Effects of Pre-Hatch Thermal Programming on Hatching Time and Chick Grade of Crossbred Chickens

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Abstract. This study evaluated the effects of pre-hatch thermal programming on hatching time and chick grade of crossbred chickens. A total of 200 fertile eggs were randomly distributed across four treatments, namely T0: Standard incubation at 37.5°C throughout the entire 21.5-day incubation period (control), T1: Incubation at 37.5°C with a temperature increased to 38.5°C for 6 hours/day from days 10 to 18, T2: Incubation at 37.5°C with a temperature increased to 39.5°C for 6 hours/day from days 10 to 18, and T3: Incubation at 37.5°C with a temperature increased to 40.5°C for 6 hours/day from days 10 to 18. Each treatment has five replicates, with 10 eggs in each replicate. Variables observed were hatching time and chick grade. Hatching time was categorized into three intervals based on hours post-incubation, including early (480–492 hours), middle (492–504 hours), and late (504–516 hours). Chick grade were classified based on their body weight at hatching, including platinum (>37 g), gold (34-37 g), and silver (30–34 g). The results showed no significant differences (P>0.05) among the treatments across all hatching phases, indicating that the treatments produced comparable outcomes. The range of hatching time in early, middle, and late phases were 60.00-64.00%, 8.00-14.00%, and 2.00-8.00%, respectively. Pre-hatch thermal programming also did not significantly (P>0.05) affect chick grade. The range of chick grade in platinum, gold, and silver categories were 58.00-68.00%, 8.00-18.00%, and 0.00-4.00%, respectively. It could be concluded that pre-hatch thermal programming is a safe approach to be applied in crossbred chickens, which had no adverse effect on hatching time and chick grade.

Keywords: chick grade, climate change, crossbred chickens, hatching time, thermal programming.

1 Introduction

Climate change has become a critical global challenge that significantly impacts agricultural systems, including poultry production [1,2]. Extreme heat events are frequent in tropical climates. As a result, poultry performance and productivity are particularly vulnerable. High temperatures can lead to reduced growth rates and increased mortality in chickens [3-5]. These effects pose a serious threat to smallholder farmers who depend on poultry for income and nutrition. Heat stress not only reduces the market value of poultry products but also increases production costs, such as those for healthcare and

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cooling systems [6]. Additionally, the nutritional security of communities relying on poultry as a key protein source is at risk [7].

Closed-house systems equipped with advanced climate control technologies are commonly used to reduce heat stress in poultry and maintain optimal production conditions [8,9]. These systems effectively regulate temperature, relative humidity, and wind speed to create a stable environment that minimizes the adverse effects of heat stress [10]. However, their high installation and operating costs make them inaccessible to many smallholder farmers, particularly in developing regions. This financial barrier leaves small-scale poultry producers vulnerable to the negative impacts of climate change. As a result, there is growing interest in developing affordable and sustainable strategies to improve heat tolerance in poultry.

One promising approach to improving heat stress resilience in poultry is the use of epigenetic methods, such as pre-hatch thermal programming. This method involves exposing embryos to carefully controlled temperature variations during incubation [11]. These temperature changes are applied during critical developmental periods, influencing gene expression and triggering adaptive responses [12]. These responses are designed to persist after hatching, allowing chickens to better tolerate heat stress throughout their lives [13]. By enhancing the bird's natural ability to cope with high temperatures, pre-hatch thermal programming can improve thermal resistance and support more optimum growth performance in hot climates [14]. This method holds significant potential as a cost-effective and sustainable strategy for addressing the challenges posed by heat stress in poultry production.

Incubation conditions play a crucial role in influencing hatching outcomes and post-hatch performance [15-17]. To fully harness the potential of pre-hatch thermal programming, it is vital to evaluate its effects on key hatching traits before its widespread application. Parameters such as hatching time and chick grade serve as critical indicators of the feasibility and potential success in poultry production systems. This study was therefore undertaken to evaluate the effects of pre-hatch thermal programming on the hatching time and chick grade of crossbred chickens.

2 Materials and Methods

2.1 Experimental Design

A total of 200 fertile eggs from a crossbreed of male native chickens and commercial laying hens were used in this study. The average egg weight was 62.76±4.40 with a coefficient of variation was 7.01%. The eggs were randomly distributed into four treatment groups, each with five replicates (10 eggs per replicate). The treatments were T0: Standard incubation at 37.5°C throughout the entire 21.5-day incubation period (control), T1: Incubation at 37.5°C with a temperature increased to 38.5°C for 6 hours/day from days 10 to 18, T2: Incubation at 37.5°C with a temperature increased to 39.5°C for 6 hours/day from days 10 to 18, and T3: Incubation at 37.5°C with a temperature increased to 40.5°C for 6 hours/day from days 10 to 18. All eggs were incubated in a

forced-air incubator. Eggs were turned automatically every hour during 1-18 days of incubation.

2.2 Hatching Time and Chick Grade Evaluation

Hatching time was categorized into three intervals based on hours post-incubation, including early (480–492 hours), middle (492–504 hours), and late (504–516 hours). The percentage of chicks hatched in each time category was calculated relative to the total number of fertile eggs in each replicate. At 516 hours, all chicks were removed from the incubators and weighed immediately using a digital balance. Chick grade were classified based on their body weight at hatching, including platinum (>37 g), gold (34-37 g), and silver (30–34 g). The percentage of chicks in each grade category was calculated relative to the total number of fertile eggs in each replicate.

2.3 Data Analysis

Data were analyzed using analysis of variance to determine the effects of pre-hatch thermal programming on hatching time and chick grade. A significance level of $P<0.05$ was used. Statistical analysis was conducted using IBM SPSS Statistics 25.

3 Results and Discussion

Table 1 presents the effects of pre-hatch thermal programming on the hatching time of crossbred chickens, categorized into three phases: early (>480–492 hours), middle (>492–504 hours), and late (>504–516 hours). The results showed no significant differences ($P>0.05$) among the treatments across all hatching phases, indicating that the treatments produced comparable outcomes. The range of hatching time of crossbred chickens in early, middle, and late phases were 60.00-64.00%, 8.00-14.00%, and 2.00-8.00%, respectively. In line with this finding, Han et al. [18] also found that thermal programming with high temperature during embryogenesis had no significant effect on hatch time of layer chickens. In another study by Shah and Özkan [19], it was also reported that pre-hatch thermal programming did not significantly affect hatch time of broiler chickens observed at 488- and 496-hours post-incubation.

Table 1. Effects of pre-hatch thermal programming on hatching time of crossbred chickens.

Treatment	Early (>480-492 h)*	Middle (>492-504 h)*	Late (>504-516 h)*
T0	64.00 ± 13.42	14.00 ± 8.94	8.00 ± 8.37
T1	62.00 ± 4.47	10.00 ± 10.00	4.00 ± 5.48
T2	66.00 ± 8.94	10.00 ± 7.07	4.00 ± 5.48
T3	60.00 ± 7.07	8.00 ± 4.47	2.00 ± 4.47

* Early: hatched at >480-492 hours post-incubation, Middle: hatched at >492-504 hours post-incubation, Late: hatched at >504-516 hours post-incubation.

Table 2 shows the effects of pre-hatch thermal programming on the grade distribution of crossbred chicks, classified into three weight categories: platinum (>37 g), gold (>34-37 g), and silver (>30-34 g). The results indicate that there were no significant differences (P>0.05) among treatments across chick grade categories. This finding confirm that pre-hatch thermal programming can be considered a biologically safe intervention, as it does not negatively influence the chick grade distribution of crossbred chicks. The range of chick grade in platinum, gold, and silver categories were 58.00-68.00%, 8.00-18.00%, and 0.00-4.00%, respectively. Previously, Abdel-Fattah et al. [20] observed that thermal programming during incubation had no negative effect on chick weight of broiler chickens. Hanafi et al. [21] also noticed that thermal treatments during embryonic development phase of broiler chickens had no adverse effect on body weight at hatch. Moreover, Meteyake et al. [22] also found that pre-hatch thermal programming did not affect chick weight of broiler chickens.

Table 2. Effects of pre-hatch thermal programming on chick grade of crossbred chickens.

Treatment	Platinum (%)*	Gold (%)*	Silver (%)*
T0	68.00 ± 13.04	18.00 ± 8.37	0.00 ± 0.00
T1	66.00 ± 15.17	8.00 ± 4.47	2.00 ± 4.47
T2	66.00 ± 11.40	10.00 ± 7.07	4.00 ± 5.48
T3	58.00 ± 10.95	10.00 ± 7.07	2.00 ± 4.47

* Platinum: body weight >37 g, Gold: body weight >34-37 g, Silver: body weight >30-34 g.

The absence of significant differences on hatching time and chick grade may be attributed to the specific temperature levels used in the treatments, which may not have been sufficient to trigger physiological changes. Moderate increases in incubation temperature likely did not surpass the threshold required to impact critical developmental processes in the embryos [23]. Additionally, the genetic composition of crossbred chickens may provide natural resilience to environmental variations. The male parent of the crossbred chickens is native chickens, which is known for its adaptability to thermal variation in tropical regions [24,25]. This trait likely enables crossbred chickens to sustain consistent embryonic development, even under the applied thermal programming conditions.

4 Conclusion

This study highlights that pre-hatch thermal programming had no adverse effect on key hatching traits such as hatching time and chick grade, making it a safe approach to be applied in crossbred chickens.

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