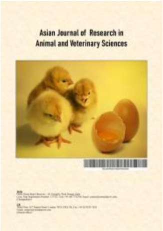

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Evaluating the Impact of Abattoir Waste as an Alternative Protein Source on Broiler Meat Quality

Omotolani Sarah Fabayo [a*] and Patience, O. Fakolade [a]

[a] *Department of Animal Science, Faculty of Agricultural Production and Management, College of Agriculture, Ejigbo Campus, Osun State University, Osogbo, Nigeria.*

Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

Quality characteristics of muscle foods are influenced by muscle appearance, color, texture, juiciness, mouth feel characteristics and tenderness. These quality parameters depend on many predetermining factors affecting the live animal before being converted from muscle to meat. This study was designed to evaluate the nutritional quality of broiler muscle-fed abattoir waste as an alternative protein. This evaluation includes proximate analysis, palatability and microbial load. A total of 150-day-old Ross breed chicks were used for the experiment. The significance of using abattoir waste as an alternative protein source lies in its potential to reduce feed costs, minimize environmental waste, and provide a sustainable and nutritionally viable option for improving broiler meat quality. Abattoir waste was sourced from a nearby abattoir's waste management and the wastes used were blood, bones, rumen contents, horns, and hooves. The experiment was conducted by producing five dietary treatments which consisted of: Treatment 1: Compounded feed

**Corresponding author: E-mail: omotolanisarah0@gmail.com;*

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with abattoir waste at 5%; Treatment 2: Compounded feed with abattoir waste at 10%; Treatment 3: Compounded feed with abattoir waste at 15%; Treatment 4: Compounded feed with abattoir waste at 20%; and Treatment 5: Compounded feed with abattoir. The experimental design was completely randomized (CRD) and all the data collected were subjected to analysis of variance (ANOVA) with the procedure of SAS (2010). Statistically significant observed means were compared using the Tukey test of the same package at a 5% probability level. The results of this research work revealed that the inclusion of abattoir wastes in broiler feed affects the chicken meat positively in treatment 1 (5%) and treatment 5(0%) since they gave the best quality of broiler muscles.

Keywords: Broilers; abattoir waste; alternative protein; muscle quality; dietary treatments.

1. INTRODUCTION

The quality of poultry meat is increasingly important as consumers now prefer cuts or processed products over whole carcasses [1]. Meat consists of muscle, connective tissue, fat, and bone, with muscle accounting for approximately 75% water, 20% protein, and 5% fat, carbohydrates, and minerals. The appearance, color, texture, juiciness, and mouthfeel determine meat quality, which is influenced by factors affecting the animal before it is converted into meat [2]. Breast and thigh muscles are highly valued for their culinary properties, and water-holding capacity, pH, color, and tenderness are key indicators of quality [3]. These factors are influenced by environmental conditions, particularly feed, which can degrade or enhance muscle quality and affect consumer acceptance [4]. With increasing demand for poultry and a focus on meat quality [1], there is a need to reduce feed costs while maintaining quality. This shift toward processed poultry products stems from economic and health concerns. Consumers seek convenient, ready-to-cook or ready-to-eat products to match fast-paced lifestyles while prioritizing low-fat, high-protein options for health benefits. Feed composition plays a pivotal role, as it can degrade or enhance muscle quality and, by extension, consumer acceptance [4]. With increasing demand for poultry and a focus on quality [1], there is a pressing need to develop cost-effective feed solutions that maintain or improve meat quality.

Abattoir waste presents a potential alternative protein source, offering a cost-effective, locally available feedstuff for broilers [5]. However, using abattoir waste in animal feed raises ethical considerations and public perception challenges, particularly concerning food safety and consumer acceptance. Transparent processing methods and strict adherence to safety standards are essential to address these concerns and build consumer confidence. Beyond its economic benefits, such as reducing feed costs, incorporating abattoir waste in feed supports environmental sustainability by minimizing waste accumulation and promoting recycling within agricultural systems.

Compared to other alternative proteins like insect meal, which offers high protein content but faces similar public perception hurdles, abattoir waste leverages existing by-products of meat production, reducing the need for additional resources. On the other hand, plant-based proteins, such as soybean meal, are more widely accepted but require significant land, water, and energy inputs, raising environmental concerns. This study evaluates the effect of abattoir waste on broiler muscle quality, focusing on its proximate and mineral composition, microbial load, cholesterol levels, and palatability. While previous studies suggest monogastric can obtain adequate protein from abattoir waste mixtures [5], research on its impact on the organoleptic qualities of broiler meat remains limited.

Appearance is a crucial quality attribute, as consumers associate it with freshness. Factors influencing poultry meat color include feed composition, pre-slaughter conditions, and processing methods [6]. Pigmentation is affected by carotenoids in the feed, and factors like breed, environment, and health also play a role [7]. Texture, a key factor in consumer satisfaction, is influenced by water retention, connective tissue maturity, bird age, and processing conditions [7]. Flavor, a combination of taste and odor, develops during cooking due to chemical reactions involving lipids and proteins, with poultry fat contributing to the characteristic flavor [6]. Chicken meat is low in fat, contains no trans-fats, and is high in monounsaturated fats, making it desirable from a health perspective [8,9]. Water-holding capacity influences tenderness and juiciness, and meat with high water-holding capacity retains more water during processing [2].

pH also impacts quality, including tenderness, water-holding capacity, and color. Meat with a higher pH retains more water and is often more tender. The pH of broiler meat depends on the amount of glycogen in the muscle before slaughter and its conversion to lactic acid post-slaughter [10]. Feed composition influences muscle growth and fat deposition in birds, with high-energy, high-protein diets improving carcass yield and reducing fatness [7]. Adjusting the protein-to-energy ratio can also affect muscle mass and quality [11]. Biochemical changes after slaughter, including glycogen depletion and lactic acid accumulation, impact tenderness and water-holding capacity [7]. Other factors, including genetics, pre-slaughter conditions, and broiler management, also affect meat quality.

Understanding the nutritional requirements of broilers is essential for optimizing meat quality. Nutrients like carbohydrates, fats, proteins, minerals, vitamins, and water are critical for growth and overall health (Atteh, 2002). The nutrient needs of broilers vary with age and growth rate [12]. Energy is the primary dietary requirement, provided mainly through carbohydrates and fats, and balancing energy and protein in the diet is crucial for growth [13]. Protein, especially amino acids, is essential for broiler growth, with deficiencies adversely affecting growth and meat quality [10]. Water is vital for metabolism and regulating body temperature, and its consumption increases with protein intake and environmental temperature [14]. Minerals, particularly calcium and phosphorus, are crucial for bone development and metabolic processes [15].

This study addresses the gaps in the literature regarding the use of abattoir waste as a protein source for broilers and its impact on meat quality. By evaluating the proximate composition, microbial load, cholesterol levels, and palatability of broiler muscle, this research aims to assess the potential of abattoir waste as a cost-effective alternative protein source for poultry feed.

2. MATERIALS AND METHODS

Experimental site: The experiment was carried out at the poultry Unit, Teaching and Research Farm, College of Agriculture, Osun State University, Osogbo, Ejigbo campus, Ejigbo, Osun State.

Experimental materials: Experimental pen, disinfectant, tarpaulin, digital scale, thermometer, wood shavings, coal pot, charcoal, feeder, drinker, and abattoir waste such as rumen concentrate, blood, bone, horn and hooves.

Experimental bird management: This study, which lasted 8 weeks, involved a total of 150-day-old Ross breeds. The birds were obtained from a well-known farm in Osun State, Nigeria. In two phases, the experimental birds were grown in an intensive management system in a deep litter system (The starter phase and the finisher phase). The starter phase, also known as the brooding period, lasted 4 weeks and the birds were fed compounded broiler starting feed, while the finisher phase entailed feeding the birds compounded broiler finisher with varying levels of abattoir waste. This phase lasted for another four weeks to make a total of 8 8-week experimental period. Before the arrival of the chicks, the poultry pen and all equipment were thoroughly washed, cleaned, and disinfected. Wood shaving was sourced and was spread evenly to a depth of 3-10cm, leveled and compacted in the brooding house. All equipment was assembled in the appropriate configuration. The pen was preheated, immediately after the arrival of the chicks, the chick boxes were carefully offloaded, and the chicks were distributed evenly throughout in the pen. Chicks were tipped quickly, gently, and evenly, and the empty boxes were removed from the house. A solution of glucose and vitamins was served to the chicks as anti-stress, and they were left to settle for 1-2 hours to become accustomed to their unique environment. A one to two hourly check was mandated during the brooding stage.

Table 1. Vaccination program for broiler chicken

Age	Vaccination
DAY 1	NDV-1/0 (HATCHERY)
DAY 2	1ST GUMBORO VACCINE
2 WEEKS	NDV (LASOTA VACCINE)
3 WEEKS	2ND GUMBORO VACCINE
4 WEEKS	NDV (LASOTA VACCINE)

Table 2. Medication programme for broiler chicken

Age of the Birds	Medication
DAY 1-2	Anti-stress, glucose
DAY 3-5	Antibiotic in water
DAY 10-12	Anticoccidial in water
DAY 17-19	Antibiotic in water
DAY 24-26	Wormazine

Experimental material procurement, sample collection, and preparation: Abattoir waste was sourced from a nearby abattoir's waste management. The selection of the abattoir for this study was based on several criteria to ensure the reliability and quality of the materials used. Proximity to the experimental site at Osun State University, Ejigbo campus, was a key factor, minimizing transportation time and preserving the freshness of the waste. The abattoir was chosen for its consistent availability of the required components, including blood, bones, rumen contents, horns, and hooves, essential for the research. Additionally, its organized waste management system facilitated efficient collection, while its capacity to supply the required quantities ensured uninterrupted feeding throughout the eight-week study period.

Content of the abattoir waste used:

Blood and bones: Blood was collected during the slaughtering of cattle. The blood was then placed to a drum and coagulated for 45 minutes on a burner at 100 ℃ It was sieved after coagulation to eliminate any excess water. The coagulated blood was sun-dried on a clean aluminum sheet in a well-aerated environment, and it was turned often to aid drying. Using mining equipment, the dried blood was crushed into a fine ground blood meal. Mining equipment was chosen for crushing due to its efficiency in processing hard materials into fine particles, ensuring consistency in blood meal quality. While not standard in feed production, it adapts well to large-scale processing. Simpler methods like manual pounding or small grinders could suffice for local, small-scale farmers to reduce costs. The sourced bones were sun-dried until the moisture content was eliminated, at which time they were shattered with a hammer or mortal. After being crushed into small particles, it was steamed at 100oC for more than 30 minutes. It was dried and milled using a milling machine to fine particles.

Rumen content: Rumen content was obtained from an abattoir, collected, and emptied into a clean bag, and the rumen fluid was squeezed out locally using hands to lower the moisture content and bulkiness of the rumen content. The rumen was spread on a clean nylon sheet to dry in the sun in a well-aerated atmosphere. It was flipped often while drying to assist drying. The dried rumen content was milled into a fine ground rumen content meal using a milling machine.

Horn and hooves: The sourced cattle horns and hoofs were processed individually. The hoofs were soaked in water until they became spongy and could be detached from the bones, at which point they were spread out to dry in the sun. The horns were sun-cured until the horn pith had dried completely and may be hammered out. The horns and hoofs were mixed and steam-cooked in an autoclave for seven hours at 100-112°C (digester). The substance is next dried and finely ground.

Mixing of milled abattoir waste: Separately milled abattoir waste was taken to a laboratory for chemical examination to determine its chemical composition content. The mixture was then blended at a 1:1 ratio and used to replace soybean meal at various levels in finisher growth diets. All of the above-mentioned processed slaughterhouse waste will be mixed and added to compounded feed at a rate of 5%,10%, 15%, 20%, and 0%.

Experimental treatments: The experimental treatment system was chosen for its ability to evaluate varying levels of abattoir waste inclusion, reflecting realistic feed practices and resource optimization commonly adopted in the target region's poultry farming industry. The chicks were randomly distributed to five treatments (30 birds each) with three (3) replicates of ten (10) birds per replicate to make a total of 150 birds. The treatment diet included:

Treatment 1: Compounded feed with abattoir waste at 5%
Treatment 2: Compounded feed with abattoir waste at 10%
Treatment 3: Compounded feed with abattoir waste at 15%
Treatment 4: Compounded feed with abattoir waste at 20%
Treatment 5: Compounded feed with abattoir.

Experimental diets:

Table 3. Experimental diet fed to broilers (starter stage)

Ingredients	0	5	10	15	20
Maize	58.94	58.64	59.58	60.65	60.40
Soya bean meal	16.0	16.0	16.0	12.35	9.90
Groundnut cake	14.5	15.38	10.0	8.2	6.2
Fishmeal	3.0	0	0	0	0
Abattoir waste meal	0	5	10	15	20
Wheat offal	4.06	1.48	0.92	0.3	0
Bone meal	2.7	2.7	2.7	2.7	2.7
Premix	0.25	0.25	0.25	0.25	0.25
Salt	0.25	0.25	0.25	0.25	0.25
Lysine	0.15	0.15	0.15	0.15	0.15
Methionine	0.15	0.15	0.15	0.15	0.15
ME in MJ kg−1	12.56	12.56	12.56	12.56	12.56
%CP	22.19	22.01	22.04	22.05	22.08
%CF	3.32	3.39	4.47	4.95	5.01
%Ca	1.26	1.09	1.09	1.09	1.1
%P	0.96	0.79	0.79	0.76	0.74
%Lysine	1.15	1.38	1.67	1.9	2.01
%Methionine	0.48	0.48	0.5	0.52	0.53

Table 3a. Experimental diet fed to broilers (finisher stage)

Ingredients	0	5	10	15	20
Maize	61.42	62.47	63.75	64.37	60.75
Soya bean meal	15.8	9.8	7.2	4.25	4.01
Groundnut cake	7.0	7.8	4.5	2.85	2.21
Fishmeal	0	0	0	0	0
Abattoir waste meal	0	5	10	15	20
Wheat offal	12.28	11.43	11.05	10.03	9.53
Bone meal	2.7	2.7	2.7	2.7	2.7
Premix	0.25	0.25	0.25	0.25	0.25
Salt	0.25	0.25	0.25	0.25	0.25
Lysine	0.15	0.15	0.15	0.15	0.15
Methionine	0.15	0.15	0.15	0.15	0.15
ME in MJ kg−1	12.34	12.34	12.34	12.34	12.34
%CP	18.02	18.17	18	18.18	18.21
%CF	3.65	4.08	4.57	5.05	5.14
%Ca	1.07	1.07	1.07	1.07	1.07
%P	0.79	0.74	0.72	0.7	0.68
%Lysine	0.97	1.18	1.43	1.69	1.73
%Methionine	0.42	0.44	0.46	0.48	0.5

Data collection:

At the end of the 8-week experiment, three birds per replicate from each treatment were starved overnight, weighed before slaughtering, and weighed after slaughtering. Muscles were cut from the breast and thigh. The muscles collected were sent to a laboratory for analysis, which included proximate composition, mineral composition, cholesterol status, and microbial loads. Proximate composition was determined using the AOAC (2005) procedures, ensuring accuracy through duplicate sample runs and calibration of equipment. Mineral composition was analyzed using atomic absorption spectrophotometry, with standardized reagents to maintain precision. Cholesterol levels were assessed via the modified method of Ahmed et al. (2015), using reference standards for validation. Microbial loads were measured using serial dilution and plate count techniques, with aseptic handling and quality control checks to avoid contamination.

Proximate composition of muscle: Skinless breasts (*musculus pectoralis major) from* each treatment were taken for evaluation. The samples' protein, ether extract, ash, and moisture contents were analyzed according to A.O.A.C 18th Edition, (2005).

Mineral composition: Magnesium, calcium, and phosphorus were determined chemically according to the Official Analytical Chemist (A.O.A.C, 18th Edition, 2005)

Cholesterol status of muscle: Cholesterol content was measured using the procedure described by (Ahmed *et al.,* (2015). Briefly, the cholesterol was determined from fat, which was segregated via the extraction of 5 g of minced muscle (mixed with reference material; 0.5 mL of 5-α-cholesterol) with a chloroform and methanol mixture. The cholesterol was separated from fat using the modified method.

Microbial loads of muscle: For the microbiological analysis, 25 g of surface meat tissue, with a size of 3.5 × 7 × 0.5 cm, was aseptically taken using a sterile scalpel. Thereafter, 225ml of the serially diluted stock solution was transferred aseptically into a mixture of nutrient agar and Mac Conkey agar. The inoculated culture media will be incubated inversely overnight at 37^{0}C. The bacteria were identified and the number of bacterial colonies recorded was expressed as colony forming unit per gram (CFU/g) according to the procedure of (Bhandari *et al*., 2013).

Palatability status: The breast muscle from the experimental broilers that were fasted were boiled, for 20 minutes at 100 ^{0}C, and allowed to cool, at room temperature. Palatability was determined using a nine-point hedonic scale for juiciness, color, flavor, tenderness, texture, and overall acceptability. A total number of 10 trained panelists were used based on past performance. The boiled samples were randomly allocated. The panelists were provided with unsalted cracker biscuits and water to change the taste of their mouths after each bite.

Experimental design: A complete randomized design (CRD) design was adopted for the experiment.

Statistical analysis: All data collected was subjected to analysis of variance (ANOVA) with the procedure of SAS (2010). Statistically significant observed means were compared using the Tukey test of the same package at a 5% probability level.

3. RESULTS

The proximate composition of diets, particularly protein and crude fiber levels, directly impacts meat quality by influencing muscle development and texture. Higher protein levels in T1 and T5 align with the superior meat quality observed in these treatments, as adequate protein supports muscle growth. Similarly, balanced crude fiber levels enhance digestive efficiency, indirectly affecting nutrient absorption and meat characteristics like tenderness and juiciness. These findings highlight the importance of formulating diets with optimal nutritional composition to achieve desirable meat quality in broilers.

Table 4. Sample of a 9- Point - hedonic Scale for palatability evaluation

Score	Color	Flavor	Tenderness	Juiciness	Texture	Acceptability
1	Dark	Not acceptable	Extremely tough	Extremely dry	Extremely coarse	Dislike extremely
2	Just dark	Just perceptible	Very tough	Very dry	Very coarse	Dislike very much
3	Moderately dark	Moderately perceptible	Moderately tough	Moderately dry	Moderately coarse	Dislike moderately
4	Slightly perceptible	Slightly perceptible	Slightly tough	Slightly dry	Slightly coarse	Dislike moderately
5	Intermediate	Intermediate	Intermediate	Intermediate	Intermediate	Intermediate
6	Slightly light	Slightly strong	Slightly tender	Slightly fine	Slightly light	Slightly liked
7	Moderately light	Strong intense	Moderately tender	Moderately fine	Moderately light	Liked moderately
8	Very light	Slightly intense	Very tender	Very fine	Very light	Very much
9	Extremely light	Extremely fine	Extremely fine	Extremely fine	Extremely fine	Liked Extremely

Table 5. Proximate composition of diet fed to the broiler chicken

PARAMETERS	T1	T2	T3	T4	T5	SEM
% PROTEIN	14.1^{b}	12.19^{a}	12.58^{b}	13.2^{b}	14.47^{b}	2.03
%ASH	8.90^{ab}	8.50^{ab}	7.90^{b}	8.30^{ab}	9.20^{a}	0.65
%FAT	6.50	6.30	5.90	5.90	6.10	0.47
%CRUDE FIBRE	6.50^{b}	6.90^{ab}	6.60^{ab}	6.90^{ab}	7.40^{a}	0.49
%NFE	63.9^{b}	61.11^{c}	67.02^{a}	65.7^{b}	64.50^{b}	2.19
%DRY MATTER	93.30	93.15	93.00	92.96	92.80	0.46
%MOISTURE CONTENT	6.70	6.85	7.00	7.05	7.20	0.39

^{abcd} means of different alphabet along the row are significantly different [p<0.05]
T1 – 5%, T2-10%, T3-15%, T4-20%, T5-0%, abattoir waste inclusion

Proximate compositions of the diets fed to broiler chickens: Table 6 shows the protein, ash, fat, crude fibre, nitrogen free extract, dry matter, and moisture contents of the experimental broiler meats. Protein was significantly highest (P<0.05) in T_1 (27.93 %) and T_5 (27.80) and was significantly lowest in T_2 (25.47) and T_4 (25.45), with T_3 (27.35) falling in between. Ash contents ranged between 0.70 – 2.04 with T_1 having the highest statistically significant value. There was no significant difference in the values obtained for fat across all treatments. Crude fibre was significantly highest (P<0.05) in T_2 and T_3 and lowest in T_1, T_4 and T_5. The significantly highest NFE value (P<0.05) was recorded in T_2, while the lowest was recorded in T_1 and T_5. T_1 (30.39) and T_5 (30.41) had the significantly highest (P<0.05) dry matter, with T_2 having the significantly lowest (P<0.05) (28.57). Moisture content was significantly highest in T_2 and T_4 and lowest in T_3. Moisture content significantly influences meat storage and consumer preference. Higher moisture content, as observed in T2 and T4, may reduce shelf life due to increased microbial activity, making the meat more perishable. Conversely, lower moisture content, as seen in T3, often enhances storage stability. From a consumer perspective, moderately high moisture levels improve juiciness and tenderness, key attributes for meat quality and overall palatability. Therefore, balancing moisture content is critical to achieving both storage efficiency and consumer satisfaction.

Proximate compositions of the meats of broiler chickens fed abattoir waste: The proximate composition of the experimental diets is presented in Table 7. Protein was significantly highest (P<0.05) in T_2. Ash ranged between 7.90 (T_3) and 9.20 (T_5). There were no significant differences (P<0.05) in the values obtained for fat, dry matter, and moisture content. The highest nitrogen free extract (NFE) was recorded in T_3 which had a value of 67.02% and the lowest NFE was recorded in T_2 which had a value of 61.11 %.

Table 6. Proximate composition of broiler chicken meat fed abattoir waste

Parameters	T1	T2	T3	T4	T5	SEM
% PROTEIN	27.93^{a}	25.47^{c}	27.3^{b}	25.45^{c}	27.80^{a}	1.16
%ASH	2.04^{a}	0.70^{e}	0.92^{d}	1.73^{c}	1.83^{b}	0.55
%FAT	5.13	5.15	5.16	5.15	5.15	0.27
%CRUDE FIBRE	0.23^{b}	0.25^{a}	0.23^{b}	0.26^{a}	0.23^{b}	0.02.
%NFE	64.70^{d}	68.44^{a}	66.35^{c}	67.43^{b}	64.8^{d}	1.50
%DRY MATTER	30.39^{a}	28.5^{d}	29.9^{b}	29.04^{c}	30.41^{a}	0.77
%MOISTURE CONTENT	69.87^{b}	71.44^{a}	70.01^{c}	70.97^{a}	69.3^{b}	0.73

^{abcd} means of different alphabet along the row are significantly different [P<0.05]
T1 – 5%, T2-10%, T3-15%, T4-20%, T5-0%, abattoir waste inclusion

Table 7. Microbial load of broiler chicken meat fed abattoir waste

Parameters	T1	T2	T3	T4	T5	SEM
TVC (×10-7) CFV/G	7.89ab	8.84a	7.19b	8.75a	8.63a	0.86
TBC (×10) CFV/G	6.90ab	7.11ab	6.76b	7.60a	7.49ab	0.47
TFC (×10-5) CFV/G	1.88	1.70	1.35	1.76	1.60	0.40
TCC (×10-1) CFV/G	1.45	1.33	0.99	1.38	1.24	0.49

^{abcd} means of different alphabet along the row are significantly different [P<0.05]
T1 – 5%, T2-10%, T3-15%, T4-20%, T5-0%, abattoir waste inclusion

Table 8. Cholesterol and minerals of broiler chicken meat fed abattoir waste

Parameters	T1	T2	T3	T4	T5	SEM
Cholesterol	31.88^{c}	43.67^{b}	44.13^{b}	45.27^{ab}	46.114^{a}	5.49
Fe	0.65	0.53	0.79	0.83	0.88	0.26
K	24.70^{e}	26.404^{d}	31.80^{c}	35.50^{b}	35.60^{a}	4.38
Na	76.60	78.40	83.20	59.77^{b}	91.30	20.17

^{abcd} *means of different alphabet along the row are significantly different [P<0.05]*

Table 9. Palatability status of broiler chicken meat fed abattoir waste

Parameters	T1	T2	T3	T4	T5	SEM
Colour	4.58^{bc}	4.93^{ab}	3.93^{c}	5.57^{a}	5.29^{ab}	0.88
Flavour	5.15^{a}	4.29^{b}	3.07^{d}	3.86^{bc}	3.57^{cd}	0.86
Tenderness	6.07^{b}	6.86^{a}	5.79^{b}	5.81^{b}	5.79^{b}	0.63
Juicness	6.07^{ab}	6.64^{a}	5.72^{b}	5.07^{c}	5.86^{b}	0.71
Texture	6.21^{a}	6.29^{a}	5.43^{b}	5.86^{ab}	5.29^{b}	0.64
Acceptability	6.93^{a}	6.93^{a}	6.14^{b}	6.42^{ab}	6.93^{a}	0.53

^{abcd} *means of different alphabet along the row are significantly different [p<0.05]*

The microbial load of broiler chicken meat fed abattoir waste: Table 7 shows that there were no significant differences in the total fungi count (TFC) and total coliform count (TCC). Total viable count (TVC) was significantly highest ($P<0.05$) in T_2 (8.84×10^{-7}), T_4 (8.75×10^{-7}), and T_5 (8.63×10^{-7}), but lowest in T_3 (7.19×10^{-7}). Total bacteria count (TBC) ranged from 6.76×10^{-7} (T_3) to 7.60×10^{-7} (T_4). While these microbial levels are within the range commonly observed in fresh poultry meat, according to industry standards (10^7 CFU/g for TVC as the threshold for spoilage), the higher levels in T2 and T4 may pose a safety concern if proper storage and handling practices are not maintained. These results highlight the importance of adhering to cold-chain logistics to minimize microbial growth and ensure consumer safety. Comparatively, T3 exhibits the lowest microbial load, suggesting better suitability for prolonged storage and reduced spoilage risk.

Cholesterol and minerals of broiler chicken meat fed abattoir waste: Table 8 presents the cholesterol, Fe, K, and Na levels of the meat of broiler chicken fed abattoir wastes. There were no significant differences ($P<0.05$) in the values obtained for iron (Fe) and sodium (Na) across all five treatments. Cholesterol was significantly highest ($P<0.05$) in T_5 (46.11) and lowest in control (31.88). The values for potassium (K) ranged from 24.70 (control) – 35.60 (T_5).

Palatability status of broiler chicken meat fed abattoir waste: Table 9 shows the colour, flavor, tenderness, juiciness, texture, and acceptability of the experimental meats. Colour was significantly highest ($P<0.05$) in T_4 and lowest in T_3. Flavour ranged from 3.07 (T_3) to 5.15 (T_1). For tenderness, there were no significant differences in the values obtained in T_1, T_3, T_4, and T_5, however, T_2 was significantly the highest ($P<0.05$) (6.86). Juiciness followed a similar trend as in tenderness in that it was significantly highest in T_2, however, it was lowest in T_4. Texture ranged from 5.29 (T_5) to 6.29 (T_2). Acceptability was significantly highest in T_1, T_2, and T_5 which all had a value of 6.93, but was lowest in T_3 with 6.14.

4. DISCUSSION

Proximate composition of diet fed to the broiler chicken: Table 5 shows the proximate composition of the abattoir waste diet fed to the broiler chicken. The values in the Table 5 are significantly lower than the one obtained by [5], who worked on an "assessment of abattoir waste on carcass characteristic, internal organs, and organoleptic properties of broiler with 9.34% moisture content, 35.55% protein, 3.60 % ash. Table 5 shows the percentage inclusion of the abattoir waste to feed composition. The protein content value of the feed ranges between 12.19 - 14.47%, these values fall within the values obtained for protein content of the proximate composition for experimental diets fed to pigs with hatchery and poultry- by-products. Crude fiber content in the experimental diet ranges from 5.27 to 8.20% which are ($P<0.05$) lower than 6.10 to 10.39% respectively by (Ojabo and Wunduga, 2020) who worked on the proximate analysis of selected commercial feeds in Makurdi metropolis, north-central, Nigeria. However, the values obtained by them fall within the values obtained from this study crude fiber content on the proximate composition of diet fed to the broiler chicken meat of T1(6.50), T2(6.90), T3(6.60), T4(6.90) and T5(7.40). Having the values within the same range could be a result of both works being on broiler experiments, unlike the pigs, which had lower values compared to what was reported by [16]. With the inclusion of abattoir waste at T1(5%), T2(10%), T3(15%), T4(20%), and T5(0%), the ash content had higher (P<0.05) values from 7.90 - 9.20% compared to what was reported by Ibikunle *et al*., [17] on the experiment of performance of broiler chicken fed diets containing cassava peel and leaf meals as replacements for maize and soya bean meal. The reasons for this could probably be due to the addition of horn and hooves in the abattoir waste which may cause the increase in the ash content.

Proximate composition of broiler chicken meat fed abattoir waste: Moisture content can be defined as the amount of moisture in the sample given as a percentage of the sample's original (wet) weight. Poultry meat was observed to be made up of approximately 60 to 80% water, 15 to 25% protein, and 1.5 to 5.3% fat by Oliveira et al [18]. However, the moisture content of Table 6 had values (69.84 – 71.44%), and the moisture content fell within the values of Oliveira in [18]. This may be because of the feed fed which is abattoir waste and the breed of animal used for the experiment. The protein content of Table 6 with values (25.45 -27.93%) is higher than that of Oliviera [18] on the chemical composition (wet basis) of breast meat of broilers fed different concentrations of R-gelatinous biomass with the values 19.4 - 20.2% and also on the chemical proximate composition (wet basis) of thigh meat of broilers fed different concentrations of R-gelatinous biomass with (21.8 - 22.6%). This difference may be attributed to the inclusion of abattoir waste, which provided a richer and more balanced protein source, promoting higher muscle protein deposition. Additionally, broilers generally exhibit higher protein content due to their rapid growth rate, high feed conversion efficiency, and genetic selection for meat production, factors that enhance muscle development and protein accumulation compared to other feed and management systems. This could be due to the feed fed (abattoir waste of varied percentages). However, the protein content in Table 6 is higher (P<0.05) compared to what was reported by Williams [19] for cattle meat. The proximate composition of the broiler chicken meat was observed to be significantly higher in protein than 22.13% obtained by FAO (2010) for the longissimus of cattle meat. The differences may be due to the feed fed.

Fat is the most variable component which could be due to the influence of diet, animal age, breeding environment, and anatomical cut, in which the highest contents are in the chicken thigh [20]. However, in this study, I focused on the breast muscle which falls within the same range gotten by (Oliveira, 2016). The values for fat found in breast meat [21] are lower than the fat content in this study. The ash reported in T1(inclusion of abattoir waste at 5%) and T5 (inclusion of abattoir waste at 10%) with the values 2.04 and 1.83 % in this experiment was observed to be the highest, the other treatments evaluated. The ash content in this study was higher (P<0.05) compared to that of [22] in the experiment conducted on proximate composition and meat quality of broilers reared under different production systems. The differences in the values could be a result of the feed fed (inclusion of abattoir waste in varied percentages) and the breed of chicken and or the environment.

Cholesterol and mineral status of broiler chicken meat fed abattoir waste: The mean mineral composition (g/kg) of breast muscles from the experimental chickens is presented in Table 8. The results show that potassium (K) was the most abundant mineral, followed by sodium (Na) and iron (Fe), consistent with findings by Lawrie (1990), Demirbas et al. (1999), and Podgórski et al. (2001). However, the cholesterol levels observed were higher than the levels reported by Katarzyna and Joanna (2013), raising important consumer health implications. Elevated cholesterol levels in meat can increase the risk of cardiovascular diseases, such as atherosclerosis and hypertension, particularly for individuals with existing health conditions or those consuming excessive quantities of high-cholesterol foods.

Dietary cholesterol is known to contribute to the buildup of plaque in arteries, which may impair blood flow and lead to heart complications. While moderate consumption of such meat may not pose significant risks for healthy individuals, public health guidelines recommend limiting dietary cholesterol intake to mitigate these risks. For health-conscious consumers, the higher cholesterol content underscores the need for balance in dietary planning and potential consideration of leaner protein sources or broilers fed with modified diets designed to reduce cholesterol deposition. These findings highlight the importance of nutritional labeling and public education to ensure informed consumer choices.

Microbial loads of broiler chicken meat fed abattoir waste: The parameters evaluated in Table 7 are TVC-total Viable Count, TFC-total fungi count, TBC-total bacteria count, and TCC-total Coliform Count. The Total Viable Count is the quantitative sanitary standard to identify the process conditions and contamination degree of meat. TBC-Total Bacteria Count is a quantitative estimate of the number of micro-organisms present in a sample, this measurement is represented by the number of colony-forming bacterial units (CFU) per gram (or ml) in the sample. Total fungi count is a quantitative estimate of the number of fungi present in a sample. Total Colony Count, TCC was carried out to find the presence of pathogenic bacteria, which can be responsible for food poisoning, diarrhea, etc. TVC and TBC are significantly higher across the treatments than T3 which has the lowest value, the differences may be as a result of handling during processing. The TBC in this study was lower in values than the values obtained from the experiment conducted by (Hamid Reza Tavakoli *et al*., 2017) this could probably be due to a good sanitary process. In scaling up such feed practices, maintaining strict sanitation is crucial to minimize microbial contamination and ensure the safety of the final product. Effective sanitation practices—such as proper waste handling, sterilization, and hygiene during processing—are essential to control microbial load, prevent foodborne illnesses, and meet food safety standards for large-scale poultry production. Aside from microbial contaminates, heavy metals present at abattoir sites could also contaminate broilers, as well as their feeds [23,24]

Palatability status of broiler chicken meat fed abattoir waste: The palatability status of the broiler chicken meat shows the overall acceptability of broiler chicken based on the color, texture, juiciness, flavor, and tenderness of the meat shown in Table 9. Color is the first criterion consumers use to judge meat quality, appearance, and acceptability (Conforth, 1994). Juiciness of meat depends on the raw meat quality and the cooking method and is made up of two effects, the impression of moisture released during chewing and also the salivation produced by flavor factors (Aaslyng *et al.,* 2003). Meat flavor is a combination of several chemical interactions involving proteins, lipids, and continuous activity of the endogenous hydrolase during post-mortem which can easily be designated during the boiling process (Koohmaraie, 1996). Tenderness could be described as the ease with which the teeth sink into the meat when chewed (Omojola *et al*., 2014). Abdelbary, (1995) noticed that tenderness and juiciness are closely related, the more tender the meats, the more quickly the juice is released when chewed and the juicer the meat appears. Some major components of the meat that contribute to tenderness can be conveniently divided into 3 groups, which are the connective tissues, the muscle fiber, and lastly, the lipids associated with the muscle tissue. The result obtained in Table 9 shows that T1 (inclusion of abattoir waste at 5%), T2 (inclusion of abattoir waste at 10%), and T5 (inclusion of abattoir waste at 0%) were rated higher by the panelist, which shows that they are more palatable and acceptable compared to other treatments [25-28].

5. CONCLUSION

The results of this study indicated that the inclusion of abattoir waste in broiler feed positively impacts chicken muscle quality, especially in Treatment 1 (5% abattoir waste) and Treatment 5 (0% abattoir waste). This finding highlights the potential scalability of using abattoir waste as an alternative protein source, providing a cost-effective and sustainable solution for poultry farmers. Additionally, incorporating abattoir waste into feed contributes to environmental benefits by reducing waste accumulation and promoting recycling in agricultural systems, aligning with global efforts toward sustainable farming practices. These treatments showed the highest protein content and superior palatability characteristics such as flavor, texture, and juiciness, which are critical factors in meat quality evaluation. The positive effects of abattoir waste in these particular proportions suggest that it could serve as a valuable alternative protein source, contributing to sustainable and cost-effective poultry production. Moreover, it was observed that the inclusion of abattoir waste did not compromise meat quality but rather enhanced it in moderate amounts. While this study provides valuable insights, further research is recommended to explore the broader implications of using abattoir waste across different protein sources and its potential environmental benefits. Future studies could focus on assessing consumer acceptance of poultry fed with abattoir-based diets, including sensory evaluations and market surveys. Additionally, scaling production for larger farms should be explored by evaluating the logistical challenges, cost-effectiveness, and infrastructure requirements for processing and incorporating abattoir waste at a commercial scale. These next steps are essential for ensuring the feasibility and widespread adoption of this sustainable feeding practice.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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