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IMPACT OF HEAT STRESS ON GROWTH, CARCASS TRAIT, MEAT QUALITY AND SENSORY EVALUATION OF ABBOR AND COBB BROILER CHICKEN STRAINS

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ABSTRACT

This study evaluated the physiological responses, carcass characteristics, organ development, meat quality, and sensory attributes of Abbor Acre and Cobb 500 broiler chickens under heat stress. The experiment was conducted at the Department of Animal Science Teaching and Research Farm, University of Jos, Plateau State, Nigeria, using 120 day-old chicks assigned to four treatment groups in a completely randomized design, with exposure to either control (24°C) or heat stress conditions (35°C day/30°C night for six hours daily) from weeks 3 to 6 post-hatch. Birds were monitored for heart rate, respiratory rate, rectal temperature, growth performance, and carcass traits, while meat quality and sensory attributes were assessed post-slaughter. Results indicated that physiological responses showed no significant differences between strains, although Cobb 500 exhibited a slightly higher heart rate and rectal temperature, while Abbor Acre had a higher respiratory rate. Carcass and primal cut yields were comparable, with Abbor Acre showing heavier thighs and wings, whereas Cobb 500 had higher breast and back weights. Internal and external organ characteristics did not differ significantly, though Abbor Acre tended to have heavier visceral organs, while Cobb 500 had slightly heavier external body parts. Meat quality analysis revealed a significantly higher pH in Cobb 500 (6.20 vs. 6.02, $p = 0.006$), while oxidative rancidity and water-holding capacity were similar between strains. Sensory evaluation showed Cobb 500 scored higher in color and flavor, while Abbor Acre was rated better in juiciness and tenderness, with overall acceptability being equal (6.70) for both strains. In conclusion, both Abbor Acre and Cobb 500 broilers exhibit similar physiological, carcass, and organ responses under heat stress, with minor differences in meat quality and sensory traits.

Keywords: Heat stress, carcass trait, meat quality and sensory evaluation, abbor and cobb broiler chicken strains

INTRODUCTION

Poultry has undergone dramatic transformation over recent decades, driven by the global demand for affordable, high-quality animal protein. Broiler chickens, in particular, have been intensively selected for rapid growth, high feed efficiency, and superior carcass yield. While these advances have greatly improved productivity, they have also rendered modern broiler strains increasingly vulnerable to environmental stressors-chief among them, heat stress (Brugaletta *et al.,* 2022). Heat stress (HS), defined as a physiological condition where the bird cannot adequately dissipate excess body heat, arises when ambient temperatures exceed the thermoneutral zone for poultry. This challenge is especially acute in tropical and subtropical regions, where high temperatures and humidity prevail for extended periods each year (Nawaz *et al.,* 2021).

Broiler chickens are inherently susceptible to heat stress due to several physiological and anatomical factors. Unlike mammals, chickens lack sweat glands and rely primarily on panting and behavioral modifications to regulate body temperature. Their dense feather coverage, high body mass-to-surface area ratio, and elevated basal metabolic rate-traits accentuated by genetic selection for growth-further limit their capacity for heat dissipation (Brugaletta *et al.,* 2022 and Cartoni Mancinelli *et al.,* 2023). As a result, even moderate increases in environmental temperature can precipitate a cascade of behavioral, metabolic, and physiological changes that compromise both welfare and productivity.

The impact of heat stress on broiler chickens is profound and multifaceted, affecting nearly every aspect of growth and carcass quality. Numerous studies and meta-analyses have demonstrated that exposure to elevated temperatures significantly reduces feed intake (FI) and body weight gain (BWG) while increasing feed conversion ratio (FCR) and mortality rates (Liu *et al.,* 2020 and Apalowo *et al.,* 2024). For example, broilers subjected to heat stress consistently show lower weight gain and higher mortality compared to those reared under thermoneutral conditions, with some studies reporting a reduction in breast muscle mass by over 30% and a marked increase in fat deposition (Liu *et al.,* 2020 and Apalowo *et al.,* 2024). These physiological shifts are not solely attributable to reduced feed consumption; heat stress also disrupts hormonal balance, impairs protein synthesis, and alters lipid metabolism, leading to increased fat storage and diminished muscle accretion (Apalowo *et al.,* 2024).

Behavioral adaptations are among the earliest and most visible responses to heat stress. Broiler chickens exposed to high temperatures typically reduce their physical activity, spend more time resting, and increase behaviors aimed at dissipating heat, such as panting, wing elevation, and seeking cooler areas within their environment (Brugaletta *et al.,* 2022 and Cartoni Mancinelli *et al.,* 2023). These behavioral

changes are closely linked to physiological stress markers, including oxidative and inflammatory responses, as evidenced by altered blood parameters and increased protein oxidation in muscle tissues (Cartoni Mancinelli *et al.*, 2023). Chronic heat exposure further exacerbates these effects, leading to persistent reductions in meat quality, such as decreased water-holding capacity, altered pH, and increased tenderness-traits that can undermine consumer acceptance and market value (Cartoni Mancinelli *et al.*, 2023).

Importantly, the magnitude and nature of heat stress effects can vary significantly between broiler strains. Modern commercial broilers, bred for maximum growth and efficiency, often exhibit greater sensitivity to heat stress compared to slower-growing or native strains, which may possess adaptive traits conferring greater resilience (Cartoni Mancinelli *et al.*, 2023). Comparative studies have highlighted these genetic differences, noting that while all broilers experience some degree of performance decline under heat stress, the extent of growth suppression, carcass yield loss, and fat accumulation is often more pronounced in fast-growing commercial lines (Cartoni Mancinelli *et al.*, 2023).

The economic and welfare implications of heat stress in broiler production are substantial. Losses associated with decreased growth rates, inferior carcass traits, and increased mortality can erode profitability, while the compromised welfare of heat-stressed birds raises ethical and regulatory concerns. The poultry industry has responded with a range of mitigation strategies, including improved housing design, ventilation, and nutritional interventions, but these solutions are often costly and may not fully offset the detrimental effects of sustained high temperatures (Nawaz *et al.*, 2021 and Brugaletta *et al.*, 2022).

MATERIALS AND METHODS

Experimental Site

The experiment will be carried out at the Department of Animal Science Teaching and Research Farm, Faculty of Agriculture, Jos, Plateau State. Jos, Plateau State, Nigeria is a highland stand at an average height of 1,200 meters above sea level, and the State is covering about 5358 square kilometers with a population of 3,283,704 (NRC 1991). Plateau State is located in the middle belt zone of Nigeria between

latitudes 8'22' and 10'24' North and longitudes 8'22' and 10'24' East. The congenial weather in Plateau makes results comparable to Europe easily attainable and desirable for poultry production.

Arrival of Two Broiler Strains

The study involved two strains of broiler chickens, specifically strain A (Cobb 500) and strain B (Ross 308), which was sourced from a reputable hatchery. Upon arrival at the experimental facility, the chicks were acclimatized for one week under standard conditions to minimize stress before the commencement of the experiment. The chicks were housed in a controlled environment with adequate ventilation, temperature regulation, and lighting to ensure optimal growth conditions during the acclimatization period.

3.3 Experimental Design for the Two Broiler Strains Under Control and Heat Stress

A completely randomized design (CRD) will be employed for this study, consisting of four treatment groups:

1. Control group for strain A (normal temperature)
2. Heat stress group for strain A
3. Control group for strain B (normal temperature)
4. Heat stress group for strain B

3.4 Housing Conditions

Chickens were housed in an environmentally controlled poultry facility. The temperature was maintained at 22°C during the acclimatization period (first week), followed by a gradual increase to simulate heat stress conditions (32°C) for the subsequent three weeks. Humidity levels were kept constant at approximately 60%. Each group was housed in separate pens with adequate space to minimize stress from overcrowding.

Heat stress will be simulated by maintaining ambient temperatures at 35°C during the day and 30°C at night for a duration of six hours daily from weeks 3 to 6 post-hatch. The control groups were maintained at a standard temperature of approximately 24°C throughout the experiment.

Each treatment group consisted of three replicates with ten birds per replicate, totalling 120 birds in the study.

3.5 Management of the Two Strain Broilers

All birds were provided with ad libitum access to feed and water throughout the experimental period. The diet to used will be commercial feed, ensuring that all nutritional requirements were met for optimal growth performance. The feeding program included starter feed from weeks 1-3, grower feed from weeks 4-6, and finisher feed from weeks 7-8.

Birds were monitored daily for health status, behaviour, and any signs of heat stress such as panting or reduced activity levels. Biosecurity measures were strictly adhered to prevent disease outbreaks.

3.6 Physiological Measurements

Physiological responses were measured weekly during the heat stress period:

- **Body Temperature:** Cloacal temperatures were recorded using a digital thermometer.
- **Respiratory Rate:** The number of breaths per minute was counted for one minute after handling.
- **Heart Rate:** Heart rate was measured using a pulse oximeter placed on the comb.

3.7 Procedures Data Collection for All Growth Traits

Data collection commenced at week one post-hatch and continued until week eight. The following growth traits were measured weekly:

- **Body Weight Increase:** Individual body weights were recorded weekly using an electronic scale.
- **Thigh Length:** Measured from the hip joint to the knee joint using calipers.
- **Breast Length:** Measured from the breastbone tip to the end of the breast muscle.
- **Wing Length:** Measured from the shoulder joint to the wingtip.
- **Shank Length:** Measured from the hock joint to the footpad.

Carcass traits were evaluated after slaughtering birds at eight weeks of age:

- **Week Body Weight:** Recorded immediately post-slaughter.
- **Thigh Weight:** Weighed after removing feathers and skin.
- **Breast Weight:** Weighed after deboning.
- **Wing Weight:** Weighed after removal of feathers.
- **Shank Weight:** Weighed after cleaning.
- **Dressing Percentage (DP)**: Calculated as carcass weight divided by live weight multiplied by 100.
- **Breast Yield (BY), Thigh Yield (TY), Drumstick Yield (DY):** Weights taken post-slaughter from respective carcass parts
- **Feed Intake (FI):** Total feed consumed was recorded weekly.
- **Breast Yield (BY), Thigh Yield (TY), Drumstick Yield (DY):** Weights taken post-slaughter from respective carcass parts.

3.8 Data Analysis

Statistical analysis will be performed using SPSS version 26 software. Data were going to be subjected to analysis of variance (ANOVA) with a significance level set at $p < 0.05$. Post-hoc comparisons among treatment means were conducted using Tukey's HSD test when significant differences were detected. Correlations between growth traits and carcass traits were analysed using Pearson correlation coefficients to determine relationships between variables within each strain under both control and heat stress conditions.

RESULTS

Table 1 shows the physiological parameters of Abbor Acre and Cobb 500 broiler chickens exposed to heat stress. The physiological responses of Abbor Acre and Cobb 500 broiler chickens under heat stress showed some numerical differences, but none were statistically significant ($p > 0.05$). Cobb 500 broilers had a higher heart rate (167.00 bpm) compared to Abbor Acre (149.00 bpm)**,** suggesting a slightly greater cardiovascular response. In contrast, Abbor Acre had a higher respiratory rate (40.83 vs. 36.50 breaths/min)**,** indicating relatively more reliance on panting as a cooling mechanism. Rectal temperature was marginally higher in Cobb 500 **(**41.10°C**)** than in Abbor Acre **(**40.90°C), though this difference was not significant ($p = 0.181$).

Table 1: Physiological parameters of Abbor Acre and Cobb 500 broiler chickens exposed to heat stress

Parameters	Abbor Acre	Cobb 500	P-value
Heart rate (bpm)	149.00	167.00	0.437
Respiratory rate (breaths/min)	40.83	36.50	0.441
Rectal Temperature (°C)	40.90	41.10	0.181

Table 2 shows the carcass characteristics of Abbor Acre and Cobb 500 Broilers under Heat Stress. The carcass characteristics of Abbor Acre and Cobb 500 broilers under heat stress revealed no statistically significant differences ($p > 0.05$) across all measured parameters. Live weight was slightly higher in Abbor Acre (1726.40 g) compared to Cobb 500 (1708.42 g), while bled weight followed a similar pattern (1638.65 g vs. 1587.63 g**).** For defeathered weight**,** both strains showed nearly identical values (1583.50 g in Abbor Acre **vs.** 1579.63 g in Cobb 500**),** and eviscerated weight was marginally higher in Abbor Acre (1391.98 g**)** compared to Cobb 500 (1350.78 g**).** Similarly, dressed weight was higher in Abbor Acre (1143.70 g) than in Cobb 500 (1109.65 g), though the difference was not significant ($p = 0.676$). Dressing percentage was comparable between the two strains, with Abbor Acre at 66.24**%** and Cobb 500 at 65.35% ($p = 0.854$).

Table 2: Carcass characteristics of Abbor Acre and Cobb 500 broiler chickens exposed to heat stress.

Parameters (g)	Abbor Acre	Cobb 500	P-value
Live weight	1726.40	1708.42	0.817
Bled weight	1638.65	1587.63	0.477
Defeathered weight	1583.50	1579.63	0.961

Eviscerated weight	1391.98	1350.78	0.691
Dressed weight	1143.70	1109.65	0.676
Dressing percentage	66.24	65.35	0.854

Table 3 shows the primal cuts of Abbor Acre and Cobb 500 broiler chickens exposed to heat stress. The comparison of primal cuts between Abbor Acre and Cobb 500 broilers under heat stress showed no significant differences ($p > 0.05$), although Abbor Acre tended to yield heavier thighs (200.77 g vs. 171.47 g) and wings (156.28 g vs. 148.60 g), while Cobb 500 had higher back (269.50 g vs. 225.28 g) and breast weights (381.55 g vs. 368.87 g), with drumstick weights remaining nearly the same (167.32 g vs. 164.52 g), indicating that both strains produced comparable primal cuts with only slight variations in muscle distribution.

Table 3: Primal cuts of Abbor Acre and Cobb 500 broiler chickens exposed to heat stress.

Parameters (g)	Abbor Acre	Cobb 500	P-value
Thigh weight	200.77	171.47	0.143
Drumstick weight	167.32	164.52	0.795
Back weight	225.28	269.50	0.238
Breast weight	368.87	381.55	0.802
Wings weight	156.28	148.60	0.140

Table 4 shows the internal organs characteristics of Abbor Acre and Cobb 500 broiler chickens exposed to heat stress. The internal organ traits of Abbor Acre and Cobb 500 broilers exposed to heat stress did not differ significantly ($p > 0.05$), although numerical variations were observed. Liver weight was higher in Abbor Acre (27.05 g) compared to Cobb 500 (21.72 g, $p = 0.278$), while heart weights were nearly identical (5.92 g vs. 5.62 g, $p = 0.771$). Spleen weight was greater in Abbor Acre (2.02 g) than Cobb 500 (1.55 g, $p = 0.172$), and gall bladder weight followed a similar trend (1.93 g vs. 1.78 g, $p = 0.651$).

For the digestive organs, gizzard weight was slightly higher in Abbor Acre (75.63 g) compared to Cobb 500 (72.20 g, p = 0.768), but the empty gizzard weight was greater in Cobb 500 (57.32 g) than Abbor Acre (47.87 g, p = 0.219). Intestine weight was higher in Abbor Acre (86.25 g) than Cobb 500 (73.43 g, p = 0.196), while intestine length also showed a numerical advantage in Abbor Acre (209.67 mm) over Cobb 500 (197.50 mm, p = 0.090).

Table 4: Internal organs characteristics of Abbor Acre and Cobb 500 broiler chickens exposed to heat stress

Parameters (g)	Abbor Acre	Cobb 500	P-value
Liver weight	27.05	21.72	0.278
Heart weight	5.92	5.62	0.771
Spleen weight	2.02	1.55	0.172
Gall bladder weight	1.93	1.78	0.651
Gizzard weight	75.63	72.20	0.768
Empty gizzard weight	47.87	57.32	0.219
Intestine weight	86.25	73.43	0.196
Intestine Length (mm)	209.67	197.50	0.090

Table 5 shows the external organs characteristics of Abbor Acre and Cobb 500 broiler chickens exposed to heat stress. The external organ characteristics of Abbor Acre and Cobb 500 broilers under heat stress showed no statistically significant differences ($p > 0.05$). Head weight was slightly higher in Cobb 500 (52.42 g) compared to Abbor Acre (49.85 g, $p = 0.645$). Similarly, neck weight was greater in Cobb 500 (76.22 g) than in Abbor Acre (71.42 g**,** $p = 0.667$). Shank weight followed the same trend, with Cobb 500 recording 81.48 g compared to Abbor Acre at 75.02 g ($p = 0.475$).

Table 5: External organs characteristics of Abbor Acre and Cobb 500 broiler chickens exposed to heat stress.

Parameters (g)	Abbor Acre	Cobb 500	P-value
Head weight	49.85	52.42	0.645
Neck weight	71.42	76.22	0.667
Shank weight	75.02	81.48	0.475

Table 6: Meat quality of Abbor Acre and Cobb 500 broiler chickens exposed to heat stress.

Table 6 shows the meat quality of Abbor Acre and Cobb 500 broiler chickens exposed to heat stress. The meat quality traits of Abbor Acre and Cobb 500 broilers exposed to heat stress showed some differences, with only pH being statistically significant. Cobb 500 meat recorded a higher pH (6.20) compared to

Abbor Acre (6.02)**,** and the difference was significant (*p = 0.006*), suggesting a slower post-mortem glycolysis rate or differences in muscle metabolism between the strains. For oxidative rancidity, Cobb 500 showed a higher value (0.60 mg/g) compared to Abbor Acre (0.49 mg/g), but the difference was not significant (*p = 0.429*), indicating that both strains had comparable lipid stability under heat stress. Similarly, water-holding capacity (WHC**)** was nearly identical (55.56% in Abbor Acre vs. 54.17% in Cobb 500**,** *p = 0.872*), suggesting no major strain-related differences in moisture retention.

Table 6: Meat quality of Abbor Acre and Cobb 500 broiler chickens exposed to heat stress.

Parameters	Abbor Acre	Cobb 500	P-value
pH	6.02[b]	6.20[a]	0.006
Oxidative randicity (mg/g)	0.49	0.60	0.429
Water holding capacity (%)	55.56	54.17	0.872

[a,b] means in the same row not sharing superscript are significantly different at $p < 0.05$.

Figure 1 shows the sensory attribute of Abbor Acre and Cobb 500 broiler chickens exposed to heat stress. The assessment of meat quality parameters revealed a significant difference in pH, where Cobb 500 meat recorded a higher value (6.20) compared to Abbor Acre (6.02) ($p = 0.006$). This difference suggests a slower rate of post-mortem glycolysis in Cobb 500, which may influence meat color stability and shelf-life. However, oxidative rancidity was slightly higher in Cobb 500 (0.60 mg/g) than in Abbor Acre (0.49 mg/g), though not significant ($p = 0.429$). Similarly, water-holding capacity (WHC) was comparable between the two strains (55.56% in Abbor Acre vs. 54.17% in Cobb 500, $p = 0.872$), indicating no substantial difference in moisture retention.

In terms of sensory attributes, Cobb 500 meat was rated higher in color (6.65 vs. 5.40) and flavor (4.80 vs. 4.15), while both strains scored similarly in aroma (5.40 vs. 5.20). On the other hand, Abbor Acre was rated higher in juiciness (6.40 vs. 6.20) and tenderness (6.60 vs. 5.90). Interestingly, despite these differences in specific traits, overall acceptability was the same (6.70) for both strains, indicating that

consumers found both equally acceptable under heat stress conditions.

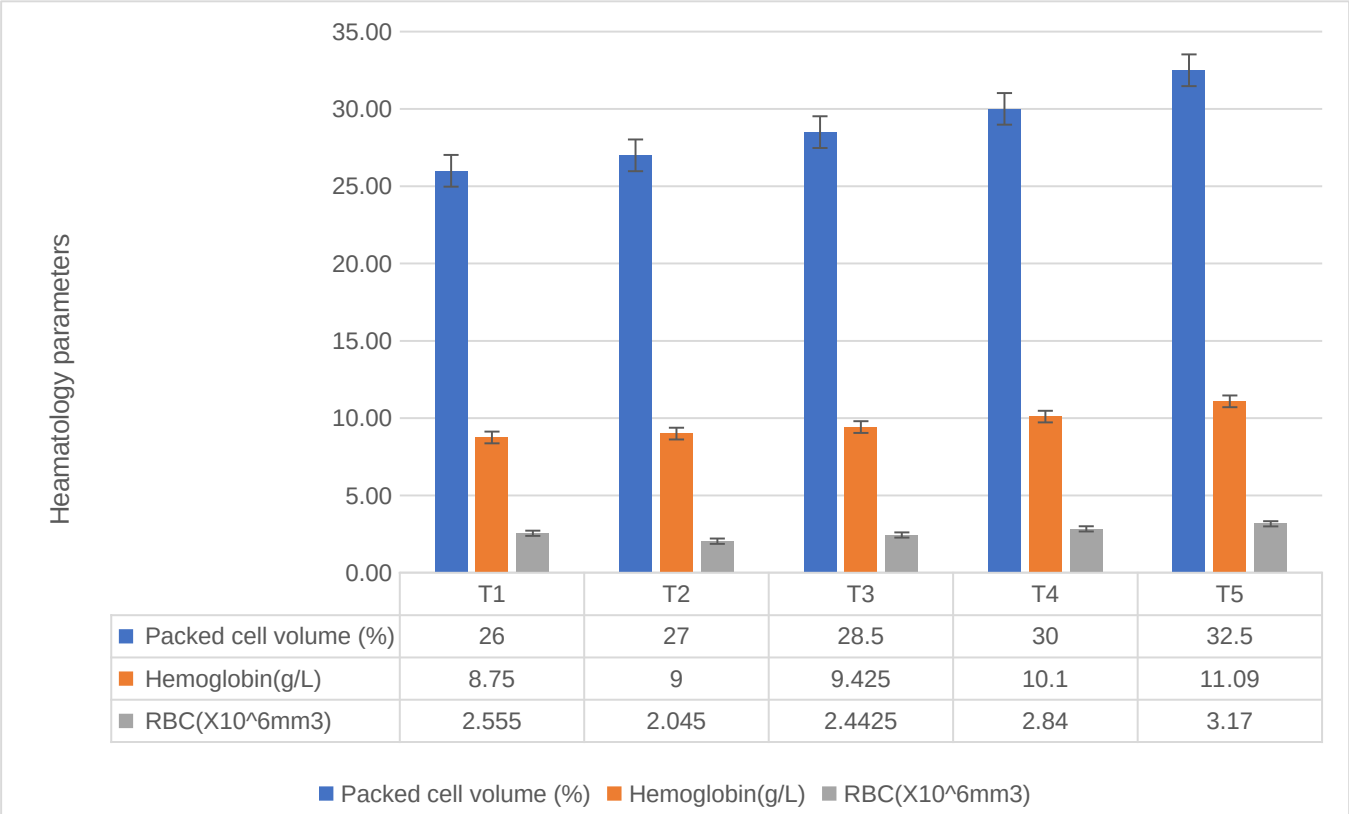


Figure 1: Sensory attribute of Abbor Acre and Cobb 500 broiler chickens exposed to heat stress.

DISCUSSION

Under heat stress conditions, the comparative evaluation of Abbor Acre and Cobb 500 broiler strains revealed largely similar physiological, carcass, internal and external organ, as well as meat quality traits, with most differences not reaching statistical significance. Although Cobb 500 broilers exhibited a numerically higher heart rate indicative of slightly elevated cardiovascular response, and Abbor Acre showed a higher respiratory rate suggestive of increased reliance on panting for thermoregulation, these variations were not significant ($p > 0.05$). The marginally higher rectal temperature observed in Cobb 500 ($p = 0.181$) may imply a somewhat greater metabolic heat load or reduced thermoregulation efficiency, consistent with previous research highlighting strain-specific heat stress responses (Lara & Rostagno, 2013). Carcass parameters including live weight, dressed weight, and dressing percentage were comparable between strains, indicating similar growth performance and carcass yield under heat stress, in agreement with findings from Sahin *et al*. (2009) who reported negligible breed differences in carcass traits under thermal challenge.

Primal cut analysis demonstrated minor numerical differences, with Abbor Acre tending to have heavier thighs and wings, and Cobb 500 showing slightly higher back and breast weights; however, none showed statistical significance, reflecting similar muscle fiber distribution and growth patterns during heat stress (Nascimento *et al*., 2020). Internal organ analyses showed that Abbor Acre broilers had higher liver, spleen, gizzard, and intestine weights and length, while Cobb 500 had a heavier empty gizzard and head weight; these moderate differences likely reflect potential strain-specific physiological adaptations to thermal stress but did not translate into significant variation (Sahin *et al*., 2009).

Meat quality evaluations identified a significant difference in pH ($p = 0.006$), with Cobb 500 meat exhibiting a higher value that suggests slower postmortem glycolysis and potentially more favorable meat color stability and shelf-life (Zhao *et al*., 2019). Despite Cobb 500 showing a slightly higher oxidative rancidity value ($p = 0.429$), lipid stability was comparable across strains. Water-holding capacity was nearly identical, indicating similar moisture retention ability, which is crucial for juiciness and processing yield (Soglia *et al*., 2016). Sensory assessments revealed that while Cobb 500 meat scored better for color and flavor, Abbor Acre meat was preferred for juiciness and tenderness, with both strains receiving equal scores for overall acceptability, suggesting that consumer preference under heat stress may balance these sensory differences (Mateescu *et al*., 2015).

CONCLUSION

This study shows that Abbor Acre and Cobb 500 broiler strains exhibit comparable physiological responses, carcass performance, organ development, and meat quality characteristics when exposed to heat stress, with only minor strain-related variations. The significant difference observed in meat pH indicates some metabolic divergence, but similar sensory acceptability suggests both strains are suitable for hot environments, each providing distinct meat quality attributes.

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