Phytochemical feed additives, garlic, ginger and their mixture on physical quality parameters and sensory attributes of broiler chicken meat

ABSTRACT

The meat quality and sensory attributes of broilers fed diets containing garlic, ginger and their mixtures was determined. Four dietary treatments: T_1- no garlic or ginger; T_2- garlic only; T_3 – ginger only and T_4- garlic + ginger respectively were utilized in a completely randomized design (CRD). On the last day of the 70-day feeding and growth trial, 3 birds were decapitated per treatment. The slaughtered birds were singed in warm water, de-feathered, eviscerated, cut into parts and deboned. Meat cuts of about 800g taken from the thigh and breast muscles of each of the representative birds per treatment were tested for meat quality (water holding capacity, cook loss, pH and fat binding capacity) parameters and sensory attributes. The meat parts were later cut into 2.5 cm – 3.0cm pieces and mixed in 0.4% of iodized common salt before boiling in a pot at a cooking temperature above 100^{o}C for 20 minutes. The pieces of the boiled meat were placed according to the four (4) feed treatments. Twelve (12) consumer panelists (6 for the thigh and 6 for the breast muscles respectively) within the age range of 20 – 26 years were used for the sensory evaluation. The meat quality and overall acceptability results depicted by the panelists on the sensory parameters (colour, flavour, tenderness, juiciness and toughness) revealed that meat (thigh and breast) of broilers fed T_2- garlic only were better preferred by consumers and was recommended.

Key words: Garlic, ginger, meat quality and sensory attributes.

1. INTRODUCTION

In the past, antimicrobial compounds such as antibiotics have usually been added to poultry diets for growth improvement and the control of disease at lower therapeutic prescriptions [1]. Consequently, it was reported that the misguided use of antibiotic drugs could cause drug resistant bacteria and antibiotic deposits in animal products, such as meat, egg and milk which could be detrimental to consumers [2]. Therefore, the use of natural antimicrobial products has been recommended as indispensable resources [3]. Further reports revealed that the use of antibiotic growth promoters or enhancers as additives in poultry feed formulations has been banned since 2006 in most parts of the world, although they play a useful role in growth performance and disease prevention among broiler chickens [4]. Thus, to avert the problems associated with the use of antibiotics in poultry feed formulations, natural products of plant origin often described as phytochemicals like spices, herbs, and many plant parts like ginger and garlic can be used as alternatives to antibiotics. In addition, and improve broiler performance, carcass characteristics, meat quality and sensory properties.

The rhizome or root parts of ginger (*Zingiber officinale*) has extensively been employed in medicine for the management of different diseased conditions such as nausea, vomiting, motion sickness, gastrointestinal ulcers, diabetes, fever, arterial tension, rheumatoid arthritis, dry mouth/ xerostomia, cancer, migraine headache, sore throat, and minor respiratory ailments in chicken [5]. Similarly, the bulb of garlic (*Allium sativum)* acts as an agent that destroys bacteria. It has been used as an antibiotic that destroys or stops the growth of micro-

organisms. It serves as an anthelmintic agent that destroys or expels intestinal worms and/or parasites such as vermicide and vermifuge as well as used as an antioxidant that can contribute to the oxidation of free radicals which are believed to contribute to premature aging and dementia [6]. It also acts as an antispasmodic agent which relieves or eases muscular spasms, cramps or convulsions. They act as natural blood thinners, play anti-cancerous activities, serve as anticoagulants that prevents the formation of clots in blood, and as antiseptic agents that inhibit the growth of microorganism on living tissue or destroying pathogenic or putrefactive bacteria, prevent the formation of tumor cells, serve as anti-viral agents that destroy viruses, serve as cholagogue agents responsible for increasing the flow of bile into the intestines, serve as diaphoretic agents that promotes perspiration, serve as diuretic agents that increases the volume and flow of urine which cleanses the urinary system, as well as acts as stimulants that excites or quickens the functional activity of the tissues giving it more energy [7].

The quality of meat can be directly or indirectly influenced by diet composition and this can lead to changes in the consumption or marketing of the meat [8]. Furthermore, diet composition and the quality of meat are closely related to consumers behaviour as well as with some sensory characteristics such as colour, texture, odour, and acceptability of the meat and the correct determination of the relationships between these variables play an important role in meat marketing and consumption [9]. The sensory evaluation of meat utilizing trained panelists could be the most appropriate means to explain differences between 'treatments' as perceived by humans [10]. Therefore, the objective of this study was to assess the effects of phytochemical feed additives (garlic, ginger and their mixtures) on the meat quality and sensory parameters of broiler chickens in Nigeria.

2. MATERIALS AND METHODS

2.1. Site of the research

The experiment was conducted at the Teaching and Research Farm of Ignatius Ajuru University of Education, Ndele Campus, Rivers State (Latitude 4^0 58' N and Longitude 6^0 48' E), Nigeria [11].

2.2. Processing of garlic and ginger used as feed test ingredients

The garlic and ginger used as test ingredients for the study was obtained fresh from the depot designated for sale of these ingredients at Mile 3 market in Port Harcourt. The outer coverings (rinds and husks) of the garlic and ginger were peeled off using a simple kitchen knife. The peeled materials were washed and sun dried properly for a duration of 2 weeks. They were later put into a motorized electric blender and grounded into a fine powder. The required quantities of these ingredients were added into the composite broiler finisher diets made up of other feed ingredients (Table 1).

Table 1: Composition of the Experimental broiler finisher diets use for the study

Feed Ingredients	Feed treatments (kg)

	T_1 Control (No Garlic or Ginger)	T_2 100% Garlic only	T_3 100% Ginger only	T_4 50% Garlic + 50% Ginger
Maize	40.00	39.00	39.00	39.00
Palm Kernel Cake	15.00	15.00	15.00	15.00
Groundnut Cake	20.00	20.00	20.00	20.00
Palm Oil	2.00	2.00	2.00	2.00
Soya bean Meal	15.00	15.00	15.00	15.00
Wheat Bran	2.00	2.00	2.00	2.00
Garlic	0.00	1.00	0.00	0.50
Ginger	0.00	0.00	1.00	0.50
Bone Meal	4.00	4.00	4.00	4.00
Lime stone	1.00	1.00	1.00	1.00
Lysine	0.10	0.10	0.10	0.10
Methionine	0.30	0.30	0.30	0.30
Salt	0.30	0.30	0.30	0.30
Mineral/Vitamin premix	0.30	0.30	0.30	0.30
Total	**100.00kg**	**100.00kg**	**100.00kg**	**100.00kg**

Premix contained the following: (Univit 15 Roche) 1500 I.U, Vit A: 1500 I.U, Vit D: 3000 I.U, Vit E: 3.0g, Vit K: 0.3g, Vit B2: 8.0g, Vit B6: 0.3g, Vit B12: 3.0g, Nicotinic Acid: 5.0g, Ca-Pantothenate: 10.00g, Fe: 0.2g, AL: 3.5g, Cu: 0.15g, Zn: 0.02g, I: 0.01g, Co: 0.01g Se.

2.3. Experimental birds and management

A total of one hundred and fifty (150) unsexed broiler day-old chicks weighing 40g each from Zartech hatchery farm were collectively brooded together throughout their starter phase with a commercial proprietary feed for four (4) weeks alternating with electricity and charcoal as sources of heat. At the end of the brooding period one hundred and twenty (120) grower broilers were balanced for their weights and ten (10) grower broilers were randomly allotted to three (3) pens (replicates) each of four (4) different dietary experimental feed treatments in a Complete Randomized Design (CRD).

Routine and periodic management practices was carried when appropriate. The feeders and drinkers were cleaned and fresh feed and water supplied on daily basis. Within the brooding and growing periods, routine medication and vaccination were carried out to ensure proper health of the birds. On arrival of the birds they were given anti-stress drugs and glucose to stabilize them from the stress of long distance transportation. At 2, 3,4 and 6 weeks of age they were given Gumboro, Lasota, Gumboro and Lasota vaccines respectively. The Gumboro and Lasota vaccines were used for the prevention of infectious bursal and Newcastle diseases respectively. The bedding materials on the floor (wood shavings) of the deep litter house were changed when they are dirty in the weeks' basis to maintain hygienic conditions to avoid diseases among the broilers. Recommended vaccination and medication were applied. Sanitation of the environment was maintained throughout the experimental period.

2.4. Determination of meat physical quality attributes

Meat samples (chunk of breast and thigh) were collected from the slaughtered broilers (3 birds per treatment of 1 bird per replicate) and taking to the Food Science Laboratory of Rivers State University for the determination of some physical meat quality attributes such as water holding capacity, cook loss, pH and fat binding capacity.

2.5. Sensory evaluation

2.5.1. Meat preparation for sensory evaluation

After slaughtering and processing of the broilers the thigh and breast muscles (meat) from the broilers fed with the test feeds were deboned and washed thoroughly. Eight hundred grams (800g) each of the meat samples per treatment was utilized. The bulk of the 800g meat were thoroughly mixed in 0.4% of iodized common salt. They were then cut into 2.5 – 3.0cm pieces before boiling. Boiling of the meat samples was done in a pot at a cooking temperature range above 100^{o}C for 20 minutes using a "camp'' gas cooker. After cooking the pieces of meat (3 replicates per treatment) were put in properly sealed plastic containers labeled according to the meat samples and placed in a cooler for about one hour to permit the internal temperature cooled to room temperature (20 – 25^{0}C) [12].

2.5.2. Data collection on sensory attributes of meat

The sensory evaluation test on the boiled meat of broilers fed the different test diets: T_1, T_2, T_3 and T_4 were carried out at the open Animal Science and Fisheries Laboratory, Department of Agriculture, Ignatius Ajuru University of Education, Ndele campus. The Laboratory was well arranged to accommodate the taste panelists.

2.5.3. Evaluation to ascertain sensory attributes of meat

Each pieces of the boiled meat (thigh and breast) were placed according to the four (4) feed treatments: T_1, T_2, T_3 and T_4. Twelve (12) consumer panelists (students) within the age range of 20 – 26 years were used for the sensory evaluation of the meat. The panelists were served the samples as soon as possible after preparation to prevent changes that may occur during holding since the samples can dry out or develop off-flavour. The panelist evaluated each sample for colour, flavor, tenderness, juiciness and toughness, based on the 4 – point scale, where: 4 = very desirable, 3 = slightly acceptable, 2 = unacceptable and 1 = very unacceptable with the help of copies of questionnaire.

The consumer panelists were seated far away from each other in a well-lit room during the session to avoid conversation and communication. At each successive chewing, the panelists were instructed to rinse their mouth with water to prevent the taste bud of the carry over effect from the previous sample tasted.

2.5.4. Data analysis on sensory attributes of meat

At the end of the sensory evaluation, the questionnaires were retrieved from the consumer panelists and a comprehensive collation of scores based on their responses were made for preference rankings and overall acceptability of the meat per treatment.

2.6. Chemical analysis

Proximate chemical analyses of the feed and meat samples per treatment were carried out according to the standard methods of [13].

2.7. Statistical analysis

The data obtained on meat quality attributes of the broilers from each treatment group were compared statistically on the basis of the different dietary treatments using Analysis of Variance (ANOVA) procedure for a Completely Randomized Design (CRD) using the SPSS version 20.0. Significant means were separated using the Duncan's New Multiple Range Test [14].

3. RESULTS AND DISCUSSION

3.1. Proximate composition of experimental diets

The proximate composition results of the broiler finisher diets containing garlic, ginger and their mixtures as phytochemical feed additives for the different experimental birds is presented in Table 2.

The results in Table 2 of proximate analysis of the experimental broiler finisher diets revealed that significant differences ($P< 0.05$) occurred among the nutritional compositions of the broiler finisher diets. Correspondingly, the range of nutrient compositions in the experimental broiler finisher diets were: (14.75 – 18.32%) for crude protein (CP), (8.00 - 11.00) for ash, (4.05 – 5.00%) for ether extract (EE), (7.50 – 10.25) for crude fibre (CF), (58.14 – 64.05%) for nitrogen free extract (NFE) and (2,974.86 – 3,223.51 kcal/kg) for metabolizable energy (ME).

The differences in the nutrient composition of the various experimental broiler finisher diets may be attributed to the variations in addition of the feed additives (garlic and ginger). For instance, the nutrient composition as presented by the proximate analysis of the formulated diets (T_1- no garlic or ginger - control; T_2- 100% garlic only; T_3 – 100% ginger only and T_4- 50% garlic + 50% ginger) is a reflection of the individual nutrients (especially, CP and NFE). It was however, noticed that, the range of CP content (14.75 – 18.32%) for the formulated experimental broiler finisher diets was lower than the average CP content (19.00%) recommended by [15] while determining the minimum crude protein level of broiler finisher rations in the tropics. Furthermore, the metabolizable energy (ME) values of 2,974.86 – 3,223.51 kcal/kg for the experimental finisher diet was within the values of 3,200kcal/kg metabolizable energy for finisher broilers recommended by [15].

Table 2: Proximate composition (g/100g dry matter) of broiler finisher diets containing Garlic, Ginger and their mixtures as phytochemical feed additives.

Parameters	T_1 Control (No Garlic or Ginger)	T_2 100% Garlic only	T_3 100% Ginger only	T_4 50% Garlic + 50% Ginger	Mean	SEM±
Crude protein (CP)	15.45b[c]	14.75[c]	18.32[a]	16.56[b]	16.27	1.52
Ash	8.00[b]	10.5[a]	8.55[b]	11.00[a]	9.51	0.75
Ether extracts (EE)	5.00a	4.55	4.75	4.05	4.59	0.25
Crude fibre (CF)	7.50[c]	9.50[b]	10.00[ab]	10.25[a]	9.31	1.07
Nitrogen free extracts (NFE)	64.05[a]	60.70[a]	58.38[b]	58.14[b]	60.32	2.05
**ME (kcal/kg DM)	3223.51[a]	3043.29[b]	3102.24[b]	2974.86[c]	3,085.98	101.04

[a,b&c]Means bearing different superscripts along the same row are significantly different ($P< 0.05$);**ME (kcal/kg) = (35 × % CP) + (81.8 × % EE) + (35.5 × % NFE) [16].

3.2. Meat quality attributes of broilers fed different experimental diets

Table 3 shows the quality attributes of the thigh and breast meat of broilers fed diets containing garlic, ginger and their mixtures as phytochemical feed additives. The feed treatments and their designations are: T_1- no garlic or ginger; T_2- 100% garlic only; T_3 – 100% ginger only and T_4- 50% garlic + 50% ginger respectively. The results of the thigh and breast meat of broilers fed these feed revealed that significant differences ($P < 0.05$) occurred among the meat quality parameters in terms of their Water Holding Capacity (WHC), pH, Fat Binding Capacity (FBC) and Cook Loss (CL).

The Water Holding Capacity (WHC) of the thigh meat of the broilers fed the different experimental diets were in the decreasing order of 64.52 > 63.57 > 61.53 > 61.20 for the broilers fed T_2- 100% garlic only; T_4- 50% garlic + 50% ginger; T_3 – 100% ginger only and T_1- no garlic or ginger respectively of the experimental diets. However, the highest value of WHC of the meat from the thighs of the broilers was reported for the broilers fed the T_2- garlic only diets, while the lowest value of WHC of the meat from the thighs of the broilers was reported for the broilers fed the T_1- no garlic or ginger experimental diets. Similarly, the WHC of the breast meat of the broilers fed the different experimental diets were in the decreasing order of 60.62 > 60.40 > 58.49 > 54.08 for the broilers fed T_4- 50% garlic + 50% ginger; T_3 – 100% ginger only; T_2- 100% garlic only and T_1- no garlic or ginger respectively of the experimental diets. However, the highest value of WHC of the meat from the breast of

the broilers was reported for the broilers fed the T_4- 50% garlic + 50% ginger diets, while the lowest value of WHC of the meat from the breast of the broilers was reported for the broilers fed the T_1- no garlic or ginger experimental diets. Therefore, for both the thigh and breast meat from the broilers the diets containing the feed additives in their various combinations exhibited meats with higher WHC. The graphical presentation of the effects of the different experimental diets on the WHC of the thigh and breast meat of broilers is presented in Fig 1.

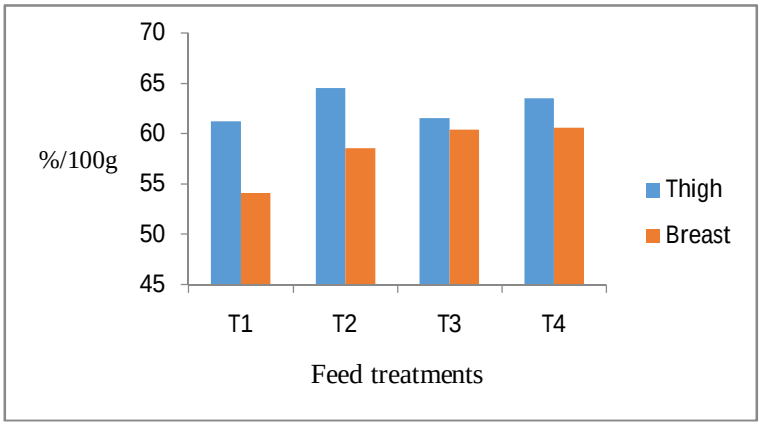

Figure 1: Water Holding Capacity (WHC) of thigh and breast meat of broilers

The pH of the thigh meat of broilers were in the decreasing order of 5.86 > 5.73 > 5.67 > 5.49 for the broilers fed T_3 – 100% ginger only, T_1- no garlic or ginger, T_4- 50% garlic + 50% ginger and T_2- 100% garlic only for the different experimental diets respectively. However, the highest value of pH of the meat from the thigh of the broilers was reported for the broilers fed the T_3 – 100% ginger only experimental diets, while the lowest value of pH of the meat from the thigh of the broilers was reported for the broilers fed the T_2 - 100% garlic only experimental diets. Similarly, the pH of the breast meat of broilers fed the different experimental diets were in the decreasing order of 5.82 > 5.59 > 5.39 > 5.21 for the broilers fed T_3 – 100% ginger only, T_4- 50% garlic + 50% ginger, T_2 - 100% garlic only and T_1- no garlic or ginger respectively of the experimental diets. However, the highest value of pH of the meat from the breast meat of the broilers was reported for the broilers fed the T_3 – 100% ginger only experimental diets, while the lowest value of pH of the meat from the breast meat of the broilers was reported for the broilers fed the T_1- no garlic or ginger experimental diets. Consequently, judging the meat quality based on pH, the meat of broilers fed T_2 - 100% garlic only revealed a better quality. This is in agreement with the reports of [17] who explained that meat of high quality has ultimate pH at the range of 5.4–5.6. The graphical presentation of the effects of the different experimental diets on the pH thigh and breast meat of broilers is shown in Fig 2.

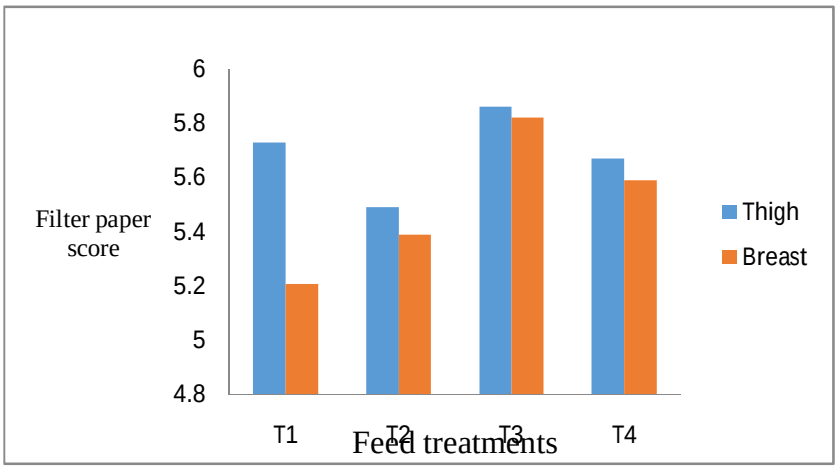

Figure 2: pH of thigh and breast meat of broilers.

The Fat binding capacity (FBC) of the thigh meat of broilers were in the decreasing order of 9.68 > 9.32 > 9.28 > 9.14 for the broilers fed T_4- 50% garlic + 50% ginger, T_1- no garlic or ginger, T_2- 100% garlic only and T_3 – 100% ginger only for the different experimental diets respectively. However, the highest value of FBC of the meat from the thigh of the broilers was reported for the broilers fed the T_4- 50% garlic + 50% ginger experimental diets, while the lowest value of PS of the meat from the thigh of the broilers was reported for the broilers fed the T_3 – 100% ginger only experimental diets. Similarly, the FBC of the breast meat of broilers fed the different experimental diets were in the decreasing order of 9.82 > 8.05 > 5.66 > 5.49 for the broilers fed T_3 – 100% ginger only, T_2- 100% garlic only, T_4- 50% garlic + 50% ginger and T_1- no garlic or ginger respectively of the experimental diets. However, the highest value of FBC of the meat from the breast meat of the broilers was reported for the broilers fed the T_3 – 100% ginger only experimental diets, while the lowest value of FBC of the meat from the breast meat of the broilers was reported for the broilers fed the T_1- no garlic or ginger experimental diets. The graphical presentation of the effects of the different experimental diets on the FBC of the thigh and breast meat of broilers is presented in Fig 3.

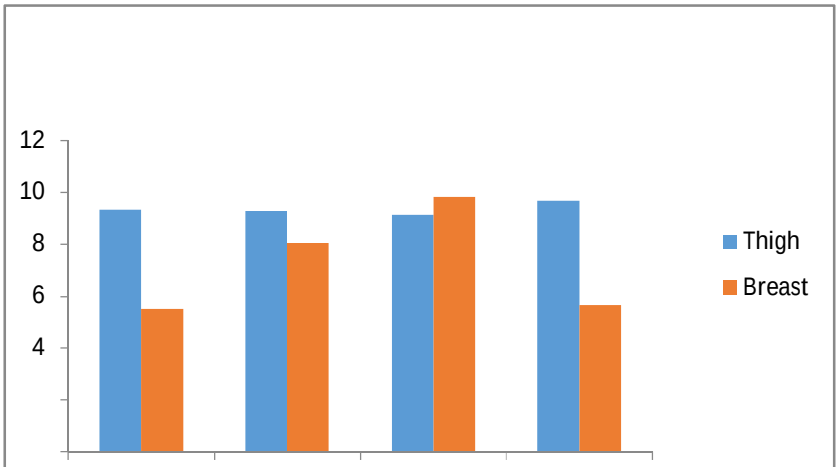

Figure 3: Fat binding capacity (FBC) of thigh and breast meat of broilers.

The Cook loss (CL) of the thigh meat of broilers were in the decreasing order of 21.86 > 20.35 > 20.24 > 19.56 for the broilers fed T_1- no garlic or ginger, T_4- 50% garlic + 50% ginger, T_3 – 100% ginger only and T_2- 100% garlic only for the different experimental diets respectively. However, the highest value of CL of the meat from the thigh of the broilers was reported for the broilers fed the T_1- no garlic or ginger experimental diets, while the lowest value of CL of the meat from the thigh of the broilers was reported for the broilers fed the T_2- 100% garlic only experimental diets. Similarly, the CL of the breast meat of broilers fed the different experimental diets were in the decreasing order of 21.44 > 20.67 > 20.01 > 19.71 for the broilers fed T_1- no garlic or ginger, T_3 – 100% ginger only, T_4- 50% garlic + 50% ginger and T_2- 100% garlic only respectively of the experimental diets. However, the highest value of CL of the meat from the breast meat of the broilers was reported for the broilers fed the T_1- no garlic or ginger experimental diets, while the lowest value of CL of the meat from the breast meat of the broilers was reported for the broilers fed the T_2- 100% garlic only experimental diets. The graphical presentation of the effects of the different experimental diets on the CL of the thigh and breast meat of broilers is shown in Fig 4.

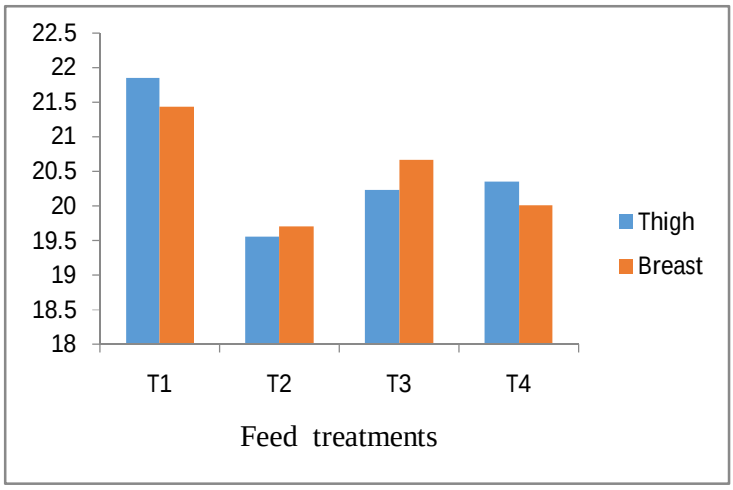

Figure 4: The cooking loss (CL) of the thigh and breast meat of broilers

3.3. Sensory evaluation of boiled (thigh and breast) meat of broilers fed the experimental diets by taste panelist

The results of the sensory evaluation scores and overall acceptability ranking of the boiled (thigh and breast) meat of broilers fed the experimental diets: T_1- no garlic or ginger (control), T_2- 100% garlic only, T_3 – 100% ginger only and T_4- 50% garlic + 50% ginger

respectively by taste panelists based on the sensory parameters: colour, flavour, tenderness, juiciness and toughness is presented in Table 4 and Figure 5 respectively. The studies on the sensory analysis of boiled broiler meat (thigh and breast) was carried out to ascertain the influence the incorporation of phytochemical feed additives (garlic only, ginger only and garlic + ginger) in broiler diets will impact on the sensory qualities (colour, flavour, tenderness, juiciness and toughness) and how these parameters may influence the preference and acceptability of meat by consumers.

The sensory analysis score (Table 4) by the taste panelists based on visual appraisal in assessing the preferred colour of the boiled meat for the thigh in ascending order was 9 > 14 > 18 and > 19 for T_1- no garlic or ginger, T_4- 50% garlic + 50% ginger, T_2- 100% garlic only and T_3 – 100% ginger only respectively. Similarly, the sensory analysis score by the taste panelists based on visual appraisal in assessing the preferred colour of the boiled meat for breast in ascending order was 10 > 13 > 15 and > 22 for T_1- no garlic or ginger, T_4- garlic + ginger, T_3 – ginger only and T_2- garlic only respectively. The meat of the broilers fed with the phytochemical feed additives had the tendency of having a better eye appeal (yellow-skinned colour) for the thighs and breast with the increasing amounts of maize in the diets as recorded by the taste panelist. The yellow-skinned colour of the meat samples (thigh and breast) may be as a result of the use of yellow maize in the experimental diet formulations. Yellow maize has been reported to possess β- carotene [18] which may have resulted the yellowish skin colour that would have influenced the choice of the taste panelist and their preference rankings [19].

The sensory analysis score (Table 4) by the taste panelists based on the preferred flavour of the boiled meat for thigh in ascending order was 10 > 11 > 19 > 20 for T_1- no garlic or ginger, T_3 – 100% ginger only, T_4- 50% garlic + 50% ginger and T_2- 100% garlic only respectively. Similarly, the sensory analysis score by the taste panelists based on preferred flavour of boiled meat for breast in ascending order was 11 > 13 > 15 > 21 for T_3 – 100% ginger only, T_1- no garlic or ginger, T_4- 50% garlic + 50% ginger and T_2- garlic only respectively. Based on the sensory scores of the taste panellists the meat samples (thigh and breast) T_2- 100% garlic only portrayed the best flavour. This may be attributed to the crude proteins in the composite experimental broiler finisher diets and type of diet [20] as well as the additional presence of vitamins and β- carotene in the yellow maize. This is agreement with the findings of [21], who explained that the availability of additional protein source and provision of some necessary vitamins, minerals and oxycarotenoids in supplemental leaf meals and spices will have an impact on the flavour of meat.

The sensory analysis score (Table 4) by the taste panelists based on the preferred tenderness of the boiled meat for thigh in ascending order was 12 > 14 > 16 >18 for T_4- 50% garlic + 50% ginger, T_1- no garlic or ginger, T_2- 100% garlic only and T_3 – 100% ginger only respectively. Similarly, the sensory analysis score by the taste panelists based on preferred tenderness of boiled meat for breast in ascending order was 13 > 14 >16 > 17 for T_3 – 100% ginger only, T_1- no ginger or garlic, T_4- 50% garlic + 50% ginger and T_2- garlic only respectively.

From the results obtained (Table 4), there were no clear patterns or relationships and explanations for the disparities in the tenderness, juiciness and toughness of the meat samples for the thigh and breast meat as scored by the panellists.

Furthermore, sensory analysis score (Table 4) based on the overall acceptability or preference of the thigh and breast meat of broilers as presented in Table 4, are in the descending order of 89 > 83 > 68 > 60 for T_2- 100% garlic only, T_3 – 100% ginger only, T_4- 50% garlic + 50% ginger and T_1- no garlic or ginger for the thigh and 84 > 80 > 72 > 64 for T_2- 50% garlic only, T_1- no garlic or ginger, T_4- 50% garlic + 50% ginger and T_3 – 100% ginger only for the breast meat respectively. The overall acceptability or preference of the thigh and breast meat by the panelists is the revelation of their cumulative sensory score (responses) to all the sensory parameters (colour, flavour, tenderness, juiciness and toughness). Thus, meat samples of the thigh and breast for T_2- garlic only were most acceptable judging by the responses of the panelists (Fig 5).

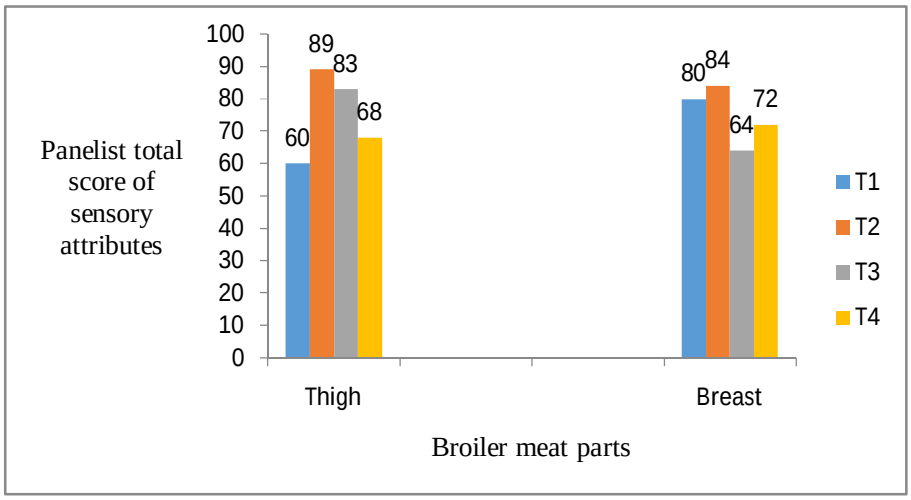

Figure 5: Overall acceptability of thigh and breast of broilers by taste panelists.

Table 3: Meat quality parameters of thigh and breast meat of broilers fed diets containing garlic, ginger and their mixtures as phytochemical feed additives

Parameters	T_1 Control (No Garlic or Ginger)	T_2 100% Garlic only	T_3 100% Ginger only	T_4 50% Garlic + 50% Ginger	Mean	SEM±
Thigh Muscle						
Water Holding Capacity (WHC)	61.20^{c}	64.52^{a}	61.53^{c}	63.57^{b}	62.71	0.54
Ph	5.73^{b}	5.49^{c}	5.86^{a}	5.67^{b}	5.69	0.08
Fat Binding Capacity (FBC)	9.32^{bc}	9.28^{c}	9.14^{d}	9.68^{a}	9.36	0.05
Cooking Loss (CL)	21.86^{a}	19.56^{d}	20.24^{c}	20.35^{b}	20.50	0.04
Breast Muscle						
Water Holding Capacity (WHC)	54.08^{c}	58.49^{b}	60.40^{a}	60.62^{a}	58.40	0.62
Ph	5.21^{d}	5.39^{c}	5.82^{a}	5.59^{b}	5.50	0.06
Fat Binding Capacity (FBC)	5.49^{d}	8.05^{b}	9.82^{a}	5.66^{c}	7.26	0.05
Cooking Loss (CL)	21.44^{a}	19.71^{d}	20.67^{b}	20.01^{c}	20.46	0.04

$^{a-d}$ Means bearing different superscripts along the same row are significantly different ($P< 0.05$). SEM = Standard Error of Mean.

Table 4: Sensory evaluation scores and overall acceptability rankings of thigh and breast meat of boiled meat of broilers fed diets supplemented with phytochemical feed additives.

Meat samples	Sensory parameters							Sensory parameters						
	Thigh							Breast						
	Col	Flav	Tend	Juice	Tough	Total	Acceptability Ranking	Col	Flav	Tend	Juice	Tough	Total	Acceptability Ranking
T1	18	10	14	9	9	60	4^{th}	22	13	14	14	17	80	2nd
T2	19	20	16	17	17	89	1^{st}	15	21	17	13	18	84	1st
T3	14	11	18	20	20	83	2^{nd}	13	11	13	17	10	64	4th
T4	9	19	12	14	14	68	3^{rd}	10	15	16	16	15	72	3rd
Total	60	60	60	60	60	300		60	60	60	60	60	300	

T_1 = no garlic or ginger (control); T_2 = garlic only; T_3 = ginger only and T_4- garlic + ginger; Col = colour; Flav = flavour; Tend = tenderness; Tough = toughness.

4. CONCLUSION AND RECOMMENDATION

The meat quality water holding capacity (WHC), pH, fat binding capacity (FBC), cooking loss (CL), sensory (colour, flavour, tenderness, juiciness and toughness) attributes, consumers' preference and overall acceptability of the thigh and breast meat from broilers fed diets containing garlic, ginger and their mixtures as phytochemical feed additives was very positive.

Ethical Approval:

Animal Ethic committee approval has been collected and preserved by the author(s)

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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