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POTENTIAL OF BROCCOLI LEAF MEAL FOR REDUCING HEAT AND ALTERING BEHAVIOR IN BROILER CHICKENS

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Abstract
This research examined the efficacy of broccoli leaf meal (BLM) in decreasing heat stress and modifying behaviors in broiler chickens. Five treatment diets were created for the broilers, incorporating different amounts of BLM: 0% (control), 2.5% (A1), 5% (A2), 2.5% (B1), and 5% (B2). In the A1 and A2 diets, BLM was added without changing other ingredients, while in B1 and B2, adjustments were made to keep crude protein and energy levels comparable to the control diet. A total of 150 day-old unsexed broiler chicks were allocated to five treatment groups, with each group containing three replicates of ten chicks each. Over the course of 42 days, the chicks' body temperatures were measured daily along with behavioral assessments. The findings indicated that a diet with 5% BLM, without protein adjustments, was more effective in lowering heat than the control diet, while the 5% BLM diet with protein adjustments also provided some reduction, albeit less effectively. The significant drop in body temperature for birds on the unadjusted protein diet resulted in less stress, as indicated by the absence of panting and unchanged activity levels, suggesting that BLM is effective in lower protein diets and a 5% inclusion is advisable.

***Keywords*: broccoli leaf, broiler chickens, heat reduction, behavioral, body temperature**

Introduction

Like mammals, birds are endothermic (warm-blooded) and maintain a consistent body temperature independent of the environment, typically ranging from 37.7 to 43.5°C (Yakubu *et al*., 2020), which is higher than the 36-39°C range in mammals (Jones and Adams, 2022). Birds regulate their temperature to minimize heat loss in cold conditions and to avoid excess heat in warm environments (Yakubu *et al*., 2020). Panting is the primary method of heat loss, with breathing rates soaring under high temperatures. Other heat reduction responses include gular fluttering, which contributes significantly to cooling in chickens (Yakubu *et al*., 2020). Heat stress occurs when a bird's core temperature rises dangerously high due to inadequate heat loss, leading to behavioral changes such as decreased feeding or increased water intake. High temperatures can lead to heat stroke and substantial mortality unless conditions are mitigated by improved airflow, evaporative cooling, and adequate water supply (Adeyemi and Peters, 2021; 2022).

Broiler behavior is largely shaped by genetics, environmental factors, and management practices (Jeffery *et al*., 2003). Abnormal behaviors exhibited by broilers during high temperatures, including panting and lethargy, are signs of severe heat stress and indicate that the chickens are attempting to cope with the stress. Broilers are particularly susceptible to heat stress due to their rapid growth, high metabolic heat production, and lack of sweat glands, which can lead to detrimental effects if not addressed promptly. Reducing feed respectively is a primary strategy to alleviate heat stress rather than increasing it (Jeffery *et al*., 2003; Jones and Adams, 2022; Sudik *et al*., 2024a&b). Heat generation in broilers arises from basal metabolism and the heat increment associated with feeding, particularly when digesting protein.

Plants consist of two types of compounds: primary metabolites, vital for life, and secondary metabolites, which, while not essential, enhance a species' ability to thrive (Winkel-Shirley, 2001). Secondary metabolites also help plants deal with various stresses and can provide health benefits to humans. One notable example is glucosinolates found in cruciferous vegetables, including broccoli. When glucoraphanin, a glucosinolate in broccoli, interacts with the enzyme myrosinase, it produces sulfuraphane that activates the body's antioxidant defenses, aiding in detoxifying harmful substances (James *et al*., 2012; Jeffery *et al*., 2003). Understanding the potential of broccoli leaves for reducing heat stress and influencing behavior in broiler chickens is essential.

Material and methods

Mature broccoli leaves were harvested, air-dried, ground, and processed into broccoli leaf meal (BLM) for nutrient analysis. BLM's composition was evaluated at the Central Laboratory of Federal University, Gashua, following established protocols (AOAC, 2005). Nutrient levels, including various minerals, were measured using an atomic absorption spectrophotometer, Five treatment diets for the broilers were created with varying different percentages of BLM: 0% (control), 2.5% (A1), 5% (A2), 2.5% (B1), and 5% (B2). In A1 and A2, BLM was added without altering other ingredients, while in B1 and B2, adjustments were made to match crude protein and energy levels to the control. A total of 150 day-old ROSS 308 broiler chicks were evenly distributed across the five treatment groups, each consisting of three replicates of ten chicks. Chicks had ad libitum access to feed and water, while anti-stress and antibiotic treatments were administered during the initial days, along with vaccinations against Gumboro and Newcastle diseases. The study lasted for 42 days, during which body temperatures, water intake, and behavioral changes were recorded daily

Results and Discussion

Table 3 presents the average body temperature (ºC) of broiler chickens that were fed diets supplemented with varying levels of broccoli leaf meal (BLM). Significant differences in body temperature were observed across treatments over the week, except in the first week, where no significant difference was noted (p>0.05). The birds on the control diet consistently exhibited the highest body temperatures, followed by those on the 2.5% BLM diet (both unadjusted and. adjusted protein). In contrast, those receiving the 5% BLM diet (both unadjusted and adjusted

Table 1: Ingredients and composition of the experimental starter

Ingredients (%)	Control	A1	A2	B1	B2
Maize	50.05	50.05	50.05	49.35	49.50
Wheat offal	8.00	6.00	4.00	6.25	4.50
Broccoli leaf meal	0.00	2.50	5.00	2.50	5.00
Full fat soybeans	20.05	20.05	20.05	21.05	21.60
Groundnut cake	11.50	11.00	11.00	11.00	10.00
Fish meal	4.00	4.00	4.00	4.00	3.50
Bone meal	3.00	3.00	3.00	3.00	3.00
Limestone	1.50	1.50	1.50	1.00	1.00
Premix*	0.25	0.25	0.25	0.25	0.25
Lysine	0.25	0.25	0.25	0.25	0.25
Methionine	0.15	0.15	0.15	0.15	0.15
Common salt	0.25	0.25	0.25	0.25	0.25
Vegetable oil	1.00	1.00	0.50	0.95	1.00
Total	**100**	**100**	**100**	**100**	**100**
Crude protein (%)	22.56	22.36	22.06	22.56	22.56
Energy (kcal/kg)	3187.08	3197.13	3181.34	3201.00	3199.37

protein) had lower body temperatures, with the unadjusted protein group showing the lowest levels.

Table 4 outlines the behavioral changes in the experimental broilers. The birds on the control diet and those receiving the 5% BLM with adjusted protein exhibited the most distressing behaviors, which included panting, wing spreading, inactivity, crowding around water sources, and wet droppings. Those consuming the 2.5% BLM with unadjusted protein and the 5% BLM with adjusted protein demonstrated fewer of these behavioral changes.

Broilers, like all birds and mammals, are homeothermic, meaning they actively manage their internal body temperature (Olaniyi *et al.*, 2022). Birds can maintain a constant deep body temperature within a specific range of environmental temperatures. Deviations from this thermoneutral zone lead to increased heat production (Peteira *et al.*, 2023). Thermoneutrality refers to conditions where birds do not expend energy to regulate body heat. When air temperatures drop below 16.6°C, heat production in birds rises; if temperatures drop too low, they cannot maintain heat and may die. Conversely, at temperatures above 27.5°C (with some species tolerating up to 38°C), birds struggle to dissipate heat, leading to heat stress and a higher risk of mortality. Heat stress poses a greater danger to birds than cold stress (Smith *et al.*, 2023). This study aimed to investigate whether bioactive compounds in broccoli leaf could assist in regulating body temperature. The observed decrease in body temperature with increased levels of broccoli leaf in the diet suggests the presence of compounds in the leaves that help regulate temperature, with a significant reduction noted at 5% BLM without protein adjustment. This effect may be partly due to protein levels since high-protein diets generate more heat.

Table 2: Ingredients and composition of the experimental finisher

Ingredients (%)	Control	A1	A2	B1	B2
Maize	52.55	52.05	50.05	52.00	51.25
Wheat offal	8.00	7.00	7.00	7.00	5.50
Broccoli leaf meal	0.00	2.50	5.00	2.50	5.00
Full fat soybeans	17.50	17.00	17.00	18.55	19.35
Groundnut cake	12.10	12.10	12.00	10.10	10.00
Fish meal	3.45	3.45	3.05	3.45	3.00
Bone meal	3.00	3.00	3.00	3.00	3.00
Limestone	1.00	1.00	1.00	1.00	1.00
Premix*	0.25	0.25	0.25	0.25	0.25
Lysine	0.25	0.25	0.25	0.25	0.25
Methionine	0.15	0.15	0.15	0.15	0.15
Common salt	0.25	0.25	0.25	0.25	0.25
Vegetable oil	1.50	1.00	1.00	1.50	1.00
Total	**100**	**100**	**100**	**100**	**100**
Crude protein (%)	20.75	20.37	20.49	20.76	20.76
Energy (kcal/kg)	2957.18	2957.18	2957.18	2957.18	2957.18

Practically, providing less feed during the hottest parts of the day can help minimize heat production associated with feeding (Johnson and Williams, 2023), and improving airflow can significantly reduce instances of heat stress (Adeyemi and Peters, 2022; Osei *et al.*, 2023). Reduced digestive activity results in less internal heat production, which enables birds to maintain their core body temperature more easily. Sudik *et al.* (2024b) found that incorporating BLM into diets positively affected performance, carcass quality, hematology, and serum metabolites in broiler chickens. Birds often decrease their voluntary feed intake by 10-30% in heat, an instinctive survival response that lowers metabolic rates and affects overall performance. The adaptation to BLM may enhance activities such as feeding, dust-bathing, and play. Observations of heat stress such as panting and wing spreading— along with reduced feed intake in the control and 5% BLM unadjusted protein groups suggest that the control diet lacked compounds to manage body heat effectively, or that the proportions in the 5% BLM diet were insufficient

Table 3: Average Body temperature (ºC) of the experimental birds

Age (weeks)	Control 1	A1	A2	B1	B2	±SEM	p-value
1	41.30	41.30	41.20	41.30	41.30	0.40	0.999
2	41.80^{a}	41.40^{a}	39.51^{c}	40.70^{b}	40.10^{bc}	0.50	0.064
3	41.70^{a}	41.40^{a}	40.10^{c}	40.71^{b}	40.14^{c}	0.50	0.011
4	41.70^{a}	41.40^{a}	39.66^{c}	40.56^{b}	40.10^{b}	0.48	0.071
5	42.10^{a}	41.30^{a}	40.00^{c}	40.60^{b}	40.10^{bc}	0.48	0.044
6	42.30^{a}	41.80^{a}	40.00^{c}	40.69^{b}	40.10^{bc}	0.43	0.081

T1 (Control) = 0% BLM, A1=2.5% BLM (unadjusted protein), A2=5% BLM unadjusted protein, B1=2.5% BLM (adjusted protein) and B2= 5% BLM (adjusted protein).
Values in the same row not sharing common superscript are significantly different (p<0.05).
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Table 4: Behavioral changes of the experimental birds

Parameters	Control	A1	A2	B1	B2
Panting	+++	++	+	+++	++
Wing spreading and drooping	+++	++	+	+++	++
Reduced activity	+++	++	+	+++	++
Crowding around drinkers	+++	++	+	+++	++
Wet droppings	+++	+	+	+	+

T1 (Control) = 0% BLM, A1=2.5% BLM (unadjusted protein), A2=5% BLM unadjusted protein, B1=2.5% BLM (adjusted protein) and B2= 5% BLM (adjusted protein).

Conclusion

The findings indicated that the 5% BLM in unadjusted protein diets significantly lowers body temperature compared to both the control diet and the 5% BLM in adjusted protein diets, though the latter still provided some heat reduction. The decreased body temperature in birds consuming the 5% BLM unadjusted protein diet correlated with reduced distress, as these birds did not exhibit panting or reduced activity. Thus, it can be concluded that BLM is effective in low-protein diets, with the recommendation of a 5% inclusion rate.

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