CORRELATION OF *IGF-1* GENE EXPRESSION AND CARCASS CHARACTERISTICS IN HEAT-STRESSED SAGA, SASSO, AND COBB 500 CHICKENS

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ABSTRACT

This study investigated the correlation between Insulin-like Growth Factor 1 (IGF-1) gene expression and carcass characteristics in three commercial chicken breeds (SAGA, Sasso, and COBB 500) exposed to heat stress (HS) (34 °C) in a controlled environment from two weeks of age to four weeks. Birds were subjected to controlled heat stress, and IGF-1 gene expression in breast muscle (Pectoralis major) was measured using qPCR. Carcass weights, including breast muscle, drumstick, thigh, shank, and wing weights, were assessed. qPCR was performed, and the Ct values were collected and correlated with relative carcass weight values. Results revealed varying relationships between IGF-1 expression and carcass traits within and across breeds. In SAGA chickens, IGF-1 showed a weak positive correlation with carcass weight (r = 0.26) and a moderate negative correlation with breast muscle weight (r = -0.48); other traits showed weak correlations. Sasso chickens exhibited a weak negative correlation with carcass weight (r = -0.116) and weak positive correlations with other traits. Conversely, COBB 500 chickens demonstrated strong negative correlations between IGF-1 and carcass weight (r = -0.74), breast muscle weight (r = -0.60), and other carcass traits, suggesting a negative impact of IGF-1 expression on carcass traits under heat stress. The differing patterns in SAGA and Sasso chickens compared to COBB 500, emphasized the role of genetic background in HS responses. These insights enhance the understanding of heat tolerance mechanisms and can guide targeted breeding strategies for better poultry production in HS conditions.

Keywords: *IGF-1*, Gene Expression, Carcass Characteristics, Heat Stress, Diverse Chickens

INTRODUCTION

Heat stress adversely affects the production and signalling of IGF-1 in chickens, resulting in diminished muscle development, changes in carcass traits, and meat composition, and a decline in meat quality (Uyanga et al. 2022). Insulin-like growth factor-1 (IGF-1), a key regulator of growth and metabolism in chickens, plays a critical role in mediating growth hormone action and influencing muscle development, fat deposition, and overall carcass characteristics (Li et al. 2021). Heat stress can disrupt IGF-1 expression, consequently affecting carcass traits like weight, muscle yield, and fat distribution (Dalólio et al. 2024) While some studies suggest that elevated temperatures can decrease IGF-1 expression, potentially leading to adverse effects on growth and carcass quality the precise relationship between IGF-1 gene expression and carcass traits under heat stress remains complex and breed-dependent.

This study focuses on the selection of three chicken breeds with distinct genetic backgrounds and growth characteristics: SAGA, Sasso, and COBB 500. SAGA chickens, known for their adaptability to local environments, may exhibit different heat stress responses. compared to the fast-growing, commercially optimised COBB 500 breed. The COBB 500 broiler breed is preferred for its accelerated growth rate, efficient feed utilization, and high meat yield (Collins et al. 2014; Pandit et al. 2024). Sasso chickens, a dual-purpose breed (Aman et al. 2017), offer another valuable perspective on the interplay between heat stress, IGF-1 expression, and carcass traits (Uyanga et al. 2022). Understanding the correlation between IGF-1 gene expression and carcass characteristics in these diverse breeds under heat stress is crucial for developing effective breeding strategies to enhance thermotolerance and improve meat production in challenging thermal environments.

This research aimed to examine the relationship between insulin-like growth factor 1 (*IGF-1*) gene expression levels and commercially important carcass traits in heat-stressed SAGA, Sasso, and COBB 500 broiler chickens. By characterizing breed-specific responses to thermal stress, the study aims to elucidate the molecular mechanisms governing variations in growth performance and meat quality. The resulting data may inform the development of breed improvement programs, nutritional strategies, and environmental management protocols designed to ameliorate the negative impacts of heat stress and enhance poultry production efficiency in tropical and subtropical climates.

MATERIALS AND METHODS

The Animal Ethics Committee of the Malaysian Agricultural Research and Development Institute (MARDI) approved the experimental procedures (approval number 20230622/R/MAEC00127). The research was conducted at the Animal Research Unit of the Institute of Tropical Agriculture and Food Security (ITAFoS), Universiti Putra Malaysia (UPM), adhering to standard management protocols. A total of 150 chicks, with 50 from each breed, were used in this study. At two weeks of age, after the brooding period, the breeds were divided into five replicates of ten animals each and exposed to heat stress (HS) 34ºC for 6 hours daily for 28 days in a controlled environment. They were housed in battery cages measuring 122 cm × 91 cm × 61 cm and provided *ad libitum* access to a commercial broiler diet and water.

Slaughter and sample collection

Slaughter was conducted under Halal procedures at the Universiti Putra Malaysia Animal Science Department's slaughter Unit. Fifty birds per breed were stratified into five replicates of 10. Two birds per replicate were randomly selected for slaughter. Carcasses were dissected to fit size for analyses, relative values were calculated, and tissue samples for qPCR (*pectoralis major*) were collected in 2 mL microtubes, immediately flash-frozen in liquid nitrogen, and kept at -80°C until RNA extraction.

RNA Extraction and cDNA Synthesis:

Total RNA was extracted from Pectoralis major tissues using the PrimeWay Total RNA Extraction Kit (JTC MedTech Hub, Singapore) following the manufacturer's protocol. Eluded RNA was stored at -80°C. Complementary DNA (cDNA) was synthesized using the RevertAid First Strand cDNA Synthesis Kit (Thermo Scientific, USA).

Primers Sequence

IGF-1 primers (Nawaz et al. 2023) were used for qPCR analysis of mRNA expression.

Table 1: **Gene Primer Sequences**

Genes		Primer Sequence (5'-3')	Annealing Temp. (ºC)	Product Length (bp)
IGF-1	F:	5'-ACCTTGGCCTGTGTTTGCTTAC-3'	58	111
	R:	5'-AGCCTCTGTCTCCACATACGAAC-3'		
GAPDH	F:	5'-GAGGGTAGTGAAGGCTGCTG-3'	58	113
	R:	5'-CATCAAAGGTGGAGGAATGG-3'		

Note: *IGF-1* = insulin growth factor-1, *GAPDH* = Glyceraldehyde 3-phosphate dehydrogenase, and Temp. = Temperature.

qPCR Analysis

qPCR was performed using a 20 µl reaction mixture containing a cDNA template, gene-specific primers, and SYBR Green qPCR mix (Fisher Scientific, UK). The protocol included an initial denaturation at 94°C for 3 minutes, followed by cycles of denaturation at 94°C for 10 seconds and annealing at 58°C for 30 seconds. GAPDH, selected for its stability under heat stress, served as the reference gene for normalization.

Experimental Design and Statistical Analyses

A complete Randomized Design (CRD) was used, the relative carcass trait values and the qPCR-derived Ct values were collected, and a Correlation analysis was conducted using MS Excel (Microsoft 365).

RESULTS AND DISCUSSION

The results presented in Tables 2, 3, and 4 reveal intricate relationships between heat stress, IGF-1 expression, and carcass traits in different chicken breeds, underscoring the need for targeted strategies to mitigate the adverse effects of thermal stress on poultry production. In SAGA chickens (Table 2), a weak positive correlation (r = 0.26) was observed between IGF-1 and carcass weight (CW), suggesting a potential stimulatory role of IGF-1 in overall growth, even under heat stress.

Table 2: Correlations Between IGF-1 and Relative Carcass Characteristics in SAGA Chickens under heat stress

	IGF-1	CW	BM	BC	TW	DR	WW	SW
IGF-1	1							
CW	0.26	1						
BM	-0.48	-0.43	1					
BC	-0.08	0.14	0.09	1				
TW	-0.06	0.54	-0.074	0.31	1			
DW	0.16	0.26	0.049	0.264	0.71	1		
WW	-0.01	0.42	-0.24	-0.065	0.54	0.33	1	
SW	0.11	0.48	-0.33	0.067	0.44	0.42	0.41	1

Note: IGF-1 (Insulin-like Growth Factor-1), CW (Carcass Weight), BM (Breasts Muscle), BC (Back cut), TW (Thighs), DW (Drumstick Weight), WW (Wings), and SW (Shank Weight)

Table 3: Correlations Between IGF-1 and Relative Carcass Characteristics in Sasso Chickens under heat stress.

	IGF-1	CW	BM	BC	TW	DR	WW	SW
IGF-1	1							
CW	0.116	1						
BM	0.012	0.709	1					
BC	0.305	0.568	0.551	1				
TW	0.092	0.895	0.774	0.686	1			
DW	-0.002	0.895	0.780	0.605	0.883	1		
WW	0.302	0.732	0.630	0.646	0.789	0.670	1	
SW	0.237	0.704	0.540	0.698	0.816	0.732	0.908	1

Note: IGF-1 (Insulin-like Growth Factor-1), CW (Carcass Weight), BM (Breasts Muscle), BC (Back cut), TW (Thighs), DW (Drumstick Weight), WW (Wings), and SW (Shank Weight).

Table 4: Correlations Between IGF-1 and Relative Carcass Characteristics in Cobb Chickens under heat stress

	IGF-1	**CW**	**BM**	**BC**	**TW**	**DR**	**WW**	**SW**
IGF-1	1							
CW	-0.24	1						
BM	-0.60	0.50	1					
BC	-0.26	0.72	0.84	1				
TW	0.32	0.25	0.15	0.37	1			
DW	-0.45	0.50	0.97	0.86	0.31	1		
WW	-0.73	0.36	0.68	0.48	-0.55	0.52	1	
SW	-0.57	0.77	0.90	0.88	0.21	0.87	0.67	1

Note: IGF-1 (Insulin-like Growth Factor-1), CW (Carcass Weight), BM (Breasts Muscle), BC (Back cut), TW (Thighs), DW (Drumstick Weight), WW (Wings), and SW (Shank Weight).

This aligns with the established role of IGF-1 in promoting growth and development (Ahmad et al., 2020). However, the weak nature of this correlation implies that heat stress may partially blunt IGF-1's growth-promoting effects. Notably, a moderate negative correlation (r = -0.48) between IGF-1 and breast muscle weight (BM) was found, which may reflect heat stress-induced metabolic shifts. Under thermal stress, resources may be reallocated from muscle protein synthesis to survival mechanisms, as suggested by Sanni (2024), potentially explaining the reduced breast muscle mass despite elevated IGF-1 levels.

In Sasso chickens (Table 3), the correlations between IGF-1 and carcass traits were generally weaker compared to SAGA chickens. For instance, IGF-1 showed a weak positive correlation with CW (r = 0.116) and no significant correlation with BM (r = 0.012). However, stronger correlations were observed among carcass traits themselves, such as between CW and BM (r = 0.709) and between CW and TW (r = 0.895). This suggests that while IGF-1 may have a limited direct influence on individual carcass traits under heat stress, other factors or interactions between traits may play a more significant role in determining carcass composition. The weak positive correlation between IGF-1 and shank weight (SW) (r = 0.237) aligns with IGF-1's known role in bone growth (Sanni, 2024), but the overall weak associations highlight the complexity of these relationships under thermal stress.

In Cobb chickens (Table 4), the correlations between IGF-1 and carcass traits were more pronounced but varied in direction. A strong negative correlation (r = -0.60) was observed between IGF-1 and BM, further supporting the hypothesis that heat stress disrupts IGF-1's growth-promoting effects, particularly in breast muscle development. Additionally, IGF-1 showed negative correlations with CW (r = -0.24), DW (r = -0.45), and WW (r = -0.73), indicating that heat stress may significantly alter IGF-1's role in regulating these traits. However, positive correlations were noted between IGF-1 and TW (r = 0.32) and between IGF-1 and SW (r = -0.57), suggesting that IGF-1's influence may vary across different carcass components.

CONCLUSION

These findings emphasize the need for further research to elucidate the molecular mechanisms underlying IGF-1's interactions with heat stress and its impact on carcass traits, as well as to explore strategies for optimizing IGF-1 signaling to improve poultry production under high-temperature conditions.

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