Effects of Chronic Heat Stress on Growth Performance, Meat Quality, and Blood Parameters in Yellow-Feathered Broilers: Postprint

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Abstract

This study aimed to investigate the effects of chronic heat stress on growth performance, meat quality, and blood parameters in yellow-feathered broilers. A total of 192 male yellow-feathered broilers at 35 days of age were randomly allocated to a control group and a chronic heat stress group, with 8 replicates per group and 12 birds per replicate. The control group was maintained at an ambient temperature of 26°C, whereas the chronic heat stress group was subjected to continuous heat stress at 34°C with relative humidity of approximately 55% for a duration of 14 days. The results demonstrated that, compared with the control group, chronic heat stress significantly reduced final body weight, average daily gain, and average daily feed intake ($P<0.05$), but did not significantly influence meat quality parameters ($P>0.05$). On day 3 of heat stress, serum aspartate aminotransferase (AST) activity in the chronic heat stress group was significantly elevated compared with the control group ($P<0.05$); on day 7, serum AST, alkaline phosphatase (AKP) activity, and core body temperature were significantly higher than those in the control group ($P<0.05$); on day 14, serum cholinesterase (CHE) activity was significantly lower than that in the control group ($P<0.05$), while alanine aminotransferase (ALT), AST, AKP, lactate dehydrogenase (LDH), and creatine phosphokinase (CPK) activities were significantly higher than those in the control group ($P<0.05$). In summary, chronic heat stress impairs growth performance and elevates the activities of enzymes indicative of liver function injury, yet does not significantly affect meat quality in yellow-feathered broilers.

Full Text

Effects of Persistent Heat Stress on Growth Performance, Meat Quality and Blood Indexes in Yellow-Feathered Broilers

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Abstract: This experiment investigated the effects of persistent heat stress on growth performance, meat quality, and blood indexes in yellow-feathered broilers. One hundred ninety-two 35-day-old male yellow-feathered broilers were randomly allocated to either a normal temperature group or a persistent heat stress group, with 8 replicates per group and 12 birds per replicate. The normal temperature group was maintained at 26°C, while the persistent heat stress group was exposed to continuous heat stress at 34°C. Relative humidity was maintained at approximately 55% throughout the 14-day experimental period.

The results showed that compared with the normal temperature group, persistent heat stress significantly reduced final body weight, average daily gain, and average daily feed intake ($P<0.05$), but did not significantly affect meat quality parameters ($P>0.05$). On day 3 of heat stress, serum aspartate aminotransferase (AST) activity in the persistent heat stress group was significantly higher than in the normal temperature group ($P<0.05$). On day 7, serum AST and alkaline phosphatase (AKP) activities and rectal temperature were significantly higher in the heat-stressed group ($P<0.05$). On day 14, serum cholinesterase (CHE) activity was significantly lower ($P<0.05$), while serum alanine aminotransferase (ALT), AST, AKP, lactate dehydrogenase (LDH), and creatine phosphokinase (CPK) activities were significantly higher in the persistent heat stress group compared to the normal temperature group ($P<0.05$). In summary, persistent heat stress impaired growth performance and elevated activities of enzymes indicative of liver function damage, but did not significantly affect meat quality in yellow-feathered broilers.

Keywords: yellow-feathered broilers; persistent heat stress; growth performance; meat quality; blood indexes

Introduction

Heat stress is a common phenomenon in livestock and poultry production that reduces feed intake and growth performance, alters meat quality and muscle composition, causes liver damage, suppresses immune function, and negatively impacts production and reproduction [1-3]. Understanding the mechanisms of heat stress injury is essential for developing mitigation strategies. Numerous studies have investigated heat stress effects on livestock and poultry. Al Wakeel et al. [4] reported that heat stress increased body temperature, reduced growth performance, caused liver damage, and induced immunosuppression in Ross 308 broilers. Dai et al. [5] found that cyclic heat stress decreased breast meat quality and altered muscle chemical composition in broilers. Zhong et al. [6] observed that cyclic heat stress increased body temperature and respiratory rate while reducing growth performance in yellow-feathered broilers.

Blood parameters change in response to cellular function and organ status, making them valuable indicators of tissue and organ damage. Jiang et al. [7] demonstrated that high temperature significantly affected blood indexes in yellow-feathered broilers. Yellow-feathered broilers are widely distributed in southern China. These birds have high feather coverage, relatively long production cycles, and are primarily raised in free-range systems with poor environmental control, making them highly susceptible to heat stress during summer. However, most heat stress research has focused on white-feathered broilers such as Ross 308, with limited studies on yellow-feathered broilers. Furthermore, varying heat stress protocols across studies limit the direct applicability of findings to yellow-feathered broiler production. Therefore, this study investigated the effects of persistent heat stress on growth performance, meat quality, and blood indexes in yellow-feathered broilers to provide insights and methodological support for mitigating heat stress damage in commercial production.

Experimental Design

1.1 Animals and Treatments

One hundred ninety-two 35-day-old male yellow-feathered broilers were purchased from Yangzhou Lihua Livestock and Poultry Co., Ltd. Birds with similar body weights were randomly assigned to either a normal temperature group or a persistent heat stress group, with 8 replicates per group and 12 birds per replicate. Both groups were fed a basal diet. The normal temperature group was maintained at 26°C, while the persistent heat stress group was exposed to continuous heat stress at 34°C. The experiment lasted 14 days, with samples collected on days 3, 7, and 14 of heat stress exposure. The basal diet was formulated and pelleted according to the Chinese Feeding Standard of Chickens (NY/T 33-2004). The composition and nutrient levels of the basal diet are presented in .

1.2 Animal Management

The experiment was conducted at the Yizheng Experimental Base of the Poultry Institute, Chinese Academy of Agricultural Sciences. Birds were housed in three-tier cages (120 cm × 80 cm × 60 cm length × width × height) and managed according to yellow-feathered broiler feeding standards. The environmental control chambers (Beijing Kulan Technology Co., Ltd.) maintained relative humidity at approximately 55%.

1.3 Sampling Metrics and Methods

On days 3, 7, and 14 of heat stress, two birds were randomly selected from each replicate for blood collection. Growth performance was recorded throughout the experimental period, and breast meat quality was evaluated.

1.3.1 Rectal Temperature Between 10:00 and 11:00 on days 3, 7, and 14, rectal temperature was measured in two birds per replicate using a digital animal rectal thermometer (HRQ-S2009, Zhengzhou Haorunqi Electronics Technology Co., Ltd.). Each bird was measured three times, and the average was recorded as the core body temperature.

1.3.2 Growth Performance Feed weight was recorded at each feeding. Body weight and residual feed weight were measured at the start of the experiment and before sampling to calculate average daily gain (ADG), average daily feed intake (ADFI), feed-to-gain ratio (F/G), and mortality rate.

1.3.3 Blood Indexes On days 3, 7, and 14, blood samples were collected from the wing vein of two birds per replicate using procoagulant tubes. After centrifugation, serum was separated and analyzed using a UniCel DxC 800 Synchron automatic biochemical analyzer (Beckman Coulter, USA) to determine activities of alanine aminotransferase (ALT), aspartate aminotransferase (AST), alkaline phosphatase (AKP), cholinesterase (CHE), lactate dehydrogenase (LDH), and creatine phosphokinase (CPK). Reagent kits were purchased from Zhongshan Biaojia Biotechnology Co., Ltd.

1.3.4 Meat Quality On day 14, left breast muscles were collected from two birds per replicate and stored at 4°C for meat quality analysis.

1.3.4.1 Water-Holding Capacity Approximately 0.5 g of fresh breast muscle was weighed and wrapped in one layer of gauze, sandwiched between 18 layers of filter paper on each side, and compressed to 35 kg for 5 minutes using a strain-controlled unconfined compression apparatus (YYW-2, Shengkewei Technology Co., Ltd., Tianjin). The post-compression weight was recorded to calculate drip loss. Moisture content was determined using proximate analysis, and water-holding capacity was calculated. Three muscle pieces were analyzed per sample, and the average value was recorded.

Drip loss (%) = 100 × (pre-compression weight - post-compression weight) / pre-compression weight
Water-holding capacity = 100 × [1 - (drip loss / moisture content)]

1.3.4.2 Meat Color Fresh breast muscle samples were analyzed using a CR-10 colorimeter (Konica Minolta, Japan) to determine lightness (L*), redness (a)*, and yellowness (b*) values. Each sample was measured three times, and average values were recorded.

1.3.4.3 pH at 24 Hours Fresh breast muscle samples were stored at 4°C for 24 hours. A small incision was made in the center of each sample, and pH was measured using a Leici PHS-2F digital pH meter (Yidian Scientific Instruments Co., Ltd., Shanghai). Each sample was measured three times, and the average was recorded as pH h.

1.3.4.4 Shear Force Fresh breast muscle samples were trimmed along the fiber direction into strips 1.0 cm wide and 0.5 cm thick. Shear force was measured using a C-LM2 muscle tenderness analyzer (Beijing Penglichixian Technology Co., Ltd., Beijing). Three muscle fiber strips were analyzed per sample, and the average value was recorded.

1.4 Statistical Analysis

Data were initially processed using Excel 2013. Univariate one-way ANOVA was performed using SPSS 20.0 software, with Duncan's multiple range test used for intergroup comparisons. Results are expressed as mean ± standard deviation. $P<0.05$ was considered statistically significant, and $P<0.10$ indicated a tendency toward significance.

Results

2.1 Effects of Persistent Heat Stress on Rectal Temperature

As shown in , rectal temperature on day 7 was significantly higher in the persistent heat stress group compared to the normal temperature group ($P<0.05$).

2.2 Effects of Persistent Heat Stress on Growth Performance

shows that after 14 days of persistent heat stress, final body weight, average daily gain, and average daily feed intake were significantly lower in the heat stress group ($P<0.05$), while feed-to-gain ratio was significantly higher ($P<0.05$).

2.3 Effects of Persistent Heat Stress on Meat Quality

indicates that the persistent heat stress group showed a tendency toward lower water-holding capacity and a* values compared to the normal temperature group ($P<0.10$).

2.4 Effects of Persistent Heat Stress on Blood Indexes

demonstrates that on day 3 of heat stress, serum AST activity was significantly higher in the persistent heat stress group ($P<0.05$), with a tendency toward increased LDH activity ($P<0.10$) and decreased CHE activity ($P<0.10$). On day 7, serum AST and AKP activities were significantly higher ($P<0.05$), with a tendency toward increased LDH activity ($P<0.10$). On day 14, serum ALT, AST, AKP, LDH, and CPK activities were significantly higher ($P<0.05$), while CHE activity was significantly lower in the heat stress group compared to the normal temperature group ($P<0.05$).

Discussion

3.1 Effects of Persistent Heat Stress on Rectal Temperature

Rectal temperature most accurately reflects core body temperature and is commonly used to assess thermal status [8]. During heat stress, metabolic rate increases through sympathetic nervous system activation and the hypothalamic-pituitary-adrenal (HPA) axis, elevating heat production while high ambient temperature reduces heat dissipation efficiency, resulting in increased body temperature [9]. Yuan et al. [10] reported that high environmental temperatures trigger physiological regulatory responses to maintain body temperature. Wen et al. [11] confirmed that body surface temperature serves as both an adaptive physiological response and a marker for evaluating heat stress. Bohmanova et al. [12] demonstrated that heat stress significantly elevated rectal temperature in dairy cows. In this study, rectal temperature was significantly higher in the persistent heat stress group only on day 7, differing from previous findings. This may be attributed to the relatively high thermotolerance of yellow-feathered broilers, which can regulate body temperature for a certain period. However, as heat stress persisted, regulatory capacity became insufficient to counteract environmental heat gain, leading to significantly elevated core temperature on day 7. By day 14, the birds may have gradually adapted to the thermal environment and established a new heat production-dissipation equilibrium, resulting in no significant difference between groups.

3.2 Effects of Persistent Heat Stress on Growth Performance

Feed intake is essential for animal survival and production, and adequate consumption is necessary to maximize genetic potential. Heat stress alters physiological functions, and with increasing stress intensity, metabolic disturbances can cause weight loss, immune suppression, and mortality [13]. Deng et al. [14] and Mashaly et al. [15] demonstrated that reduced feed intake is the primary cause of impaired growth performance under heat stress, directly decreasing body weight, feed efficiency, egg production, and egg quality. Sohail et al. [16] also reported that heat stress significantly reduced body weight and feed efficiency in 42-day-old broilers. Our findings show that persistent heat stress significantly decreased average daily gain and feed intake while increasing feed-to-gain

ratio, indicating reduced growth rate and feed utilization efficiency. These results align with previous studies and confirm that persistent heat stress impairs growth performance in yellow-feathered broilers.

3.3 Effects of Persistent Heat Stress on Meat Quality

Meat quality is commonly evaluated using tenderness, color, pH, and water-holding capacity, with pH directly influencing color and water-holding characteristics. High ambient temperatures cause metabolic disturbances, accelerated glycogenolysis, and lactic acid accumulation, resulting in reduced muscle pH. Yang et al. [17] reported that heat stress significantly decreased breast muscle a* values and relative weight in broilers. Li et al. [18] found that high temperature increased breast muscle L* values, drip loss, and shear force while decreasing a* values. In contrast, our results show that persistent heat stress did not significantly affect breast meat quality in yellow-feathered broilers, with only a tendency toward reduced water-holding capacity and a* values. This discrepancy may be due to breed differences, as the yellow-feathered broilers used in this study may possess greater environmental resistance and self-regulation capacity, enabling them to partially mitigate the negative effects of heat stress on meat quality.

3.4 Effects of Persistent Heat Stress on Blood Indexes

Blood parameters are widely used to reflect metabolic changes and organ function in heat stress research [19]. Activities of ALT, AST, and AKP are commonly used indicators of liver function. Under normal conditions, these enzymes are released into blood only in small amounts due to physiological cell turnover [20]. However, when hepatocytes are damaged and membrane permeability increases, enzyme release accelerates dramatically, markedly elevating serum enzyme activities. Cholinesterase degrades the excitatory neurotransmitter acetylcholine, while CPK activity reflects muscle cell damage. Wang et al. [19] reported that heat stress caused hepatocellular injury and increased serum ALT and AKP activities. Song [21] demonstrated that hot environments significantly elevated serum AST and ALT activities in laying hens. Our results show that serum AST activity was significantly higher in the heat stress group on day 3; AST and AKP activities were significantly elevated on day 7; and ALT, AST, AKP, LDH, and CPK activities were significantly higher on day 14, while CHE activity was significantly lower. These findings indicate that persistent heat stress caused hepatocellular damage and impaired liver function in yellow-feathered broilers, with enzyme activities increasing as heat stress duration extended, reflecting progressive liver damage. The significant difference in CPK activity also suggests some degree of muscle cell damage. These results are consistent with previous research demonstrating that persistent heat stress elevates serum enzyme activities associated with liver function impairment.

Conclusion

Persistent heat stress reduces growth performance and increases activities of enzymes indicative of liver function damage, but does not significantly affect meat quality in yellow-feathered broilers.

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Note: Figure translations are in progress. See original paper for figures.