Haematological and serum indices, carcass traits and sensory evaluation of meat derived from broiler chickens fed *Zymomonas mobilis* treated corn cobs

Alade, A. A.[1]*, Bamgbose, A. M.[2], Oso, A. O.[2], Akinbode, R. M.[2], Oke, O. E.[3], Fafiolu, A. O.[2], Sobayo, R. O.[2] and Obadina, F. J.[4]

[1]Africa Centre of Excellence in Agricultural Development and Sustainable Environment, Federal University of Agriculture, Abeokuta, Nigeria
[2]Department of Animal Nutrition, Federal University of Agriculture, Abeokuta, Nigeria
[3]Department of Animal Physiology, Federal University of Agriculture, Abeokuta, Nigeria
[4]Goverment Science and Technical College, Abeokuta, Nigeria

Abstract

A 56-day study was conducted to determine the effects of *Zymomonas mobilis* treated corn cobs (ZTCC) on haematological and serum indices, carcass traits and sensory evaluation of meat of broiler chickens. 375 one-day old broiler chicks were randomly allotted to 5 dietary treatments with 75 broiler chicks per treatment and replicated 5 times with 15 birds each. Diets were formulated to include untreated corn cobs (UTCC) and ZTCC at varying levels of 0, 50 and 100% to replace wheat offal weight for weight. Experimental design was completely randomized design. At the starting phase, UTCC and ZTCC decreased ($p<0.05$) the red blood cell (RBC), white blood cell (WBC), but increased ($p<0.05$) mean corpuscular haemoglobin (MCH) and mean corpuscular volume (MCV). The values of total protein, albumin and cholesterol (except in 100% ZTCC) were decreased ($p<0.05$) across the treatments. At the finishing phase, broilers fed with UTCC and ZTCC had reduced ($p<0.05$) packed cell volume, haemaglobin while RBC increased with 50% ZTCC. The birds fed 50% UTCC had highest ($p<0.05$) values for total protein, albumin, globulin, uric acid and alanine amino-transferase. The birds fed 100% ZTCC had highest ($p<0.05$) values for glucose, cholesterol, creatinine and aspartate amino-transferase. The dietary treatments influenced ($p<0.05$) the live weight, dressed weight, eviscerated weight and dressing percentage. Breast meat samples from 100% UTSD and 50% ZTSD showed improved colour, flavour and overall acceptability values. In conclusion, up to 100% UTCC and ZTCC can replace wheat offal in broiler chicken diets without deleterious effects on their health status.

Keywords: corn cob, carcass traits, haematology, sensory evaluation, serum profiles, *Zymomonas mobilis*

Running headlines: Health status of broilers fed with treated corn cobs

Introduction

Poultry meat is favoured over beef because of its higher protein and lower caloric content in addition to other favourable meat qualities such as tenderness (Dafwang, 2002). Broiler meat is generally accepted and rapidly consumed by practically every tribe around the world (Okon, 1983). In many countries, per capita consumption of poultry meat has expanded directly in proportion to the increase in the availability of poultry meat at an affordable price (FAO, 1966). Agriculturists and nutritionists have generally agreed that developing the poultry industry is the fastest means of bridging the protein-deficiency gap presently prevailing in the tropics (Amos, 2006). It is also a promising source of additional income and quick returns from investment (Kekocha, 1994). There had been inadequate supply of good quality feeds throughout the year due to seasonal fluctuations in supply of conventional ingredients. This is a major problem preventing the optimum performance of poultry birds in the developing countries.

Animal nutritionists focus on cheap but suitable alternative feedstuffs especially crop residues and industrial by–products, to sustain livestock industry (Alhassan, 1985). The evaluation of these unconventional feed resources besides other strategies would reduce pressure on the demand for conventional feed resources thereby ensuring attainment of feed security for poultry (Fajimi *et* al., 1993).

Corn cob is derived from the post-harvest processing of maize which account for about 30 – 40% of the weight of the dehusked maize (Adeyemi *et al*., 2008). The militating problem affecting the use of corn cobs in chicken diet is the constituent high fibre content which can be improved by fermentation. The utilization of corn cob will reduce the attendant competition between man and animals especially in monogastric animal nutrition (Oke *et al*., 2007). The use of fermentation procedures to improve the nutritive value, utilization of fibrous feeds as well as the generation of high protein had been reported by Cantner (1995) and Rajagopal (1977).

Corn cobs are utilized as feed fillers for ruminants (Umunna *et al*., 1980; Alokan, 1998), but they are not included in commercial non-ruminant animal feed due to its high fibre content which will impair digestion and utilization by these animals (Adeyemi *et al*., 2008). Thus, the nutritive values of corn cobs depend on the availability of nutrients, lignification and crystallinity of cellulose (Olagunju *et al*., 2013).

In a trial in Nigeria, pullets fed a diet containing 10% maize cobs reached maturity earlier, but birds fed 20% maize cobs did not come into lay within the time frame of the experiment. In Ghana, diets containing up to 7.5% ground maize cobs fed *ad libitum* to commercial broiler chickens did not alter growth performance, carcass yields, health and biochemical indices (Donkoh *et al*. 2003).

Bounous *et al*. (2000) reported that the laboratory examination of blood variables would help diagnose of several diseases and livestock dysfunctions. It can provide reliable results and promote research studies on nutrition, physiology and pathology. Some authors had reported in their previous works that the blood variables (RBC, PCV, plasma protein and glucose) were most consistently affected by dietary treatments (Aletor, 1989; Aletor and Egberongbe, 1992). Duke (1985) had clearly established the functions of blood in circulating hormones, metabolites, as thermo-regulators and general homeostasis in farm animals. Also, Veulterinora (1991) reported that diets have a significant influence on haematological variables. Therefore, there is little information found in the literature concerning the utilization of untreated and/or *Zymomonas mobilis* treated corn cobs for broiler chickens. The study was conducted to evaluate the effects of the dietary inclusion of Zymomonas mobilis treated corn cobs on blood profiles and meat quality of broiler chickens.

Materials and Methods

Research station and test ingredient

The research was carried out at the Poultry Unit, Directorate of University Farms (DUFARMS), and Animal Nutrition Laboratory, Federal University of Agriculture, Abeokuta, Ogun State, Nigeria located at 7°10′N and 3°2′E, 76 m above sea level. It lies within the South-Western part of Nigeria with a prevailing tropical climate, mean annual rainfall of 1,238 mm and an average temperature of 27.1 °C (Climate-data.org Nigeria Ogun, 2020).

The corn cobs were collected from the maize shelling unit of the Obasanjo farm Nigeria, Ltd., Igboora, Nigeria. The corn cobs were crushed using hammer mill and screened using 3.5mm sieve before storage on pallets.

Pure strains of *Zymomonas mobilis* used in this study were extracted from fresh palm wine used to inoculate the corn cobs (CC) to obtain CC starter inoculum.

This was prepared in the traditional setting under laboratory condition as stated by Anigbogu *et al*. (2009) using a fermentation vat (volume 3.5 litres). The following materials were weighed and homogeneously mixed, 500g corn cobs as a substrate with 100ml of *Zymomonas mobilis* suspended in a cultured media in the fermentation vat. Two litres of water were poured into the vat and stirred to obtain a homogeneous mixture at a room temperature (23.1ºC to 24.6 ºC) for 20 days and turned 24 hourly using a plastic rod. The fermented product (fermented dough) was used as a starter inoculum for the study.

The life enzyme was prepared as in Anigbogu *et al*. (2009) using 25 kg corn cobs placed in the fermentation vat (capacity = 100 litres) with 50 litres of water added to 2.5 kg fermented dough (starter inoculum). The sample was homogeneously mixed and kept to ferment for 20 days. The fermented product was sun-dried, analysed and stored as life-enzyme corn cobs.

Management of broiler chickens and experimental diets

Three hundred and seventy-five (375) 1-day old unsexed marshal broiler chicks were obtained from Obasanjo Farms Nigeria limited, Lanlate, Nigeria. They were weighed on group basis and the weight was divided by the number in the group to obtain individual weight, and randomly allotted to five dietary treatments with 75 broiler chicks per treatment and were replicated 5 times with 15 birds each. The chicks were brooded for 2 weeks, routine vaccinations and necessary medication were administered. Feed and water were given *ad libitum*. The birds were raised for eight weeks (0 – 4 weeks for the starter phase and 5-8 weeks for the finisher phase). The diets were formulated to include untreated and *Z. mobilis* treated corn cobs at varying levels of 0, 50 and 100% to replace wheat offal weight for weight.

The composition of the experimental diets is shown in Table 1.

Table 1. Percentage Composition of Experimental Broiler Chicken Diets (DM- Basis)

Ingredients	Starter Diets					Finisher diets				
	0%	-Zmobilis 50%	-Zmobilis 100%	+Zmobilis 50%	+Zmobilis 100%	0%	-Zmobilis 50%	-Zmobilis 100%	+Zmobilis 50%	+Zmobilis 100%
Maize	53.60	53.60	53.60	53.60	53.60	54.60	54.60	54.60	54.60	54.60
Soyabean meal	29.50	29.50	29.50	29.50	29.50	23.50	23.50	23.50	23.50	23.50
Fish meal	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Groundnut cake	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
Wheat offal	5.00	2.50	0.00	2.50	0.00	10.00	5.00	0.00	5.00	0.00
Corn cobs	0.00	2.50	5.00	2.50	5.00	0.00	5.00	10.00	5.00	10.00
Bone meal	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Limestone	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
Broiler premix[ab]	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Lysine	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Methionine[c]	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Toxin binder	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Salt	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
TOTAL	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**
Calculated analysis:										
Metabolizable energy (MJ/Kg)	12.00	11.94	11.88	12.10	12.20	11.92	11.81	11.69	12.12	12.31
Crude Protein (%)	23.38	23.04	22.70	23.19	23.01	21.68	21.00	20.32	21.31	20.93
Crude Fibre (%)	3.62	4.54	5.45	3.88	4.14	3.67	5.51	7.34	4.20	4.72
Ether Extract (%)	3.83	3.76	3.69	3.95	4.08	3.83	3.69	3.55	4.08	4.33
Ash (%)	2.60	2.80	3.00	2.65	2.70	2.26	2.65	3.05	2.36	2.46
Nitrogen Free Extract (%)	50.57	49.86	49.16	50.32	50.07	52.56	51.14	49.73	52.06	51.56
Calcium (%)	1.48	1.55	1.63	1.54	1.59	1.47	1.62	1.76	1.58	1.69
Phosphorus (%)	0.57	0.59	0.61	0.59	0.61	0.54	0.57	0.61	0.57	0.61

[a]Starter Vitamin-Mineral Premix: (Rotinol) based on 2.5 kg/ton (Thiamine, 2000 mg, riboflavin, 7000 mg, pyridoxine, 5000 mg, cyanocobalamine, 1700 mg, niacin, 30,000 mg, D-panthotenate, 10,000 mg, folic acid, 800 mg, biotin, 2000 mg, Retinyl acetate, 12,000 iu., cholecalciferol, 2,400,000 iu., tocopherol acetate, 35,000 iu., menadione, 4,000 mg, ascorbic acid, 60,000 mg, manganese, nill, iron, 70,200 mg, zinc, nill, copper, nill, cobalt, 200 mg, iodine, 400 mg, selenium, 80 mg, choline chloride, 500,000 mg.

[b]Finisher Vitamin-Mineral Premix: (Rotinol) based on 2.5 kg/ton (Thiamine, 1000 mg, riboflavin, 6000 mg, pyridoxine, 5000 mg, cyanocobalamine, 25 mg, niacin, 60,000 mg., D-panthotenate, 20,000 mg, folic acid, 200 mg, D-biotin, 8 mg, Retinyl acetate, 40 mg, cholecalciferol, 500mg, tocopherol acetate, 40,000 mg., menadione, 800 mg, ascorbic acid, 60,000 mg, manganese, nill, iron, 80,000 mg, zinc, nill, copper, nill, cobalt, 80 mg, iodine, 400 mg, selenium, 40 mg, choline chloride, 80,000 mg

[c]Methionine Hydroxyl Analog (MHA): (Novus International Inc.St. Charles, MO), feed supplement providing 84% Methionine activity

Data collection

Blood collection and analysis

Blood samples were collected individually from 25 broiler chickens (5 birds per treatment) via the wing vein using sterilized syringe at the end of the starting and finishing phases of the feeding trials. About 2.5ml of blood sample was collected from each bird into vials containing ethylene diamine tetra-acetic acid (EDTA) as anticoagulant for the determination of haematological parameters (Red Blood Cell, White Blood Cell, Packed Cell Volume and Haemoglobin). However, another set was collected into plain tubes for serum biochemistry measurement (Glucose, Cholesterol, Total Protein, Albumin, Globulin, Uric acid, Creatinine, Aspartate aminotransferase and Alanine aminotransferase). The blood samples were allowed to clot, and put in a refrigerator for 6 hours and later spun in a centrifuge at 900 rpm for 20 minutes. The separated blood sera was labelled for each bird and stored in the freezer at 2^{o}C prior to analysis. The sera were allowed to thaw under room temperature before subsequent analyses. Haemoglobin concentration was estimated using the cyanmethaemoglobin method (Cannan, 1958), packed cell volume (PCV), red blood cell (RBC) and white blood cell (WBC) count of the blood samples were determined in Wintrobe haematocrit tube according to the method of Schalm *et al*. (1975).

Carcass and organ weight determination

At the end of 8 weeks feeding trial, twenty-five broiler chickens (5 birds per treatment) whose weights were similar or close to the average weight of the chickens in each treatment were selected and starved for about 18 hours to empty their crops. They were slaughtered by cervical dislocation, allowed to bleed, scalded in warm water and defeathered. They were thereafter taken to the laboratory where other measurement like the dressed weight, weight of the cut-up parts and organs were taken with a sensitive electronic scale. The weight of the cut-up parts and organs was expressed as percentage of live weight according to “Modified Kosher” method as described by Abe *et al*., (1996), while the dressing percentage was calculated as follows:

$$\text{Dressing \%} = \frac{\text{Eviscerated weight}}{\text{Liveweight}} \times \frac{100}{1}$$

Sensory Evaluation

Sensory evaluation of cooked minced breast samples from five birds per treatment were carried out by fifteen panelists. Parameters evaluated includes. colour, juiciness, flavour, tenderness and overall acceptability. Each meat sample was coded and presented one after the other to each member of the panel. Each member rinsed his or her mouth with water after assessing each meat sample to avoid carry over effect. The panelists awarded scores using a nine (9) point hedonic scale of (i) Dislike extremely (ii) Dislike very much (iii) Dislike moderately (iv) Dislike slightly (v) Intermediate (vi) Like slightly (vii) Like moderately (viii) Like very much (ix) Like extremely (Ogunwole *et al*., 2013).

Experimental design and Statistical analysis

The experimental design used for this study was completely randomized design (CRD). All data collected were subjected to one-way analysis of variance (ANOVA) as outlined by Daniel (1995) with the aid of SAS (2001) and the significant means separated by Duncan’s multiple range test at 5% level of significance (Steel and Torrie, 1980).

Results

The haematological and serum metabolites of starting broiler chickens fed corn based diets are shown in Table 2. The dietary inclusion of untreated and *Z. mobilis* treated corn cobs significantly ($p<0.05$) decreased the red blood cell (RBC), white blood cell (except in birds fed 50% ZTCC) but increased ($p<0.05$) mean corpuscular haemoglobin (MCH) and mean corpuscular volume (MCV). Moreover, there were influence ($p<0.05$) on the eosinophil, monocytes, and basophils. The dietary treatments influenced ($p<0.05$) all the serum metabolites observed in the current study. The dietary inclusion of UTCC and ZTCC decreased ($p<0.05$) total protein, albumin and cholesterol (except in 100% ZTCC) across the treatments.

Table 2. Haematological parameters and serum metabolites of starting broiler chickens (0 – 4 weeks) fed diets containing untreated and treated corn cobs

Parameters	Dietary treatments					SEM
	1	2	3	4	5	
	Control diet	50% UTCC	100% UTCC	50% ZTCC	100% ZTCC	
Haematological parameters:						
Packed cell volume (%)	27.00	25.00	25.00	28.00	30.00	0.79
Haemoglobin (g/dl)	9.00	8.30	8.00	9.30	10.00	0.32
Red blood cell ($x10^{12/L}$)	3.70^{a}	1.30^{d}	2.10^{c}	1.20^{d}	3.00^{b}	0.27
Mean Corpuscular Haemoglobin (pg)	24.00^{e}	64.00^{b}	38.00^{c}	78.00^{a}	33.00^{d}	5.44
Mean Corpuscular Haemoglobin in Concentration (g/dl)	33.30	33.20	32.00	33.20	33.30	0.57
Mean Corpuscular Volume (fl)	73.00^{d}	192.00^{b}	119.00^{c}	233.00^{a}	100.00^{c}	16.14
White blood cell ($x10^{9/L}$)	16.10^{ab}	14.50^{b}	11.80^{c}	18.20^{a}	15.40^{b}	0.63
Heterophil (%)	32.00^{ab}	33.00^{ab}	24.00^{c}	30.00^{b}	36.00^{a}	1.21
Lymphocytes (%)	69.00^{ab}	65.00^{ab}	72.00^{a}	70.00^{ab}	63.00^{b}	1.22
Eosinophil (%)	0.00^{b}	1.00^{a}	0.00^{b}	0.00^{b}	0.00^{b}	0.12
Monocytes (%)	0.00^{b}	1.00^{a}	1.00^{a}	0.00^{b}	0.00^{b}	0.13
Basophils (%)	1.00^{b}	0.00^{c}	2.00^{a}	0.00^{c}	1.00^{b}	0.20
Serum metabolites:						
Total protein (g/dl)	4.50^{a}	3.50^{b}	3.10^{c}	3.10^{c}	3.20^{bc}	0.15
Albumin (g/dl)	2.30^{ab}	2.50^{a}	2.00^{bc}	1.80^{cd}	1.60^{d}	0.10
Globulin (g/dl)	2.20^{a}	1.00^{c}	1.10^{bc}	1.30^{bc}	1.60^{b}	0.13
Glucose (mg/dl)	120.00	128.00	121.00	113.00	118.00	3.55
Cholesterol (mg/dl)	90.00^{ab}	88.00^{ab}	80.00^{b}	83.00^{ab}	100.00^{a}	2.31
Uric Acid (mg/dl)	3.60^{bc}	4.50^{ab}	4.50^{ab}	2.80^{c}	5.27^{a}	0.28
Creatinine (mg/dl)	0.50^{a}	0.60^{a}	0.70^{a}	0.10^{b}	0.70^{a}	0.07
Aspartate Amino-Transferase (U/L)	42.00^{ab}	45.00^{ab}	42.00^{ab}	50.00^{a}	38.00^{b}	1.63
Alanine Amino-Transferase (U/L)	24.00^{ab}	21.00^{ab}	25.00^{a}	20.00^{b}	24.00^{ab}	0.71

Means on the same row having different superscripts are significantly different ($P<0.05$);
SEM: Standard Error of Mean n = 5

The haematological and serum metabolites of finishing broiler chickens fed corn cobs based diets are shown in Table 3. The dietary treatments influenced ($p<0.05$) the haematological parameters except mean corpuscular haemoglobin concentration (MCHC). The birds fed 50% UTCC had highest ($p<0.05$) values for PCV, and haemoglobin which were similar ($p>0.05$) to the values obtained across the dietary treatments. The finishing broiler chickens fed 50% UTCC had highest ($p<0.05$) values for total protein, albumin, globulin, uric acid and ALT. The least values for total protein and albumin was observed in birds fed 50% ZTCC while birds fed 100% ZTCC had least values for globulin and uric acid. The birds fed diet 5 had highest ($p<0.05$) values for glucose, cholesterol, creatinine and AST, while the least values for these metabolites were recorded in control diet, 100% UTCC and 50% ZTCC.

Table 3. Haematological parameters and serum metabolites of finishing broiler chickens (5– 8weeks) fed diets containing untreated and treated corn cobs

Parameters	Dietary treatments					SEM
	1	2	3	4	5	
	Control diet	50% UTCC	100% UTCC	50% ZTCC	100% ZTCC	
Haematological parameters:						
Packed cell volume (%)	30.00^{b}	39.00^{a}	29.00^{b}	27.00^{b}	26.00^{b}	1.63
Haemoglobin (g/dl)	10.00^{b}	13.00^{a}	9.70^{b}	9.00^{b}	8.60^{b}	0.51
Red blood cell (x10$^{12/L}$)	1.00^{b}	1.20^{b}	1.20^{b}	2.00^{a}	1.40^{b}	0.11
Mean Corpuscular Haemoglobin (pg)	100.00^{a}	108.00^{a}	81.00^{b}	45.00^{d}	61.00^{c}	6.53
Mean Corpuscular Haemoglobin in Concentration (g/dl)	33.30	33.30	33.40	33.30	33.10	0.52
Mean Corpuscular Volume (fl)	300.00^{b}	325.00^{a}	242.00^{c}	135.00^{e}	186.00^{d}	18.91
White blood cell (x10$^{9/L}$)	12.00^{b}	10.60^{b}	15.10^{a}	16.80^{a}	11.80^{b}	0.65
Heterophil (%)	29.00^{b}	38.00^{a}	22.00^{c}	21.00^{c}	36.00^{a}	1.98
Lymphocytes (%)	70.00^{b}	60.00^{c}	78.00^{a}	77.00^{ab}	62.00^{c}	2.17
Eosinophil (%)	0.00^{b}	0.00^{b}	0.00^{b}	0.00^{b}	1.00^{a}	0.11
Monocytes (%)	1.00^{b}	2.00^{a}	0.00^{c}	1.00^{b}	1.00^{b}	0.17
Basophils (%)	0.00^{b}	0.00^{b}	0.00^{b}	1.00^{a}	0.00^{b}	0.11
Serum metabolites:						
Total protein (g/dl)	3.10^{c}	6.30^{a}	4.60^{b}	2.10^{e}	2.70^{d}	0.41
Albumin (g/dl)	1.80^{b}	2.90^{a}	1.50^{bc}	1.00^{c}	1.80^{b}	0.18
Globulin (g/dl)	1.30^{c}	3.40^{a}	3.10^{b}	1.10^{d}	0.90^{e}	0.29
Glucose (mg/dl)	120.00^{c}	122.00^{b}	112.00^{e}	115.00^{d}	133.00^{a}	1.94
Cholesterol (mg/dl)	87.00^{b}	76.00^{e}	84.00^{c}	82.00^{d}	90.00^{a}	1.29
Uric Acid (mg/dl)	3.20^{b}	5.00^{a}	4.80^{a}	3.00^{b}	2.80^{b}	0.28
Creatinine (mg/dl)	0.10^{c}	0.40^{ab}	0.40^{ab}	0.30^{b}	0.50^{a}	0.04
Aspartate Amino-Transferase (U/L)	45.00^{c}	50.00^{b}	49.00^{b}	48.00^{b}	63.00^{a}	1.69
Alanine Amino-Transferase (U/L)	24.00^{b}	28.00^{a}	14.00^{d}	19.00^{c}	23.00^{b}	1.33

Means on the same row having different superscripts are significantly different ($P<0.05$);
SEM: Standard Error of Mean n = 5

The carcass characteristics of broiler chickens fed corn cobs based diets is shown in Table 4. The dietary treatments influenced ($p<0.05$) the live weight, dressed weight, eviscerated weight and the dressing percentage. The birds fed the control diet had highest ($p<0.05$) value for breast which was ($p>0.05$) similar to the values obtained in birds fed 50% UTCC and 100% ZTCC. The highest value of drumstick recorded in birds fed 100% ZTCC was similar ($p>0.05$) to the values obtained in the birds fed the control diet and diets 2, 4 and 5. The highest value of the back was recorded in 50% ZTCC but, the lowest value was observed in the control group. The birds fed 50% UTCC and 100% UTCC had the same highest value for heart while the least value was obtained in the birds fed the control diet. The birds fed 5 had highest ($p<0.05$) value for whole GIT while the least value was obtained in birds fed the control diet.

Table 4. Carcass characteristics of broiler chickens fed diets containing untreated and treated corn cobs

Parameters	Dietary treatments					SEM
	1	2	3	4	5	
	Control diet	50% UTCC	100% UTCC	50% ZTCC	100% ZTCC	
Live weight (g)	2200.00[a]	1900.00[b]	2000.00[b]	1900.00[b]	2000.00[b]	32.46
Dressed weight (g)	2120.00[a]	1820.00[c]	1940.00[b]	1780.00[c]	1900.00[b]	32.24
Eviscerated weight (g)	1700.00[a]	1460.00[c]	1380.00[d]	1460.00[c]	1540.00[b]	29.08
Dressing percentage (%)	77.28[a]	77.00[a]	69.13[b]	76.85[a]	77.00[a]	1.05
Cut parts (% of LW)						
Head (%)	2.73[e]	4.21[a]	3.00[d]	3.16[c]	4.00[b]	0.16
Breast (%)	20.00[a]	17.89[ab]	16.00[b]	15.79[b]	18.00[ab]	0.51
Thigh (%)	10.91[b]	10.53[c]	11.00[a]	10.53[c]	11.00[a]	0.06
Drumstick (%)	10.91[a]	10.53[a]	8.00[b]	10.53[a]	11.00[a]	0.33
Wing (%)	8.18[ab]	8.42[ab]	7.00[b]	8.42[ab]	9.00[a]	0.27
Back (%)	17.27[c]	15.79[d]	16.00[d]	18.95[a]	18.00[b]	0.32
Neck (%)	3.64[b]	3.16[c]	3.00[c]	4.21[a]	4.00[ab]	0.13
Shank (%)	4.55[c]	4.21[d]	4.00[e]	5.26[a]	5.00[b]	0.13
Organ weight (% of LW)						
Heart (%)	0.91[c]	1.05[a]	1.00[b]	1.05[a]	1.00[b]	0.01
Spleen (%)	0.18[a]	0.13[b]	0.11[bc]	0.13[b]	0.10[c]	0.01
Lungs (%)	0.82[ab]	0.95[a]	0.75[bc]	0.63[c]	0.80[b]	0.03
Liver (%)	3.64[a]	3.16[b]	3.00[b]	3.16[b]	4.00[a]	0.11
Kidneys (%)	0.73[b]	0.68[b]	0.43[d]	0.58[c]	0.90[a]	0.04
Proventriculus (%)	0.91	1.05	1.00	1.05	1.00	0.03
Gizzard (%)	2.73[c]	5.26[a]	5.00[a]	4.21[b]	3.00[c]	0.28
Empty gizzard (%)	1.82[c]	3.16[a]	3.00[ab]	3.16[a]	2.50[b]	0.15
Abdominal fat (%)	0.91[c]	1.05[b]	1.00[b]	2.11[a]	1.00[b]	0.12
Whole GIT (%)	15.45[d]	18.95[b]	17.00[c]	16.84[c]	21.00[a]	0.53

Means on the same row having different superscripts are significantly different ($P<0.05$)
LW: Live weight; GIT: Gastro-intestinal tract; SEM: Standard Error of Mean; n = 5

The sensory evaluation of meats from broiler chickens fed corn cobs based diets is shown in Table 5. The dietary treatments slightly increased ($p<0.05$) the values of colour, juiciness, flavour, tenderness and overall acceptability while least values were recorded for meat of birds fed 50% UTCC.

Table 5. Sensory evaluation of meat from broiler chickens fed diets containing untreated and treated corn cobs

Parameters	Dietary treatments					SEM
	1	2	3	4	5	
	Control diet	50% UTCC	100% UTCC	50% ZTCC	100% ZTCC	
Colour	6.65^{a}	5.75^{c}	6.60^{a}	6.60^{a}	6.25^{b}	0.09
Juiciness	6.05^{b}	5.35^{c}	6.35^{a}	5.95^{b}	6.12^{ab}	0.10
Flavour	5.75^{a}	5.15^{b}	6.10^{a}	5.70^{a}	5.85^{a}	0.10
Tenderness	6.20^{c}	5.95^{d}	6.45^{b}	6.65^{a}	6.40^{b}	0.07
Overall acceptability	6.50^{a}	6.00^{b}	6.40^{a}	6.40^{a}	6.15^{b}	0.05

[abc]Means on the same row having different superscripts are significantly different ($P<0.05$)
SEM: Standard Error of Mean

Discussion

The packed cell value and haemoglobin were not influenced by the dietary treatments at the starter phase. The PCV values (25.00 – 30.00%) are within the normal range of 22.0 - 35.0% for broiler chickens (Anon, 1980; Swenson, 1999). Church *et al*. (1984) and Babatunde *et al*. (1987) showed that PCV and Hb are correlated with the nutritional status of the animal which directly related to the nutritional balance of the diet fed to the animals. The birds on the control diet had higher value of red blood cell, followed by birds fed 100% ZTCC but the birds on 50% UTCC and 50% had similar lowest values. Olugbemi *et al*. (2010) reported that red blood cells are responsible for the transportation of oxygen and carbon dioxide in the blood as well as the manufacture of haemoglobin. Therefore, higher values indicate a greater potential for these functions and a better state of health.

The dietary treatments influenced the MCH and MCV but did not affect the MCHC. The values obtained for birds were within the normal range (33.00 - 47.00pg and 90.00 – 140.00fl) for broiler chickens (Jain, 1993). However, the birds fed 50% UTCC and 50% ZTCC had higher values for MCH and MCV. Seivered (1972) reported that high values of MCV, MCH and MCHC caused anaemia in livestock. On the other hand, MCH indicates the blood carrying ability of the red blood cell which may suggest that the birds on 50% UTCC and 50% ZTCC are more efficient in performing respiratory functions as reported by Soetan *et al*. (2013). The values of white blood cell count recorded in the dietary treatments are within the normal values ($1.20 – 3.00 \times 10^4$µl) stated by Jain (1993). High WBC may be associated with inflammatory diseases, infection diseases or stress, or may be common in young birds (Fudge, 1997; Fudge, 2000 and Clark *et al*., 2009). The values for heterophil and lymphocytes were within the normal values (15.00 – 40.00% and 45.00 – 70.00%) for healthy broiler chickens (Jain, 1993). This suggested the resistance of the birds in disease condition. The inclusion of treated and untreated corn cobs in the diets depressed the total protein, albumin and globulin of the birds.

At the finisher phase, the values obtained in birds on 50% ZTCC for MCH and MCV were within the normal range (33.00 - 47.00pg and 90.00 – 140.00fl) reported by Jain (1993) and Benerjee (2004) but the values obtained in the other dietary treatments were higher than the normal values for healthy broiler chickens. The similar values of MCHC obtained in the dietary treatments revealed that replacement of wheat offal with treated and untreated corn cobs has no deleterious effect on the broiler chickens as they maintained their normal MCHC. The values of uric acid obtained in this study were lower than the normal value for urea (7.00 – 21.00mg/dl) reported in literature (Am. Met laboratory, 2001). The metabolism of uric acid is influenced by the quantity of protein and amino acids in the diet (Oduguwa *et al*., 1996). Serum uric acid (Morgensten *et al*. 1966) and creatinine (Eggum, 1970) can be utilized as an indirect measure of protein adequacy. High levels of AST and ALT may indicate an occurrence of liver damage/low plane of nutrition as observed by Ekpenyong and Biobaku (1986).

The birds fed the control diet had higher average live weight which led to higher dressed weight and eviscerated weight. But this was closely followed by the values from the birds fed 100% ZTCC. This could be attributed to the fact that the broiler chickens performed well on *Zymomonas mobilis* treated corn cobs based diets as well as on control diet. The findings agreed with the reports of Duruna *et al*. (2006). They reported differences on the live weight, eviscerated weight and dressing percentage of broiler chickens fed varying levels of *Anthronata macrophyla* seed meal. The values of dressing percentage were higher than the values (65.63 - 73.33% and 63.02 – 63.06%) reported by Adeyemo and Longe, (2007) and Akinleye *et al*. (2008) but lower than the values (79.00 – 81.00%) obtained by Donkoh *et al*. (2003). Higher body weight and lower offal weight reflect good performance characteristics of poultry birds (Plumber and Kiepper, 2011). The treated and untreated corn cobs based diets affected the cut-up parts of the broiler chickens expressed as the percentage of live weight. This was contrary to the reports of Donkoh *et al*. (2003) who reported no influence of ground maize cobs level on the carcass yield of broiler chickens processed at 56 days of age.

The values of breast, thigh and drumstick obtained in 100% ZTCC compared to the control group revealed the adequacy of the treated corn cobs to replace wheat offal without retarding muscle development. However, Aduku and Olukosi (2000) observed that most of the cut-up parts are based on individual processors' knowledge and efficiency because there was no standard to follow in the fabrication of carcasses of slaughtered animals and poultry in most developing countries.

The birds fed 50% UTCC and 100% UTCC had higher values for gizzard than birds fed the control and other diets. This may be as a result of handling of bulky feeds. Rose (2001) reported that increase in the development of the gizzard will enhance its grinding role. The values of empty gizzards followed the same trend as the whole gizzards. The birds fed 100% ZTCC had highest value of gastro-intestinal tract compared to the other diets. This was contrary to the report of Yeroch and Danicke (1995), they reported that birds fed high-barley or high-wheat diets had elevated intestinal weight, which negatively affect the carcass yield but the negative effect was reduced after supplementation with appropriate enzyme.

The incorporation of untreated and treated corn cobs had influence on the sensory attributes of the meat. The taste panel score for colour recorded in 100% ZTCC was similar to the values obtained in the control diet and 50% UTCC and 100% UTCC. This might be due to the influence of ground corn cobs on the colour of the meat (Briedenstein and Carpenter, 1983). The values obtained in the 50% ZTCC and 100% ZTCC compared favourably with the control group. This is an indication that *Z. mobilis* treated corn cobs had positive influence on tenderness thereby affecting the overall acceptability by the consumers. Also, the untreated and treated corn cobs influenced the colour, juiciness and flavour of the meat. It can be inferred that corn cobs based diets might have led to improvement in collagen and myofibrillar solubility, therefore, improving the tenderness of edible muscles (Waskar *et al*. 2009). The corn cobs based diets generated broiler chicken meat with a greater degree of consumer acceptability.

Conclusion

50% UTCC and ZTCC promoted the haematological parameters and serum metabolites of the broiler chickens. Inclusion of 100% ZTCC improved the blood glucose of the birds. The values of dressing percentage and cut-up parts were improved by the replacement of wheat offal by 50% UTCC and 100% ZTCC in broiler chicken diets. The sensory attributes of the meat were positively supported by the replacement of wheat offal with 50% ZTCC in the broiler chickens' diets. The availability of this agro-industrial by-product in commercial quantity and *Zymomonas mobilis* from palm wine will assist in converting it to alternative fibrous feedstuff in tropical environment.

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Conflict of Interest

There is absolutely no conflict of interest with any individual or organization regarding the materials discussed in this manuscript.

Statement of animal rights

All applicable international, national, and/or institutional guidelines for the care and use of animals were followed in the present study.

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