heat stress expressed by the lower body temperatures at daily cyclic higher ambient temperature. This may be related to lower metabolic rate of $INC_{CONT}$ broilers.

Daily cyclic high temperature reduced total breast yield but increased drumsticks yield regardless of incubation temperature (*Table 3*). The decreased in breast meat yield but increased in leg yields by heat stress support previous conclusions (Rosa *et al.,* 2007; Akşit *et al.,* 2006; Yunis and Cahaner, 1999). The magnitude of the reduction in breast meat yield of $INC_{CONT}$ broilers at high ambient temperature was almost similar to body



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weight of those birds. However, $INC_{HIGH}$ broilers tended to have heavier breast meat yield compared with broilers from $INC_{CONT}$. Heavier breast yield obtained from $INC_{HIGH}$ broilers suggested that although $INC_{HIGH}$ reduced slaughter weight of broilers reared at optimum temperatures, advantage on breast meat yield was greater when exposed to either control or higher ambient temperatures from 21 to 42 d. Higher breast meat yield of $INC_{HIGH}$ broilers may be related to accelerated cell differentiation and increased total number of fibres in the breast (Halevy *et al.*, 2001). Neither incubation temperature nor rearing temperature had an effect on wing yield (*Table 3*).

**Table 3 Body temperature, slaughter weight and carcass part yields (% of carcass) of broilers from control ($INC_{CONT}$) and higher incubation ($INC_{HIGH}$)[1].**

| | $INC_{CONT}$ | | $INC_{HIGH}$ | | |
|---|---|---|---|---|---|
| | **Control** | **Daily cyclic high temperature** | **Control** | **Daily cyclic high temperature** | **SE** |
| Body temperature, ºC | $42.2^{bx}$ | $42.9^{ax}$ | $41.5^{by}$ | $42.3^{ay}$ | 0.1 |
| Slaughter weight, g | $2506^{ay}$ | $2342^{by}$ | $2354^{bx}$ | $2477^{ax}$ | 15 |
| Total breast yield[2], % | $35.6^{a}$ | $34.3^{b}$ | $35.5^{a}$ | $34.9^{b}$ | 0.4 |
| Breast meat, % | $26.2^{ay}$ | $24.4^{by}$ | $27.2^{ax}$ | $25.9^{bx}$ | 0.4 |
| Drumsticks yield, % | $13.8^{b}$ | $14.9^{a}$ | $13.7^{b}$ | $14.7^{a}$ | 0.2 |
| Wings yield, % | 11.6 | 11.5 | 11.4 | 11.1 | 0.2 |

[1] $INC_{HIGH}$: 38.5°C from 10 to 18 d of incubation
[2] with bone and skin
[a,b] Means in a raw within an incubation temperature not sharing a letter differ significantly ($P<0.05$)
[x,y] Means in a raw within a rearing temperature not sharing a letter differ significantly ($P<0.05$)

## Conclusions

The results of the recent experiments indicated that higher incubation temperature from 10 to 18 d of incubation to acclimate the chicks to the higher post hatch ambient temperatures had no effect on hatchability and chick weights, and minimized the negative effect of post hatch heat stress on body temperatures and weights of slaughter and breast meat. These data suggest higher daily cyclic incubation temperatures from 10 to 18 d of incubation improved the ability of broilers to cope with higher environmental temperatures from 21 to 42 d of age during postnatal period.

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**Table 1 Eggshell temperature, time of pipping and duration of incubation (hour, h), chicks hatched from fertile eggs (H/F), hatchability, total embryonic mortalities in eggs and moisture of chicks from control ($INC_{CONT}$) and higher incubation ($INC_{HIGH}$).**

| Incubation | Eggshell temperature | | Pipping | Duration of incubation | H/F | Hatchability | Embryonic mortality | Chick moisture |
|---|---|---|---|---|---|---|---|---|
| | °C | | h | h | % | % | % | % |
| | 14 d | 18 d | | | | | | |
| $INC_{CONT}$ | 37.4[b] | 38.1[b] | 482.6[b] | 495.5[b] | 91.9 | 79.9 | 80.0 | 4.7 |
| $INC_{HIGH}$ | 39.0[a] | 40.0[a] | 489.8[a] | 500.5[a] | 87.9 | 80.2 | 79.5 | 5.4 |
| SE | 0.1 | 0.1 | 0.35 | 0.25 | 1.7 | 1.7 | 0.3 | 0.8 |
| P (significance) | <0.001 | <0.001 | <0.001 | <0.001 | 0.065 | 0.949 | 0.195 | 0.521 |

[1] $INC_{HIGH}$: 39.6°C /6h/d from 10 to 18 d of incubation
[a, b] Means in columns not sharing a letter differ significantly

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