



Research Article

Effect of Strains and Clove Supplemented Diet on Adaptability and Meat Quality Traits of Meat Type of Broiler Chickens under Heat Stress Condition

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Received: 27th February, 2024

Accepted: 28th March, 2024

Published: 31st March, 2024

ABSTRACT

The study was carried out to evaluate the effect of clove administration on the behavioural and meat quality traits of two broiler strains of chickens. A total of ninety-six (96) day old forty-six (46) Arbor Acre and forty-six (46) Cobb 500 of broiler chickens were used for this study. Arbor Acre and Cobb 500 were given feed supplemented with clove (400mg/kg diet) under heat stress of an average temperature of 44 °C. Their control was fed a diet free from clove. Data were collected on behavioural changes, organoleptic tests, drip loss, cooking loss, pH, and mortality rate. Our results revealed that irrespective of strains, the clove-treated chickens revealed acceptable meat organoleptic evaluation better than the non-clove chickens. There was a significant ($p < 0.05$) effect of strains on cooking loss, where Arbor acre revealed lower cooking loss than Cobb broiler chicken. No significant ($P > 0.05$) effect of treatments on drip loss was obtained. There was a significant ($P > 0.05$) effect of treatments on pH. Normal behavioural dispositions were observed in the clove-treated chickens. Reduced mortality was recorded in the chicken-fed clove. Clove improved the heat tolerant capacity of the Arbor acre and Cobb broiler strains. Therefore, it is concluded that strains and clove affected the meat quality traits of the chicken. Clove on the other hand could be used to improve broiler behavioural disposition, meat quality traits, and adaptability to heat stress conditions of strains of broiler chicken.

Keywords: Broiler chickens; clove supplementation; meat quality traits; mortality rate

Citation: Badmus, K. A., Abdullahi, A., Ahmad, A. T., Muntaka, A., Shehu, S. I. and Kamaluddeen, El H. A. (2024). Effect of Strains and Clove Supplemented Diet on Adaptability and Meat Quality Traits of Meat Type of Broiler Chickens under Heat Stress Condition. *Sahel Journal of Life Sciences FUDMA*, 2(1): 204-213. DOI: <https://doi.org/10.33003/sajols-2024-0201-025>

INTRODUCTION

There has been an unprecedented increase in global animal production, especially in subtropical and tropical areas in the last two decades (Renaudeau et al., 2012). According to FAO (2022), global meat production has reached 337 million metric tons with a growth rate of 1.3% per annum. The increase in the demand for food is due to a rise in human population (Godfray et al., 2010). The signs of heat stress in poultry are panting with open mouth, drooped and

elevated wings and squatting near to the ground, slowness and lethargic closed eyes, lying down, increased water intake, decreased appetite, drop in egg production, reduced egg size, poor egg shell quality, reduced body weight, and increased cannibalism (Nardone et al., 2010; Njoku, 1990). When birds are exposed to heat stress conditions, they spend less time during feeding, more time drinking and panting, less time moving or walking and

more time resting (Mack *et al.*, 2013). Due to its potential role to provide food and livelihood securities (Paswan *et al.*, 2014), poultry production, especially broiler production, is expected to meet the critical shortage in animal protein needed by Africa (Hatab *et al.*, 2019) as a result of environmental factor (Sinha *et al.*, 2017; Sylla *et al.*, 2016)). Due to the climatic challenge, heat stress events are expected to become more frequent in livestock species (Rahimi *et al.*, 2020; NRC, 1981). Heat stress has an adverse effect on egg production, egg weight and shell quality of laying hen (Muiruri and Harrison, 1991; Balnave and Muheereza, 1997; De Rensis and Scaramuzzi, 2003; Mahmoud *et al.* 2003). Studies by Tawfeek *et al.* (2014), Bonnet and Dick (1997) and Ayo. *et al.* (1996) showed that high ambient temperature adversely affected the performance of broiler chickens. However, Tawfeek *et al.* (2014) indicated that supplementation of antioxidants ameliorated the effects of thermal stress on the birds. The fast rate of development of the poultry production in tropical countries has also engendered a situation of overdependence on the conventional feedstuffs (Picard *et al.*, 1993; Suganya *et al.*, 2015). It is well known that feed is the most crucial cost of production as it represents the largest part of the cost of production of broiler chickens (Omole *et al.*, 2005). The growth rate of commercial broiler chickens is fast and they are able to reach market weight of two kilogram and above at about seven weeks of age or less (Smith, 1990). However, optimal growth of the birds can only take place when the chicken are reared under a thermoneutral zone of 18°C–24°C (Charles, 2002). Indeed, harsh environmental conditions circumscribe the growth potential of the birds (De Basilio *et al.*, 2001; Sohail *et al.*, 2012). Also, Ahaotu *et al.* (2019) emphasized the negative influence of seasonal fluctuations on poultry production in different parts of Africa. Cloves (*Syzygium aromaticum*) are aromatic flower buds from an evergreen tree belonging to the Myrtaceae plant family (Mbaveng and Kuete, 2017). They are considered medicinal plants in addition to nutritional spices in China and Eastern countries against several bacterial diseases (Wankhede, 2015). This 8- to 12m plant grows in tropical climates such as Indonesia, India, the West Indies, Brazil, Sri Lanka, Tanzania, and Madagascar (Bhowmik *et al.*, 2012). Different approaches have been developed to ensure a heat stress free condition in broiler chicken enterprise to ensure high production. Among the strategies employed by most researchers are the housing system (Badmus *et al.*, 2022) and nutrigenomic

approach which includes inclusion of antioxidants in the diet and water of the broiler chickens to adjust to climatic condition (Tawfeek *et al.*, 2014). Nutrigenomic is detail study of how nutrition alter gene expression or responses of Strains to nutrition due to their genetic make-up. Reducing the negative effect of heat stress are frequently modified through nutrients approach such as proteins (amino acid), energy density, prebiotics, probiotics, vitamins, minerals, and phytochemicals (Arif and Ergin, 2022). The most evaluated gene as an indicator of the rapid response of poultry to heat stress is HSP 70 (Arif and Ergin, 2022). Clove buds contain approximately 15 to 20% volatile essential oils dominated by eugenol (70–85%) (Ramadan *et al.*, 2013; El-Maati *et al.*, 2016). Clove is considered as a spices and appetizer and contains 10% volatile oils mostly of eugenol, a substance that have an anaesthetic effect (Lawless 1995) also contains vitamins B and C (Merrill and Perry 2009; Cheng, 1990). In addition, clove contains phenolic compounds that are anti-bacterial agents (Atherden, 1969). This study is designed to test the hypothesis that there is nutrigenomic effect of clove treatments on Strain responses for meat quality and heat tolerant capacity in two strains of broiler chickens raised under heat stress. Therefore, the objectives of this study are to determine nutrigenomic responses on meat quality, behaviour and heat tolerant capacity of two broiler Strains of chickens to clove supplementation under heat stress.

MATERIAL AND METHODS

Location of the Study

The study was conducted at the teaching and research farm of the Department of Animal Science, Federal University Gashua, Yobe state, Nigeria. The vegetation characteristic of the area is under Sahel Savannah. It consists of open Thorny Savannah with short Trees and grasses. It is located between Longitude 10° 02' and 11°, 11°E and Latitude 12° 48' and 12°88'N. It is situated in the Sudan Savannah ecological zone of Nigeria. The climate is characterized by high temperature and seasonal rainfall. The mean minimum temperature ranges between 10-12°C in December to January, while the mean maximum temperature is about 34-40°C in March-May. The mean rainfall is between 300-500mm per annum and is annual and last mostly from June to September while the dry season from October to May. (NEAZDP 2015).

Sources of the Experimental Materials

The clove used in these studies was purchased from the local market in Gashua, Yobe State. Clove was grinded and sieved to make it into powder.

The composition of broiler starter and finisher diets is a crucial aspect of poultry farming, as it directly impacts the growth and development of broiler chickens. In my experiment, I provided the percentage composition of different ingredients in the diets and their respective outcomes.

Table 1: Percentage (%) composition of the experimental broiler starter and finisher diets feed during the period of the experiment

Ingredients (%)	Starter diet kg	Finisher diet kg
Maize	29.70	53.74
Sorghum	20.00	0.00
SBM	25.50	10.74
GNC	9.00	22.50
Wheat offal	8.00	5.00
Fish meal	3.80	3.00
Common salt	0.25	0.30
L-lysine	0.25	0.25
DL-Methionine	0.25	0.25
Limestone	1.00	1.00
Bone meal	2.00	3.00
Vit/mineral		
Premix*	0.25	0.25
Total	100	100
Calculated		
Analysis:		
ME (kcal/kg) %	2900	3000
Crude protein %	23.50	21.00
Ether extract %	5.68	5.48
Crude fibre %	4.10	3.91
Calcium %	1.30	1.26
Phosphorus %	0.69	0.65
Lysine %	0.25	1.15
Methionine %	0.46	0.46
Meth+cystine %	0.93	0.87

Experimental Design and Management of Birds

A total of ninety-six (96) day-old of forty-six (46) Arbor Acre and forty six (46) Cobb 500 of broiler chicks purchased from a reputable hatchery and subjected to completely randomized design in a 2x2 factorial arrangement were used for this study. On arrival, the chicks were weighed and randomly assigned in to four treatments each replicated three times. The chicken were exposed under high average cyclic temperature of 44 °C after brooding and fed to clove treatment accordingly. Each treatment was allocated with twenty-four (24) bird (eight 8 birds per replicate). T1 was Cobb given feed without clove, T2 was Cobb given feed supplemented with a clove as an antioxidant (400mg/1kg of diet), T3 was Arbor Acre

given feed without clove and T4 was Cobb given feed supplemented with a clove as an antioxidant (400mg/1kg of diet) respectively. The birds were reared on deep litter system. All necessary routine management practices and the recommended vaccinations were strictly observed throughout the period of this study. Feed and water were provided ad libitum during the trial period. The experiment lasted for 6 weeks. The starter phase lasted from 0 to 3 weeks. The finisher phase lasted from 4 to 6 weeks.

Data Collection

Behavioural observation

Behavioural observation was conducted every day for 6 weeks, in 2 periods per day once in the morning

(6:00-8:00) and the second one in the afternoon (16:00-18:00) for 6 consecutive weeks. Each pen was observed for 15 minutes in each period of observation. Instantaneous scanning observations (Lee and Criag 1990) were applied in this study. The feeding, drinking, standing, walking, sitting, preening, dust bathing, wing stretching and/or wing flapping, ruffling and aggressive behaviours were scanned every 60 seconds. The percentage of birds engaged in each behaviour was calculated during all scan samples in each pen.

Measurements of the rectal temperature

The measurements of rectal temperature were conducted to compute heat tolerance capacity before slaughtering and butchering of the broiler by portable thermometer. The thermometer was placed on to the cloaca to measure the rectal temperature. Heat tolerance was calculated by using the following formula: $HTC=100-10(RT-101)$.

Where;

HTC: heat tolerant coefficients,

RT: rectal temperature.

Sensory evaluation and measurement of drip loss, cooking loss and pH value

At the end of the experiment (42 days), four birds per replicate, which represented the average weight of the group were randomly selected, starved of feed overnight so as to allow for the emptying of the crop and excretion of the undigested feed residue. Each bird was weighed, slaughtered, eviscerated and the breast muscles were cut from the carcass. Data collected were sensory evaluation, drip loss, cooking loss, and pH value.

Sensory Analysis

Sensory evaluations were performed 24h after slaughter. The samples were weighed and packed separately in autoclave bags. Sensory evaluation was done using a 3-point hedonic scale ranking rated on a 3-point sensory evaluation scale (1=Bad 2= Good 3= Very Good) by ten (10) randomly selected experienced staff and students of Animal science federal University Gashua Yobe state. Broiler meat samples were served at room temperature, with a bottle of Swan table water to the panels. Results from the hedonic scale of ranking were collected on the following: texture, juiciness, flavour of the sample.

Measurements of the drip loss

Drip loss measurements of the breast fillets were conducted after 24 h of storage. After being packed in plastic bags, meat samples were hanged on hooks through their thickest part for 24 h at 4°C to 10°C in incubator. Samples were weighed before and after hanging. Drip loss was calculated as the loss in weight, corrected for size, and expressed as a percent by using (Hakan, 2016) equation.

Drip loss= [(mass before hanging - mass after hanging)/mass before hanging] ×100%

Measurement of the cooking loss

Measurements of the cooking loss were performed 24 h after slaughter. A sample of around 3 × 5 cm was taken with a scalpel from the breast fillets. The samples were weighed and packed separately in autoclave bags. The samples were cooked at 80°C to 100°C in a water bath (Memmert, Schwa Bach, Germany) until the core temperature of the fillets reached 72°C. The core temperature was measured with a food core thermometer (Testo, Lenzkirch, Germany). A second weighing was conducted after cooking, and the cooking loss was calculated as the cooking loss of meat sample was defined as a weight percentage before and after cooking according to the following equation:

Cooking loss (%) = $\frac{\text{Weight before cooking [W1] (g)} - \text{Weight after cooking [W2] (g)}}{\text{Weight before cooking [W1] (g)}} \times 100$.

Measurement of the meat pH value

The surface pH of the breasts fillets was measured using pH meters Labtronics (Digital analysis kit) Model Lt-62). Measurements were performed for each meat sample by placing the electrode onto the meat surface and an average pH value was calculated.

Data Analysis

All data collected were statistically analysed using General Linear Model Procedure of Statistical Analysis (SAS, 2002) software package. Data obtained on organoleptic test was subjected to descriptive statistics of SAS (2002). Significant different between treatments means were separated by Duncan's Multiple Range Test (Steel and Torrie, 1980).

RESULT AND DISCUSSIONS

Behavioural Disposition of Broiler Chicken

Table 2 showed the behaviour of the birds exposed to various clove supplements under heat (44 °C) stress condition. The birds displayed less aggression, less panting, less pecking behaviour in both strains when fed with clove. Meanwhile, high aggression, high panting and pecking behaviour were observed in both strains in the control group without clove. However, both strain showed less restlessness when fed clove except the Arbor acre. Clove treated broiler chickens in both strains did not show roughness in feathers.

These normal behaviour exhibited by the clove treated broiler chicken could be attributed to antioxidant effect of clove. Badmus *et al.* (2022) reported high panting, no calmness, rough feather and high body weakness in the Cobb 500 broiler chicken exposed to heat stress whereas those in the cooling chamber house revealed normal character and better performance. With normal behavioural disposition enhanced due to expression gene of adaptive response, improved growth performance could be predicted. This showed clove has enabled receptor binding to a nutrient signalling molecule and initiating adaptive change (Reen *et al.*, 2015).

Table 2: Visual behavioural disposition of the birds exposed to clove feed-supplemented diet

Behaviour	Arbor Acre		Cobb	
	Clove	No clove	Clove	No clove
Aggression	Less	High	Less	High
Panting	Less	High	Less	High
Pecking	Less	High	Less	High
Rough feather	No	Yes	No	Yes
Restlessness	Less	High	Less	Less

Meat Quality Traits

The Results of the effects of strains and clove supplementation on meat quality traits are presented in Table 3. There is a significant ($p < 0.05$) effect of strain on cooking loss. Arbor acre revealed lower cooking loss than that of Cobb broiler chicken. However, no significant ($p > 0.05$) effects of strain and clove were observed on drip loss. A significant ($p < 0.05$) effect of clove was however observed in the pH of the meat but no effect of strain was observed. This finding disagreed with the report of Isabel and Santos (2009), who reported that drip loss was significantly higher in broilers fed with 100 ppm clove as compared with other non-clove treatments. Suliman *et al.* (2020) reported higher water-holding capacity, lower cooking loss percentages, and higher tenderness of the meat in clove in clove-fed chicken (1 or 2%) compared with the control group. Clove's nutrigenomic and antioxidant properties may have a protective effect on meat quality under heat-stress conditions. Gene expression is modified by numerous nutrients such as macronutrients (e.g. carbohydrates, proteins, fats), vitamins and minerals (e.g. Fe, Ca, Se, Zn), and phytogetic compounds (Reddy *et al.*, 2018). The reduced cooking loss observed in clove-supplemented diets may contribute to the juiciness and tenderness of the meat.

The data suggests that clove supplementation in broiler chicken diets has a positive effect on pH stability, a key parameter for meat quality. Both Arbor Acres and Cobb 500 strains exhibited consistent pH levels when fed diets containing clove, indicating its potential to maintain meat quality. Clove's antioxidant properties may play a role in preserving pH and other meat quality traits. This result agreed with the report of Suliman *et al.* (2020), who reported normal pH levels and lower temperature ranges in the clove-treated chicken compared to the control.

Organoleptic Test

The figure 1 below showed comparative analysis of the texture between Arbor Acre and Cobb 500® in terms of feed supplements. Both the strains of broiler chicken fed clove presented soft meat (better textural acceptance) compared to the non-clove counterpart. Figure 2 below presented the results of juiciness between the two groups, Arbor Acre and Cobb 500® and it indicated that clove fed chicken in Arbor Acre presented more juicy meat than non-clove chicken. In Cobb, non clove presented more juicy meat than clove fed chicken. Figure 3 below presented the flavour comparison between Arbor Acre and Cobb 500® groups. The figure indicated that non clove chicken in both Arbor Acre and Cobb presented more

flavoured meat than the clove counterpart. These responses clove were due to nutrigenomic depicted by genetic make-up. Amaral *et al.* (2018), stated that there was an improvement in meat tenderness expressed in response to clove seed inclusion. Sanwo *et al.* (2011) stated that meat colour, juiciness, meaty flavour and overall flavour of birds fed dietary clove had the numerically highest scores. Sanwo *et al.* (2019) reported that meat

sensory properties revealed better score in groups fed 3 g/kg and 4 g/kg diet of clove and turmeric powders respectively, for tenderness and overall acceptability. Meanwhile, lower cholesterol in lipoprotein profile was observed in group fed both 3 g/kg clove and 4 g/kg turmeric powder. They therefore concluded that inclusion of turmeric and clove had beneficial effects on FUNAAB Alpha (Sanwo *et al.*, 2019).

Table 3: Effects of clove supplementation in a diet on meat quality traits of two strains of broilers chickens raised under heat stress

Strains		Cooking loss	Drip loss	Ph
Arbor acre	Clove	15.38±1.04 ^b	27.6±-3.33	5.58±0.10 ^b
	No clove	16.10±1.34 ^b	29.28±1.33	5.97±0.11 ^a
Cobb	Clove	19.78±1.37 ^a	23.67±1.65	5.87±0.24 ^a
	No clove	17.67±0.87 ^a	31.63±2.82	5.87±-0.03 ^a
Strains		0.018	0.7374	0.8611
Clove		0.565	0.0623	0.0409
Strain × Clove		0.229	0.2056	0.6008

Means on the same column with different superscripts are significantly (p<0.05) different.

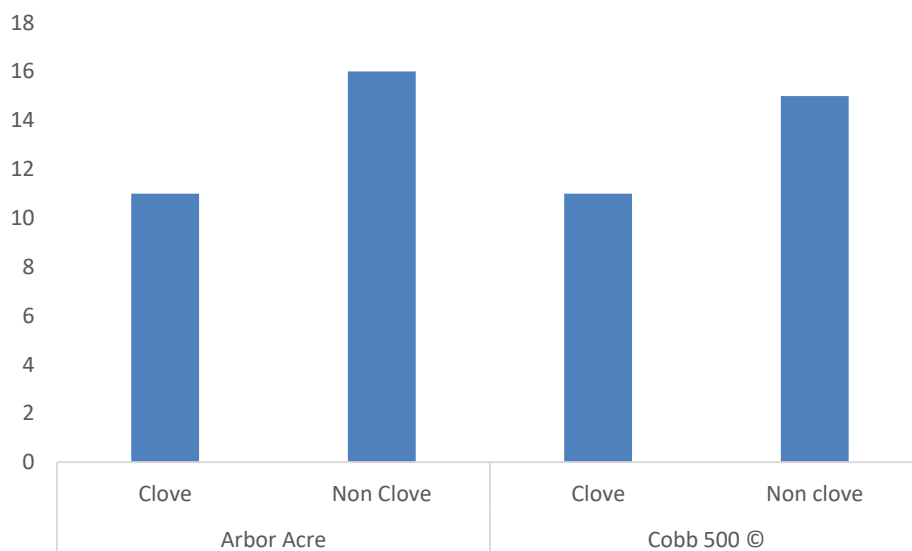


Fig. 1: Meat texture of Arbor Acre and Cobb 500 broiler chickens fed Clove and non-clove supplemented diets

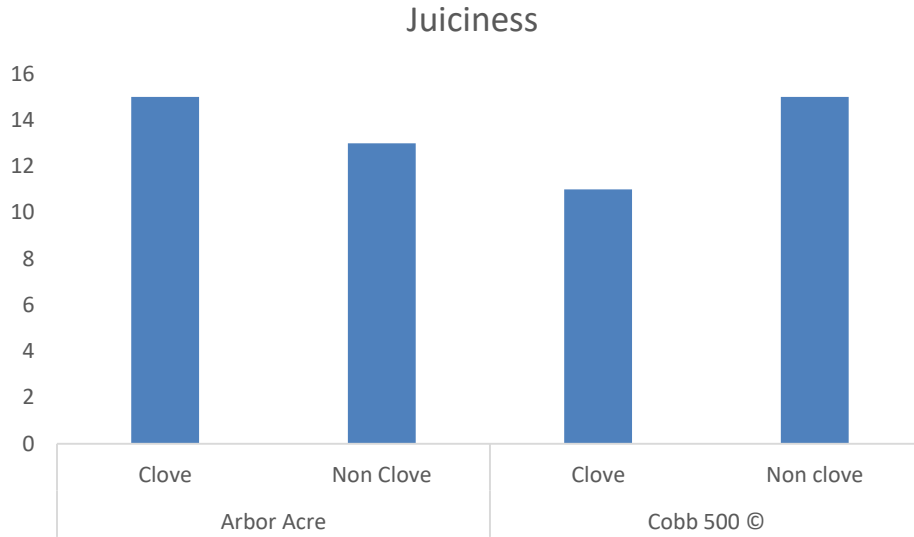


Fig. 2: Meat juiciness of Arbor Acre and Cobb 500 broiler chickens fed Clove and non-clove supplemented diets

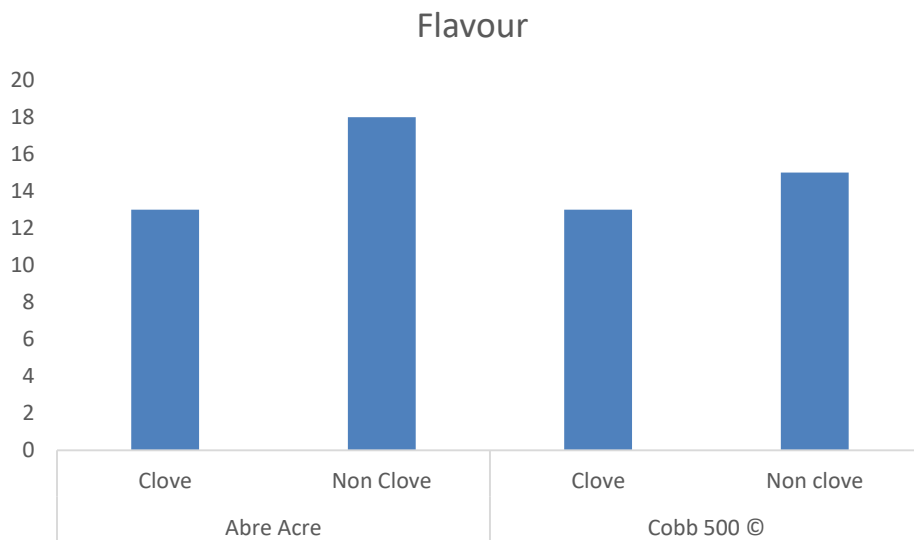


Fig. 3: Meat flavour of Arbor Acre and Cobb 500 broiler chickens fed Clove and non-clove supplemented diets

The results of the clove supplemented diet on mortality rate on broiler chickens were revealed on Table 3. The data strongly suggests that clove supplementation in broiler chicken diets has a significant positive effect on reducing mortality rates. Both Arbor Acres and Cobb 500 strains exhibited substantially lower mortality rates when fed diets containing clove, indicating its potential as a natural and effective means of enhancing broiler chicken health and overall welfare. Reduced mortality has been reported by Salman and Ibrahim (2012) and Mukhtar (2011) their experimental broiler chicken were fed clove supplemented diet through drinking

and feeding with improvement in the performance in terms of body weight, feed intake, feed conversion ratio and carcass yield. Clove's antioxidant properties likely contribute to these protective effects. This indicates that the potential benefits of clove supplementation on mortality reduction are not strain-specific. Clove's known antioxidant properties, primarily attributed to eugenol, can help protect cells and tissues from oxidative damage. By reducing oxidative stress, clove may enhance the overall health and resilience of broiler chickens, making them less susceptible to stress-related health issues and mortality.

Table 3: Effects of clove supplemented diet on the heat tolerant capacity and mortality rate of two strains of broiler chicken

	Arbor Acre		Cobb 500		Strain	P- Value	
	Clove	No clove	Clove	No clove		Clove	StrainxClove
HTC	489.60 ^a ±37.17	307.83 ^b ±42.87	424.67 ^a ±15.01	321.00 ^b ±12.00	0.3897	0.0001	0.1999
Mortality rate (%)	16.67%	37.5%	12.5%	41.67%	–	–	–

TC = Heat tolerant capacity;

CONCLUSION

In conclusion, the data strongly suggests that clove supplementation in broiler chicken diets has a significant positive effect on reducing mortality rates. Both Arbor Acres and Cobb 500 strains exhibited substantially lower mortality rates when fed diets containing clove, indicating its potential as a natural and effective means of enhancing broiler chicken health and overall welfare. These findings emphasized the influence of feed supplements like clove on the organoleptic attributes of broiler meat, underscoring the importance of optimizing broiler diets for enhanced consumer satisfaction through further research and understanding of specific supplement impacts on different broiler strains and their meat characteristics. It is concluded that strains have effect of meat quality traits with lesser effect on adaptability.

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