Research Article

Quality Evaluation of Chicken Powder from Broiler Chicken Fed Abattoir Wastes in Their Diet

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Abstract

There is an increasing desire and demand for animal products with improved nutritional quality, resulting in the inclusion of abattoir waste in the feed of broiler chickens used as a raw material for the processing of chicken powder (CP). A total of 150 Ross breed chicks were raised intensively for 8 weeks. The birds were fed compounded feed (CF) with inclusion of abattoir waste (AW) and allocated to five dietary treatments (T) in a completely randomized design: T1, CF only; T2, CF + 5% AW; T3, CF + 10% AW; T4, CF + 15% AW, and T5, CF + 20% AW. Three chickens were selected from each treatment for CP processing. Result on day 0 showed that inclusion of AW in the diet of broiler chickens increased the protein of CP. Moisture content increased with increasing AW. Cholesterol in all treatments was below the limit recommended for broilers and their products. No significant difference ($p > 0.05$) was observed in iron (Fe), while sodium (Na) and potassium (K) increased with AW. On day 28, no significant changes were observed in protein content; however, storage intervals caused variation in ash and moisture content. T2 and T3 had the lowest microbial load on day 0 and 28. Microbial load increased with AW, and T4 and T5 were significantly ($p < 0.05$) higher in total viable count (TVC) and total bacteria count (TBC). Result for palatability showed that T2 was significantly preferred, followed by T1 and T3 with no significant difference. CP is a high-protein animal product in which the nutritive component is enhanced with inclusion of 5-10% abattoir waste in the diet of broiler chicken.

Keywords: Broiler chicken, Abattoir waste, Chicken powder, Microbial load

Introduction

Abattoir waste presents a potential alternative protein source, converting waste into a usable feed stuff and offering a cost-effective and locally available feed stuff for broiler chicken when safely selected, processed, and incorporated into the broiler chicken diet (Onunkwo et al., 2018). Sakaba et al. (2017) reported that, abattoir waste is rich in vital and required nutrients containing 5.83% moisture content, 15.52% crude protein, 5.17% lipid, 48.73% fiber, 11.00% ash, and 19.98% nitrogen free extract (NFE). The findings of Onunkwo et al. (2018) established that bovine blood and rumen content have 9.34% moisture content, 35.33% protein content, 3.60% ether extract, 15.57% crude fiber, 0.98% ash, and 25.06% NFE. The nutrient profile of abattoir waste has thus qualified it to be an alternative feed source that can be explored in poultry production. Safe incorporation of well-processed abattoir waste into feed ingredients reduces the cost of feeds, minimizes abattoir waste accumulation, improves environmental hygiene, promotes recycling, and encourages integration within the livestock farming system (Onunkwo et al., 2018). The use of abattoir waste in the diet of broiler chicken will be a financial relief for poultry farmers by reducing the exorbitant cost of feeding. Othman et al. (2017) reported that, feeding is a major challenge in poultry production, necessitating the need for the development of alternative feed stuff to ensure feed quality, sustainable production, and stable consumption of chicken meat. It was also buttressed by Fakolade et al. (2025) that abattoir wastes can be used to lower the cost of production of broiler chicken and also enhance value addition of chicken meat into other products.

Chicken meat is the most consumed type of poultry and it ranks second in consumption globally (Caffyn 2021). It is affordable, low in fat, and not subjected to religious and cultural constraints (FAO 2025). By nature, broiler chicken meat is a nutrient-dense food, rich in protein, vitamins and minerals, making it susceptible to deteriorative changes (Hailemariam et al., 2022). Adding value to chicken meat becomes crucial because of its tri-effects, which are: halting or slowing down of deteriorative changes in the final product, preventing economic loss via wastage, and increasing food options in the meat industry. The shift toward value addition can thus be attributed to the economic and health concerns of consumers as they seek ready-to-cook or ready-to-eat meat products with longer shelf life and improved flavour.

Chicken powder (CP) is a flavourful additive that can be used as a seasoning with authentic chicken stock taste in homemade meals (Tian et al., 2019; Shen et al., 2023). Most of the food industry pays attention to taste and flavour with less attention to nutrition and health; this result in a shift to natural, healthy, tasty, and flavourful additives such as CP (Tian et al., 2019). The outcome of CP outmatches that of artificial flavouring spices because it is rich in amino acids, nucleotides, and other flavouring components (Tian et al., 2019; Zheng et al., 2022). Shen et al. (2023) defined CP as a natural food ingredient rich in chicken flavour, which is made from quality broiler chicken as the raw material. Anderson et al. (2014) acknowledged CP as a cheap source of quality protein that can be added to home-prepared meals to improve the flavour and nutritional value of food especially its protein and micronutrient content.

CP is achieved by cooking, drying, and grinding chunks of chicken meat into a powdery form, and utilizing an array of spices and seasonings, which provides an arsenal against microbial load. Sulieman et al. (2023) projected that the incorporation of spices and seasonings into ground and dried chicken meat retards deterioration and helps in culinary enhancement. CP can be consumed as a snack, used in spicing or fortifying meal, thus, reducing malnutrition in humans (Golden 2009). It is also reported to serve as a source of animal protein with no restriction to its use as a meal-fortification in children's and adults' diets, combating the malnutrition challenge (Anderson et al., 2014).

CP is an affordable and sustainable protein source in both rural and urban communities (Rowe et al., 2008). Aslam et al. (2000) reported that, the nutritional quality of CP did not depreciate when it was stored for 140 days at room temperature. CP, therefore, addresses the perishability issue facing meat products in a developing country as a result of epileptic power supply or lack of preservation by refrigeration. Anderson et al. (2014) also noted that, CP can be transported to under-served areas where high quality protein is not available or is limited because of cost. Therefore, this study evaluated the quality and acceptability of chicken powder produced from broiler chicken fed abattoir waste in their diet.

Materials and methods

The experiment was conducted at the Poultry unit, Teaching and Research Farm, and Meat Science Laboratory, Osun State University, Ejigbo campus, Ejigbo.

Sample collection

Abattoir wastes were carefully collected at nearby abattoirs. Abattoirs with strict hygiene measures that prioritize proper segregation and collection were visited in Ejigbo, Osun State, Nigeria. The wastes were collected in leak-proof container and processed following the procedures of Fakolade et al. (2025).

Rumen content was 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 tarpaulin and sun-dried in a well-aerated atmosphere. It was flipped often while drying to aid the drying process. The dried rumen content was milled into finely ground rumen content meal using a milling machine.

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. During the coagulation process, the heating eliminated zoonotic disease pathogens such as brucellosis and tuberculosis (in case there were any). 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 frequently turned for even dryness. The dried blood was crushed into finely ground blood meal with the aid of milling equipment.

Bones were sun-dried until the moisture content was successfully eliminated, at which time they were shattered with a hammer or mortar. After being crushed into small particles, they were steamed at 100 ^{o}C for more than 30 minutes. They were then dried and milled using a milling machine into fine particles.

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 was entirely dried for pounding to take place. The horns and hoofs were mixed and steam-cooked in an autoclave for seven hours at 100-112 ^{o}C (digester). The substance was then dried and finely ground.

Mixing of abattoir waste

Separately, milled abattoir waste was taken to a laboratory for determination of its chemical composition (Table 1). The milled mixture (rumen content, bone, horn, and hoofs) and unmilled (blood) abattoir wastes were then blended at a 1:1 ratio and used at various levels.

Table 1. Proximate composition of abattoir waste.

Parameters	%
Crude protein	17.88
Ash	53.00
Ether extract	5.44
Crude fibre	6.35
Moisture content	7.22
Nitrogen free extract	10.11
Total	**100.00**

Experimental birds and dietary treatments

A total of one hundred and fifty (150 birds) day-old Ross breeds of chicks were purchased from a reliable farm in Osun State. The chicks were raised in a deep litter housing system for 8 weeks (4 weeks for the starter phase and 4 weeks for the finisher phase) that is, from 5th of February to 30th of April, 2024. The birds were rightly vaccinated and appropriate medications were administered to prevent diseases and boost the chick immune system (Table 2). Abattoir wastes were incorporated into the feed ingredients of the broiler chicken at 0%, 5%, 10%, 15%, and 20%. The birds were fed with starter diet in phase 1 (brooding took place at this phase) and finisher diet in phase 2 (Table 3 and Table 4). The experimental birds were randomly allocated to 5 treatments; each treatment had 3 replicates with 10 birds per replicate (summing up to 30 birds per treatment). The birds were subjected to 5 dietary treatments:

Treatment 1: Compounded feed with abattoir waste at 0%
Treatment 2: Compounded feed with abattoir waste at 5%
Treatment 3: Compounded feed with abattoir waste at 10%
Treatment 4: Compounded feed with abattoir waste at 15%
Treatment 5: Compounded feed with abattoir waste at 20%

Table 2. Vaccination and medication programme for broiler chicken.

Age of the birds	Types	Vaccination/Medication
Day 1	Vaccination	Marek (at the hatchery)
1 week	Vaccination	1st (Gumboro vaccine)
2 weeks	Vaccination	1st NDV (Lasota vaccine)
3 weeks	Vaccination	2nd (Gumboro vaccine)
Day 1-3	Medication	Anti-stress, glucose
Day 4-6	Medication	Anti-biotic in water
Day 8-10	Medication	Live water
Day 10-13	Medication	Anti-coccidial in water
Day 15-17	Medication	Live water
Day 18-20	Medication	Vitamins
Day 22-24	Medication	Live water
Day 25-27	Medication	Anti-biotic in water
Day 29-33	Medication	Anti-coccidial in water
Day 34-35	Medication	Anti-coccidial in water
Day 36-37	Medication	Iodine in water
Day 37-40	Medication	Live water

Table 3. Experimental diet fed to broiler chicken (starter phase).

Ingredients	0% (T1)	5% (T2)	10% (T3)	15% (T4)	20% (T5)
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	14.50	15.38	10.00	8.20	6.20
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	0.50	0.52	0.53

Table 4. Experimental diet fed to broiler chicken (finisher phase).

Ingredients	0% (T1)	5% (T2)	10% (T3)	15% (T4)	20% (T5)
Maize	61.42	62.47	63.75	64.37	60.75
Soya bean meal	15.80	9.80	7.20	4.25	4.01
Groundnut cake	7.00	7.80	4.50	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	18.00	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	0.70	0.68
%Lysine	0.97	1.18	1.43	1.69	1.73
%Methionine	0.42	0.44	0.46	0.48	0.50

Production of chicken powder

At the end of the experiment, 3 birds were randomly selected from each treatment (one from each replicate), fasted overnight, and slaughtered for further processing. Immersion: the collected muscle from each treatment was deboned and cut into pieces of 8-9 cm long, weighing 80 grams. The deboned muscles of each treatment were immersed into a mixture of 100 ml of water and 200 ml of apple cider for 24 hours in the refrigerator to prolong their shelf life. Boiling: muscles from each treatment were boiled at 100 ^{o}C for 20 minutes with the addition of seasonings and spices. Drying: after boiling, each treatment was oven-dried at 175 ^{o}C for 2 hours. The broiler meat was turned alternately to achieve uniform doneness. Grinding: each treatment was ground with the aid of electric blender (8000 watt Kenwood multifunction commercial grinder blender, made in Germany) for 1 minute to transform it to powder (Table 5). Data collection: proximate (protein, ash, ether extract, moisture content, and cholesterol) and minerals (iron, potassium, and sodium) were carried out according to AOAC (2012). Microbial loads were carried out using the procedure of Albrecht et al. (2019). Sensorial properties were evaluated according to Fakolade et al. (2018). Analyses were carried out on day 0 and 28. A total of 20 grams of each sample of chicken powder (CP) was kept on the shelf at a room temperature (24 ^{o}C) for 28 days for laboratory analysis on the 28th day.

Table 5. Ingredients for chicken powder preparation.

Ingredients	Scientific names	Quantity (gram)
Broiler meat	-	80
Garlic	*Allium Sativum* L.	2
Ginger	*Zingiber officinale* Rosc.	2
Curry	*Murray akoenigii* L.	1.5
Thyme	*Thymus vulgaris* L.	1.5
Onions	*Allium cepa* L.	9.5
Salt	Sodium chloride	2.0
Maggi	Monosodium glutamate	1.5

Statistical analysis

The experimental design used for the study was a completely randomized design (CRD). All the data were subjected to two-ways analysis of variance (ANOVA), and means were compared using Duncan's Multiple Range Test. The SPSS computer software (IBM, SPSS statistics, Chicago, U.S.A.) was used for all statistical analysis.

Results and discussion

Table 6. Proximate and mineral composition of chicken powder (CP) produced from broiler chicken fed abattoir waste (AW) in their diet at day 0.

Parameters	T1	T2	T3	T4	T5	SEM
Crude protein (g)	79.40^{b}	91.11^{a}	90.03^{a}	85.85^{a}	85.45^{a}	5.20
Ash (%)	2.14^{c}	1.98^{c}	2.06^{c}	4.20^{a}	3.50^{b}	0.12
Fat (%)	6.07^{a}	6.09^{a}	5.88^{b}	5.32^{b}	5.52^{b}	0.47
Moisture content (%)	6.11^{b}	5.76^{c}	7.01^{a}	7.12^{a}	7.11^{a}	1.33
Cholesterol (mg)	21.86^{d}	31.06^{ab}	26.54^{c}	29.67^{b}	33.04^{a}	4.16
Fe (mg/100g)	0.57	0.48	0.52	0.65	0.61	0.32
K (mg/100g)	18.40^{c}	16.50^{d}	19.30^{c}	21.20^{b}	23.40^{a}	2.59
Na (mg/100g)	57.20^{d}	61.40^{c}	63.40^{ab}	65.80^{a}	64.30^{ab}	3.22

Note: Different superscript letters (a, b, c, d) in the same row indicate significant differences ($p < 0.05$).
Abbreviations: T1: 0% AW used for CP, T2: 5% AW used for CP, T3: 10% AW used for CP, T4: 15% AW used for CP, T5: 20% AW used for CP, Fe: Iron, K: Potassium, Na: Sodium, SEM: Standard error of means.

From Table 6, a range of 79.40-91.11 g was obtained as the crude protein of chicken powder processed from broiler chicken fed with abattoir waste in their diet with the least crude protein for chicken powder (CP) obtained in T1. CP processed from T2-T4 appeared to have the highest with no significant ($p > 0.05$) difference. The result of chicken powder produced from T1, the control treatment (79.40 g) is in agreement with the research of Aslam et al. (2000) where the authors obtained a range of 79-83 grams when chicken powder was produced from broiler chicken. However, a range of 72-75 grams was obtained by Anderson et al. (2014). Though the values are within the same range, the variations observed could be a result of differences in the feed ingredients of the feed supplied to the broiler chicken. The high values of crude protein obtained for CP in this study especially for T2-T5, could be a result of the inclusion of abattoir waste in the diet of the broiler chicken used for its processing.

Onunkwo et al. (2018) and Sakaba et al. (2017) acknowledged abattoir waste as a rich protein source in the feed of broiler chicken. It is evident that, the quality and quantity of feed supplied to an animal have a significant impact on the quality and quantity of meat obtained; Zhu et al. (2019) also noted that the crude protein in the feeds affects the nutritional component of the birds. High values for CP observed in this study could also be as a result of the whole broiler chicken used in the processing of CP, and this is established by the findings of Aslam et al. (2000), who found that whole broiler chicken gives a better and different result compared to when a particular part or cut is used. Geiker et al. (2021) also established that, a dehydrated meat product such as CP usually has higher amount of protein because the nutrient has been concentrated. This research agrees with the conclusion of Anderson et al. (2014) that, CP is a cheap source of protein since the protein of broiler chicken is 23-24 g (Liu et al., 2021), therefore, consumers have the opportunity of consuming high amount of crude protein when broiler chicken is processed into CP, and the inclusion of AW in the diet of broiler chicken offers a higher amount of crude protein in chicken and chicken powder.

For the ash content, a range of 1.98-4.20% was obtained and this is within the standard range, as ash content must not exceed 15% (Liu et al., 2019). Ash content is used in assessing the mineral composition in food products however, when it is present in higher quantity, it indicates older or contaminated food and presence of non-nutritive inorganic material affecting food quality and safety; and it may at times cause cancer and obesity (Liu et al., 2019). The result of this study (1.98-4.20) is consistent with that of Anderson et al. (2014) and Aslam et al. (2000), where the authors respectively obtained 5% and 6-7.50% for ash content in CP, confirmed CP as a safe product fit for human consumption.

Also, the inclusion of AW in the diet of broiler chicken does not influence the fat content of CP. T1 and T2 were significantly higher in fat with no significant ($p > 0.05$) difference while the least values for fat were observed in the CP of T3, T4, and T5. Treatments with low fat content (T3-T5) were significantly higher in moisture content with no significant ($p > 0.05$) difference. T2 that had high amount of fat, appeared to have the least moisture content (5.76%) and this is in line with the research of Williams (2007), who stated that, the higher the fat content, the lower the moisture content. The result obtained for cholesterol indicated that CP is safe to consume (21.86-33.04 mg), because high cholesterol can cause heart diseases, stroke, and cardiovascular problems. A report by Medical News Today (2025) stated that chicken meat should not contain more than 119 mg of cholesterol and no individual should consume an amount greater than 300 mg per day (Alyse 2025). Although the result obtained in this study is higher than 6.8-7.20 mg obtained by Aslam et al. (2000), this variation could be impacted by the feeds given to the broiler chicken (Zhu et al., 2019) and differences in cooking method (Alyse 2025).

The minerals evaluated showed that, there was no significant ($p > 0.05$) difference in the Fe and K of CP across the treatments. For Na, treatments with low ash content has the lowest amount (T1-T3) while treatments with high ash content had the highest amount of Na with no significant difference. This finding is in alignment with the conclusion of Liu et al. (2019) that ash content is used in assessing the mineral content in food products.

Table 7. Proximate and mineral composition of chicken powder produced from broiler chicken fed abattoir waste in their diet at day 28.

Parameters	T1	T2	T3	T4	T5	SEM
Crude protein (g)	78.90[b]	82.85[a]	83.46[a]	81.79[a]	84.12[a]	4.42
Ash (%)	4.60	5.00	4.52	5.27	5.17	0.92
Fat (%)	5.96	6.30	6.52	6.30	6.27	0.56
Moisture content (%)	8.11	8.33	8.79	7.46	6.89	1.96
Cholesterol (mg)	34.93	33.47	36.03	32.45	37.28	4.81
Fe (mg/100g)	1.16	1.36	1.09	1.12	1.22	0.62
K (mg/100g)	24.16	25.05	24.80	26.30	25.60	3.42
Na (mg/100g)	73.64[b]	82.66[a]	69.21[bc]	71.32[b]	76.32[b]	4.01

Note: Different superscript letters (a, b, c) in the same row indicate significant differences ($p < 0.05$).

Abbreviations: T1: 0% AW used for CP, T2: 5% AW used for CP, T3: 10% AW used for CP, T4: 15% AW used for CP, T5: 20% AW used for CP, Fe: Iron, K: Potassium, Na: Sodium, SEM: Standard error of means.

It was observed in Table 7 that there were no significant changes in the nutritive value of protein and fat; however, moisture and ash content increased with an increase in storage days. When Aslam et al. (2000) stored CP for 140 days, they also observed no significant changes in the protein and fat content while rancidity, moisture, and ash content of CP increased as the product aged. A protein content of 78.90-84.12 g was obtained, with the least recorded in T1 (78.90 g). The CP processed from broiler chicken with the inclusion of AW in their diet showed no significant changes in the protein content, having a range of 81.79-84.12 g. The values obtained for protein content on day 28 for CP processed from broiler chicken fed an AW diet are not far below but within a close range of the values obtained on day 0 (85.45-91.11 g). When Aslam et al. (2000) stored CP for 140 days, they obtained 80-81 g of protein on days 20-40, which is lower than the range of 81.79-84.12 g derived from broiler chicken fed AW-diet on day 28 of this study. This implies that AW has proven to boost the protein content of CP.

The increase in moisture and ash content confirmed the report of Aslam et al. (2000) that storage intervals can cause variation in certain components of the nutritive value. The increase in the ash content shows that the product is getting older and probably getting contaminated on the shelf during storage while the increase in moisture is an indication that the product absorbed moisture from the shelf environment, making it prone to microbial deterioration. Cholesterol and minerals evaluated (Fe, K, and Na) increased with longer storage days with no significant difference.

Table 8. Microbial load of chicken powder produced from broiler chicken fed abattoir waste in their diet at day 0.

Parameters	T1	T2	T3	T4	T5	SEM
TVC ($x10^{-7}$) cfu/g	5.41^{b}	5.07^{b}	4.95^{c}	6.14^{a}	6.06^{a}	0.58
TBC ($x10^{-5}$) cfu/g	5.03^{b}	4.66^{c}	4.29^{d}	5.75^{a}	5.58^{a}	0.57
TFC ($x10^{-5}$) cfu/g	1.20	1.10	1.06	1.25	1.22	0.15
TCC ($x10^{-1}$) cfu/g	0.65	0.50	0.39	0.71	0.55	0.08

Note: Different superscript letters (a, b, c, d) in the same row indicate significant differences ($p < 0.05$).
Abbreviations: T1: 0% AW used for CP, T2: 5% AW used for CP, T3: 10% AW used for CP, T4: 15% AW used for CP, T5: 20% AW used for CP, TVC: Total viable count, TBC: Total bacteria count, TFC: Total fungal count, TCC: Total coliform count, SEM: Standard error of means.

Chicken and chicken by-products are described as a reservoir of a variety of pathogens because they are nutrient-dense food (Zheng et al., 2022). From Table 8, based on the parameters evaluated across the treatments, it is revealed that total viable count (TVC), total bacteria count (TBC), total fungal count (TFC), and total coliform count (TCC) of CP processed from broiler chicken fed T2 (5%) and T3 (10%) inclusion of AW in their diets had the least loads of microorganisms. It can therefore be suggested that, inclusion of AW in the diet of broiler chicken should not exceed 5-10%. This is because higher level of inclusion of AW will increase the amount of protein in chicken and its products, resulting in greater susceptibility to microbial growth. T4 and T5 had the highest TVC and TBC. TVC is the number of microorganisms, especially bacteria, growing under aerobic condition; such bacteria are responsible for spoilage and deteriorative changes in meat and meat products (Mouafo et al., 2020). The result obtained for TVC (4.95-5.07 cfu/g) and TBC (4.29-4.66 cfu/g) at 5-10% inclusion of AW in the diet of broiler chicken used in the processing of CP falls within the standard limit of 5 cfu/g recommended by the European union (Mouafo et al., 2020). This suggests that CP has a low risk of transmission of pathogenic bacteria to consumers (Agbodaze et al., 2005).

There was no significant ($p > 0.05$) difference in the TFC and TCC across the treatments. When TCC is present in high amounts, it is an indication of unhygienic practices during processing and storage (Mouafo et al., 2020). The European Union recommends that coliform contamination should not exceed 2.5 cfu/g. The value of 0.39-0.65 cfu/g obtained in this study indicated good hygiene practices thus, endorsing chicken powder to be a safe product that can be consumed especially when it is processed hygienically.

Table 9. Microbial load of chicken powder produced from broiler chicken fed abattoir waste in their diet at day 28.

Parameters	T1	T2	T3	T4	T5	SEM
TVC ($x10^{-5}$) cfu/g	6.12^{ab}	5.45^{b}	5.20^{b}	6.96^{ab}	7.17^{a}	0.08
TBC ($x10^{-3}$) cfu/g	5.90^{b}	5.05^{c}	4.82^{c}	6.20^{ab}	7.03^{a}	0.85
TFC ($x10^{-3}$) cfu/g	1.45	1.38	1.26	1.64	1.55	0.38
TCC ($x10^{-1}$) cfu/g	0.72	0.59	0.48	0.91	0.66	0.11

Note: Different superscript letters (a, b, c) in the same row indicate significant differences ($p < 0.05$).

Abbreviations: T1: 0% AW used for CP, T2: 5% AW used for CP, T3: 10% AW used for CP, T4: 15% AW used for CP, T5: 20% AW used for CP, TVC: Total viable count, TBC: Total bacteria count, TFC: Total fungal count, TCC: Total coliform count, SEM = Standard error of means.

Evaluation of microbial load of chicken powder from broiler fed abattoir waste in their diet on day 28 is presented in Table 9. It was observed that, there was a slight increase in microbial activities as the storage days increased. The increase in microbial activities was not pronounced because microbial activities is always low in dried products because of low water activity (Ilansuriyan et al., 2015). A range of 5.20-7.17 x 10^{-5} cfu/g was obtained for TVC. Safe level of TBC was found in 5% (5.05 x 10^{-3} cfu/g) and 10% (4.82 x 10^{-3} cfu/g) of AW in the diet of broiler chicken with no significance difference. Although, there is no specific limit recommended for CP, the total bacteria count obtained in this study aligns with the European Union recommended limit of 5 cfu/g obtained for beef products. There was no significant difference in the TFC across the treatments. Also, no significant difference was recorded in the TCC across the treatments, indicating good hygiene measures on storage, as the values obtained were very low.

Table 10. Sensory properties of chicken powder produced from broiler chicken fed abattoir waste in their diet at day 0.

Parameters	T1	T2	T3	T4	T5	SEM
Colour	6.64^{a}	5.45^{b}	3.73^{c}	3.94^{c}	4.00^{c}	1.18
Flavour	4.82^{b}	5.91^{a}	5.10^{a}	5.18^{a}	5.36^{a}	0.17
Tenderness	5.45^{a}	5.36^{a}	4.78^{a}	3.91^{a}	4.36^{b}	0.68
Juiciness	4.09^{c}	7.42^{a}	5.18^{b}	4.09^{c}	4.64^{c}	0.17
Texture	4.55^{ab}	5.27^{a}	5.18^{a}	3.55^{c}	3.91^{c}	0.78
Acceptability	6.00^{b}	7.09^{a}	6.00^{b}	5.27^{c}	5.36^{c}	0.84

Note: Different superscript letters (a, b, c) in the same row indicate significant differences ($p < 0.05$).

Abbreviations: T1: 0% AW used for CP, T2: 5% AW used for CP, T3: 10% AW used for CP, T4: 15% AW used for CP, T5: 20% AW used for CP, SEM: Standard error of means.

Sensory analysis is a subjective and one of the oldest methods of checking meat quality (Table 10); it helps to identify, understand, and respond to consumer preferences more effectively (Ilansuriyan et al., 2015). Consumers select their preference by assessing the colour, flavour, tenderness, juiciness, texture, and acceptability. Colour is an important attribute that influences consumer acceptance of many foods (Ilanrisuyan et al., 2015) and it is the first criterion in assessing food. The colour of CP from T1 was preferred, followed by CP from T2. The colour of T3-T5 was least accepted, with no significant ($p > 0.05$) difference. This implies that the preference and level of acceptance for colour decreased with an increase in AW in broiler chicken diet. It can thus be said that AW in the diet of broiler chicken has an impact on the colour of chicken powder.

CP produced from T2 was significantly ($p < 0.05$) higher in flavor, tenderness, juiciness, and texture, and these factors are responsible for the overall acceptance of T2 (7.09). There is no significant ($p > 0.05$) difference in the acceptance level of T1 and T3, suggesting that, inclusion of AW into the diet of broiler chicken at 5-10% does not negatively affect the sensorial properties of CP. The least juiciness, tenderness, and texture were observed at T5, indicating that inclusion of higher levels of AW into broiler feeds can affect the quality of the product by imparting coarseness, toughness, and dryness. Flavour is the perception of a consumer about a particular food product. It is interesting to note that AW does not mute the flavour or aroma of CP; it, however increases flavour, as CP becomes flavourful with an increase in inclusion level of AW.

Table 11. Sensory properties of chicken powder produced from broiler chicken fed abattoir waste in their diet at day 28.

Parameters	T1	T2	T3	T4	T5	SEM
Colour	7.66^{a}	6.00^{b}	5.00^{c}	5.66^{c}	5.66^{c}	0.24
Flavour	3.00^{d}	6.00^{b}	5.00^{cd}	5.66^{c}	7.00^{a}	0.24
Tenderness	4.33^{b}	5.66^{a}	5.00^{a}	4.66^{b}	4.00^{b}	0.51
Juiciness	6.00^{b}	7.00^{a}	6.33^{b}	5.33^{c}	5.33^{c}	0.28
Texture	5.66^{a}	5.66^{a}	4.33^{b}	3.66^{c}	5.00^{b}	0.31
Acceptability	7.33^{a}	7.33^{a}	7.00^{b}	5.33^{c}	7.00^{b}	0.18

Note: Different superscript letters (a, b, c, d) in the same row indicate significant differences ($p < 0.05$).

Abbreviations: T1: 0% AW used for CP, T2: 5% AW used for CP, T3: 10% AW used for CP, T4: 15% AW used for CP, T5: 20% AW used for CP, SEM: Standard error of means.

Table 11 reflects that storage days and level of inclusion have significant effect on the sensory properties of CP. The degree of colour preference of CP decreased with the inclusion of AW in the feed of broiler chicken, while the flavour of CP increased with inclusion level of AW. When the values obtained for flavour on day 0 (4.82-5.91) are compared with the values obtained on day 28 (3.00-7.00), it can be deduced that, the flavour of CP processed from broiler fed with high amount of abattoir waste (T5) increased with storage days. Upon storage, T2 maintained its quality in terms of tenderness, juiciness, and texture, which made it more acceptable and preferable. Although T1 and T2 were acceptable at the same degree, they were followed by T3 and T5. The acceptance of T5 can be attributed to its high flavour, moderate tenderness, and texture.

Conclusion

Chicken powder obtained from broiler chicken in T2 and T3 (5% and 10% AW) performed excellently when the proximate, microbial load, and palatability scores were considered. Flavour and mineral content increased with increase in abattoir waste. Inclusion of abattoir waste does not negatively affect the nutritional quality of chicken

powder but improves it, especially the protein content when incorporated at a safe level of 5-10%. Chicken powder is therefore a high protein additives, spices, or food flavouring agent, capable of improving nutritional quality of humans, while the inclusion of abattoir waste in the diet of broiler chicken offers an improved nutritive value for chicken powder.

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