THE EFFECT OF DIFFERENT NATURAL ANTIOXIDANTS ON MEAT QUALITY OF BROILER CHICKENS

ABSTRACT

An experiment was conducted to assess the effect of natural antioxidants (black pepper, green tea, roselle and their combinations) on meat quality of broiler chickens. A total of 270 1 - day old Arbor Acre broiler chicks were randomly distributed into nine treatments of three replicates each (10 birds in each replicate) in a 2 x 5 factorial arrangement for 2 inclusion levels (0.5g and 1.0g per kg of feed) of natural antioxidants (Control (CT), Green tea (GT), Roselle (RS), Black pepper (BP) and combination (CM) of the 3 antioxidants). At the end of the feeding trial (at 8 weeks), nine birds per treatment were immobilized, slaughtered, dressed, weighed and cut into primal cuts. The growth (initial and final body weight gain, average daily feed intake and weight gain, and feed conversion) and blood assay (haematology and serum biochemistry) of the birds were monitored while the breast and thigh meat cuts were subjected to physico-chemical and sensory analysis. The result indicated that, among examined natural antioxidants, BP improved the bird's live weight. High Density Lipoprotein value was highest ($p<0.05$) in control and closely followed by birds on GT, CM, BP and RS. The lowest blood ($p<0.05$) cholesterol was recorded in RS which was closely followed by GT and CM. Carcass evaluation showed that birds fed BP had better ($p<0.05$) live weight (2.05kg) and highest acceptability ($p<0.05$) for organoleptic properties. The breast meat weight was also highest ($p<0.05$) in BP. It was concluded that the natural antioxidants increased live weight, improved performance and reduced abdominal fat. RS reduced blood cholesterol while RS, CM (GT + RS + BP) inclusion improved serum total protein of broiler chickens. Inclusion of natural antioxidant in the diets of broiler is hereby advocated for achieving optimum broilers performance and meat quality.

Keywords: Natural antioxidants, Black pepper, Roselle, Green Tea, broiler, performance, meat quality

INTRODUCTION

Fresh and processed meats offer a variety of nutritional and health advantages as well as distinctive eating satisfaction for the modern lifestyle. With the increasing demand of poultry meat over the world, poultry farmers want to improve the quality in the productivity of their poultry meat because it contains a lot of polyunsaturated fatty acids as poultry meat is especially prone to lipid oxidation (Abdulla *et al*., 2019). This informed the need to employ natural antioxidants as additive in poultry feeds in place of synthetic antioxidants to prevent lipid oxidation and increase their nutrition value. Herbs, spices, plants, and especially fragrant plants like oregano, rosemary, thyme, and saffron that are traditionally utilized in folk medicine have received a lot of attention in recent years. These plants contain a variety of bioactive substances, but polyphenols, which are well-known for their antioxidant properties, stand out. As a result, they have been incorporated into poultry diets as an easy and practical method of adding natural antioxidants to meat. Today's natural product demand has sparked interest in using plant-derived antioxidants in poultry feeding (Kairalla *et al*., 2022a, 2022b).

Black pepper (*Piper nigrum*) is known spice specie which improve digestibility. It is a common medicinal herb used in human diet. Black pepper is cultivated for its fruit, which is usually dried and used as a spice and seasoning (Moorthy *et al*, 2009). Black pepper was found to be rich in glutathione peroxidase and glucose-6-phosphate dehydrogenase. Piperine which is the active ingredient in black pepper has been proven to dramatically increase absorption of selenium, vitamin B complex, βcarotene and curcumin as well as other nutrients (Khalaf, 2008) and has been found to have antioxidants properties and anti-carcinogenic effect, especially when compared to chilli (Nalini *et al*, 2006). Green Tea is an extremely popular beverage around the world which can be served hot or cold. White, green and black teas are commonly consumed teas, obtained from the leaves or buds of the *Camellia sinensis* (Family Theaceae) plant. There have been several reports that green tea provides several functional activities related to free radicals and reduction in the incidence of cancer (Mukhtar and Ahmad, 1999) and to blood pressure. Roselle (*Hibiscus sabdariffa* L.) is recognized as a tropical shrub which belongs to the family *Malvaceae*. Roselle can be found in tropical and sub-tropical regions such as Nigeria, India, Indonesia, and Malaysia, among others (Dhar *et al.*, 2015). According to Da-Costa-Rocha *et al.* (2014), the calyx of the roselle is brightly coloured and full of nutrients like pectin, organic acids, and anthocyanins. Due to it abundance in anthocyanins, which have antioxidant characteristics and are useful in diuretic and sedative therapies, the leaves or calyces are traditionally made into a beverage (Carvajal-Zarrabal *et al.*, 2005).

However, this present study is to assess the effect of different natural antioxidants (black pepper, green tea, roselle and their combinations) as natural feed additive on performance and meat quality of broiler chicken.

MATERIALS AND METHOD

Experimental Site

The experiment was carried out at the poultry unit of the Teaching and Research farm, Faculty of Agricultural science, Ladoke Akintola University Technology, Ogbomoso, Oyo state. Black pepper, Green tea and Roselle were purchased from a nearby market and they were grounded and stored in a cool germ free container.

Procurement of Test Ingredients

Dried Roselle (*Hibiscus sabdariffa*), Green tea (*Camellia sinensis*) and Black pepper (*Piper nigrum* L.) were purchased from a local market in Ogbomoso, Oyo state. They were grounded into powdered form and stored for usage.

Management of Birds

Two hundrend and seventy (270), day old chicks were purchased from a reputable commercial farm. The birds were weighed prior to the commencement of the experiment and allotted into nine (9) dietary treatments. Thirty birds were assigned to each treatment and replicated three times with 10 birds each into 0.5g and 1.0g per kg of feed for each of the treatment group. Feed and water were offered *ad libitum*. Daily routine management was followed, and birds were vaccinated and drugs were administered when necessary.

Experimental Diet

The experimental treatments consist of control (basal diet without antioxidant) as CT, while other diets were basal diets supplemented different with natural antioxidants at 0.5 and 1.0g/kg of feed to have Green tea diets GT (0.5g/kg, 1.0g/kg), Roselle diets RS (0.5g/kg, 1.0g/kg), Black pepper diets BP (0.5g/kg, 1.0g/kg) and the combination of the 3 antioxidants (i.e GT + RS + BP) as CM (0.5g/kg, 1.0g/kg). The diets were formulated to contain 23.64% crude protein and 2985.20Kcal/kg metabolizable energy at starter phase and 22.03% CP and 2961.60Kcal/kg ME at finisher phase (Table 1 and 2).

Table 1: Basal Diet Composition

Ingredients	Starter (%) 0-4weeks	Finisher (%) 5-12weeks
Maize	53	45
Soya bean meal	34	23
Wheat offal	-	3.5
Corn bran	5	11.2
Fish meal	2.5	2.5
Groundnut cake	2	5
Palm kernel cake	-	4.5
Lime stone	1	1.5
Salt	0.25	0.25
Bone	1.5	3
Lysine	0.25	0.12
Methionine	0.25	0.18
Premix	0.25	0.25
TOTAL	**100**	**100**
Metabolizable energy	2987.32	2813.13
Crude protein	22.87	20.94
Crude fibre	4.00	4.85
Crude fat	3.68	3.72
Lysine	1.48	1.15
Methionine	0.60	0.50
Calcium	1.04	1.66
Phosphorus	0.61	0.83

Table 2: Experimental layout

Treatments	T1	T2	T3	T4	T5	T6	T7	T8	T9
		Green tea		Black Pepper		Roselle		Combined	
Replicates	Control 0g/kg	0.5g /kg	1.0g /kg	0.5g /kg	1.0g /kg	0.5g /kg	1.0g /kg	0.5g /kg	1.0g /kg
R1	10	10	10	10	10	10	10	10	10
R2	10	10	10	10	10	10	10	10	10
R3	10	10	10	10	10	10	10	10	10

Data Collection
Data were collected for the following parameters;

Carcass characteristics
Nine birds per treatment with average weights were purposively selected, slaughtered by *halal* neck cut (Alshelmani *et al*., 2016a), scalded manually and dissected (Abdullah *et al*., 2010). The live, bled, defeathered, eviscerated and carcass weights were recorded and the dressing % determined. Weights of the primal cuts (breast, thigh, and drumstick) and internal offal (liver, kidney, heart, lungs and abdominal fat) relative to live body weight were also recorded.

Blood profile
On the 56th day of the study, birds were starved of feed overnight while blood samples were randomly collected from three birds per treatment via the jugular vein into sterilized bottle. Blood samples for the determination of haematological indices were collected into vials containing Ethylene Diamine Tetraacetic Acid (EDTA), while vials without anticoagulant were used to collect blood for serum analysis. The blood samples were analyzed for total protein (TP) using Biuret method (Kohn and Aleen, 1995), albumin was determined by Bromocresol Green (BCG) method according to (Peters *et al*., 1982) while urea was determined according to the procedures of (Olorede *et al*., 1996). Blood cholesterol was analyzed enzymatically using commercially available reagent kit according to the manufacturer's guide. Cyanmethamoglobin method was used to determine haemoglobin concentration (Jain, 1986). Red blood cell (RBC), white blood cells (WBC) and platelets were determined using Wintrob micro haematocrit and haemocytometer consisting of a counting chamber and special cover slip. HGB, MCH, MCHC and HCT were also determined.

Meat quality
Cooking loss
Meat portion of the chicken carcass were cut and cooked in water bath for 20minutes. The difference in weight before and after cooking was observed according to the procedure of A.M.S.A (1995).
Cold shortening
This was determined by measuring the length of the meat before chilling and then length of the meat after chilling (King *et al*., 2003). The percentage change in length of meat is cold shortening.
Thermal loss
A portion of the chicken was cut into length of 4cm each; the meat was subjected to cooking less than 80 degree Celsius temperature in a water bath for 15minutes. The change in length before and after cooking of the parts, was observed and recorded appropriately based on the procedure of A.M.S.A (1995).
Drip loss
A known weight chicken was cut and freezed for a period of 24hours, the weight before and after was observed according to the procedure of A.M.S.A (1995).
Water holding capacity
According to the procedure of A.M.S.A (1995), Meat was cut from the breast of the chicken, the meat was put in between two filter paper and was pressed with the use of table vice, will be put

in the oven to dry for 10minutes. After which the area of water, area of meat and the weight of the dried meat was taken.

pH level

According to the procedure of A.O.A.C (2000), pH was observed using a pH meter, this was carried out by cutting meat sample and pound it in a mortal with 45ml of distil water added, after the pounding has achieve a homogenous state, then pH meter was used to take the pH of each samples.

Chemical properties

Parameters that were taken on the chemical properties are Proximate composition (Moisture contents, Dry matter, Crude protein, Ash, Ether Extract), Lipid peroxidation, Lipid profile (total cholesterol, triglyceride, high density lipoprotein cholesterol (HDL), low density lipoprotein cholesterol (LDL) and fatty acid profile. Samples of the experimental diets were analyzed for proximate composition by the methods of AOAC (2000).

Organoleptic properties

It was conducted using a 10 member trained panelists according to the procedures of AMSA (1995). Meat preparation was done using a wet cooking method. The samples were wrapped in impervious polythene pouches which could not be destroyed by cooking process. In the process, the meat samples were cooked in boiling water for 20 minutes using water bath with no spices added to the meat. The meat was then served to 10 member taste panels drawn from students in the Faculty of Agricultural science, Ladoke Akintola University of Technology, Ogbomoso. The trained panelists evaluated the samples for colour, flavour, juiciness, tenderness and general acceptability. The assessment was based on a 9 point hedonic scale. The score was arranged in a descending order, the maximum score 9 was given to extremely like condition, while the lowest score 1 was for the poorest condition.

Statistical analysis:

Data generated were subjected to Analysis of variance using the General Linear Model for factorial (2*5 factorial arrangements) within a completely randomized design (SAS, 2000). Means were separated by Duncan's range option of the same statistical software.

RESULTS

Effect of different natural antioxidants on carcass characteristics of broiler chicken

The effect of the treatment of different natural antioxidants on carcass characteristics of broiler chicken was shown in Table 3**.** Inclusion level at 1.0g/kg greatly ($p<0.05$) influenced the eviscerated weight and dressing %. The different natural antioxidants (GT, RS and BP) also improved ($p<0.05$) the dressing % above the control (60.80%) with superior ($p<0.05$) value in their combination at CM (69.10%). The interaction revealed no ($p>0.05$) difference in the carcass evaluation, except in the dressing percentage ($p<0.05$). The primal cuts was significantly highest ($p<0.05$) at 1.0g/kg when inclusion level was considered across all the parameters (Table 4). The inclusion of the additives improves ($p<0.05$) the carcass cuts with the highest also in the CM for breast, thigh and drumsticks while no particular trend was observed in the others. The interaction followed similar trend with the carcass characteristics.

Table 3: Effect of natural antioxidants on carcass characteristics of broiler chicken

	Live Weight (kg)	Bled Weight (%)	Defeathered Weight (%)	Eviscerated Weight (%)	%Dressing Weight
Natural antioxidants					
CT	2.10[a]	94.3	91.9	76.1[a]	68.8[b]
RS	1.83[b]	94.5	91.8	76.1[a]	68.9[b]
BP	2.05[a]	93.9	90.7	76.7[a]	66.1[c]
GT	1.65[c]	93.4	90.4	75.4[b]	68.7[b]
CM	1.93[b]	94.8	92.0	76.1[a]	69.1[a]
SEM	33.5	0.45	0.50	0.62	21.7
P-value	*	NS	NS	NS	NS
Inclusion level					
0.5	1.92[a]	94.65	91.75	77.06[a]	77.76[a]
1.0	1.85[b]	93.63	90.81	74.92[b]	67.71[b]
SEM	23.69	0.32	0.36	0.44	15.32
P-value	NS	NS	NS	*	*
Interactions between natural antioxidant and inclusion level					
P-value	NS	NS	*	*	*

abc Means along the same column with different superscripts are significantly different ($p < 0.05$) SEM - Standard Error of Mean. *P<0.05, NS- Non significant.

Table 4: Effect of natural antioxidants on Primal cut of broiler chicken (%)

	Breast	Thigh	Drumstick	Back	Wing	Head	Neck	Shank
Natural antioxidants								
CT	21.23[b]	10.64[b]	9.57[b]	3.01[b]	8.20[a]	2.44[b]	16.89[a]	4.15[b]
RS	21.40[b]	10.15[b]	9.78[b]	3.15[b]	7.89[b]	2.58[a]	14.95[c]	4.33[a]
BP	22.74[a]	9.81[c]	10.45[a]	2.98[c]	7.58[b]	2.58[a]	15.15[b]	4.31[a]
GT	22.14[a]	10.24[b]	9.75[b]	3.55[a]	8.46[a]	2.52[a]	14.02[c]	4.09[b]
CM	22.13[a]	11.00[a]	10.90[a]	3.78[a]	8.27[a]	2.48[b]	14.23[c]	4.39[a]
SEM	0.50	0.79	0.21	0.12	0.11	0.05	0.26	0.09
P-value	*	*	*	*	*	*	*	*
Inclusion levels								
0.5g/kg	22.84[a]	10.18[b]	10.19[a]	3.19[b]	8.10[a]	2.57[a]	15.54[a]	4.22[b]
1.0g/kg	20.96[b]	10.53[a]	10.17[b]	3.48[a]	8.02[b]	2.54[b]	13.97[b]	4.27[a]
SEM	0.35	0.19	0.19	0.08	0.08	0.04	0.18	0.06
P-value	*	*	*	*	*	*	*	*
Interaction between natural antioxidant and Inclusion level								
P-value	*	*	*	*	*	*	*	*

[abc] Means along the same column with different superscripts are significantly different ($p < 0.05$) SEM - Standard Error of Mean. *P<0.05

Effect of different natural antioxidants on internal organs of broiler chicken.

Table 5 shows the effect of treatment of natural antioxidant on internal organs of broiler chicken. The result shows that the natural antioxidants had no significant ($p>0.05$) effect on the internal

organ parameters, except on whole gizzard. The whole gizzard of the birds fed on GT shows the highest ($p<0.05$) significant in the entire dietary group. The liver of the birds fed on control has the highest values ($p<0.05$). The kidney weight of the birds fed with RS, GT and CM shows statistical similarities. The spleen of the birds fed on RS have the highest significant ($p<0.05$) effect in the entire treatment group. The intestine, pancreas, heart, and gizzard of birds fed on control have the highest weight ($p<0.05$). The natural antioxidants have no significant ($p>0.05$) effect at the two (0.5g/kg and 1.0g/kg) inclusion level, except on pancreas and heart. There were no significant difference ($p>0.05$) in the interaction level.

Effect of different natural antioxidants on haematolhaematoligical properties of broiler chicken.

Table 6 shows the main effect of natural antioxidants on haematological properties of broiler chickens. The result also reveals that the natural antioxidants at 0.5g/kg and 1.0g/kg inclusion level does not influence ($p>0.05$) the haematological parameters examined except RBC. Birds fed natural antioxidants at 0.5g/kg of feed inclusion level had the highest ($P<0.05$) RBC value compare to 1.0g/kg inclusion level. The result reveal that there was significant ($p<0.05$) difference in the haematological properties parameters examined. The WBC, RBC and Hb value of chicken fed on CT and RS was significantly ($p<0.05$) highest across the dietary treatment.

Birds fed with CT, GT and CM diet had the highest ($p<0.05$) HCT and MCHC value across the treatment group. MCV and MCH of birds fed roselle was also highest ($p<0.05$) across the treatment group. The result of the effect of the interaction between the antioxidants and inclusion levels also showed significant ($p<0.05$) differences in the haematological properties parameters examined, except WBC and RBC.

Table 5: Effects of natural antioxidants on internal organ of broiler chicken (%)

	Whole gizzard	Empty gizzard	Liver	Kidney	Lung	Spleen	Pancreas	Heart	Intestine
Natural antioxidants									
CT	2.85^{b}	1.66^{b}	2.28^{a}	0.22^{b}	0.60^{a}	0.11^{a}	0.24^{a}	0.44^{a}	6.88^{a}
RS	2.81^{b}	1.60^{b}	2.14^{ab}	0.34^{a}	0.54^{b}	0.13^{a}	0.22^{a}	0.43^{a}	6.35^{c}
BP	2.92^{a}	1.73^{a}	2.04^{b}	0.24^{b}	0.47^{b}	0.09^{b}	0.20^{a}	0.38^{b}	6.26^{d}
GT	2.97^{a}	1.77^{a}	2.03^{b}	0.35^{a}	0.37^{c}	0.10^{a}	0.23^{a}	0.40^{a}	6.67^{b}
CM	2.68^{c}	1.63^{b}	1.72^{c}	0.36^{a}	0.39^{c}	0.10^{a}	0.18^{b}	0.42^{a}	6.38^{c}
SEM	0.07	0.4	0.05	0.02	0.01	0.01	0.01	0.01	0.22
P-value	NS	*	*	*	*	*	*	*	*
Inclusion level									
0.5	2.76^{b}	1.65^{b}	1.89^{b}	0.30^{b}	0.48^{a}	0.12^{a}	0.22	0.41	6.37^{b}
1.0	2.96^{a}	1.71^{a}	2.18^{a}	0.34^{a}	0.45^{b}	0.10^{b}	0.22	0.41	6.60^{a}
SEM	0.05	0.29	0.04	0.02	0.01	0.01	0.01	0.01	0.16
P-value	*	*	*	*	*	*	NS	NS	*
Interaction between Natural antioxidant and inclusion levels									
P-value	*	*	*	*	*	*	*	*	*

^{abcd} Means along the same column with different superscripts are significantly different ($p<0.05$) SEM - Standard Error of Mean. *P<0.05, NS- Non Significant

Table 6: Effect of natural antioxidants on haematological parameters of broiler chickens.

	WBC ($X10^3/\mu l$)	RBC ($X10^6/\mu l$)	Hb (g/dI)	HCT (%)	MCV (fI)	MCH (pg)	MCHC (g/dI)	PLT ($X10^3/\mu l$)
Natural antioxidants								
CT	264.10^a	2.40^a	10.35^a	32.00^a	133.21^b	43.15^b	32.35^a	1.99^a
RS	236.83^b	2.10^b	8.93^b	20.73^b	135.03^b	43.15^b	31.95^b	113.75^b
BP	259.23^a	2.54^a	10.20^a	18.50^b	141.08^a	44.50^a	32.43^a	114.95^b
GT	242.43^b	2.21^b	9.40^b	28.85^a	130.70^c	42.30^b	32.38^a	119.00^b
CM	258.63^b	2.54a	10.68^a	33.53^a	132.50^c	42.03^b	31.68^b	248.25^a
SEM	3.93	5.56	0.25	2.29	0.79	0.37	0.18	20.23
P-value	*	*	*	*	*	*	*	*
Inclusion level								
0.5	255.19	2.64^a	10.02	25.74	133.52	43.21	32.38	157.50
1.0	246.01	2.25^b	9.66	26.63	1.36	43.22	31.83	1.51
SEM	2.78	3.93	0.18	1.62	0.56	0.26	0.13	14.30
P-value	NS	*	NS	NS		NS	NS	
Interactions between Natural antioxidant and inclusion level								
P-value	NS	NS	*	*	*	*	*	*

^{abcd}Mean with different superscript along the same column are significantly different ($p<0.05$). WBC = white blood cell; RBC = red blood cell; Hb = haemoglobin; HCT = haematocrit; MCV = mean corpuscular volume; MCH = mean corpuscular haemoglobin; MCHC = mean corpuscular haemoglobin concentration; PLT = platelets; SEM: group standard error of mean. *P<0.05

Effect of different natural antioxidants on serum parameters of broiler chicken.

The main effect of natural antioxidants on serum of broiler chicken is shown in Table 7. The result shows that the natural antioxidants have significant ($p<0.05$) effect on the serum parameters. The fed birds with RS have the highest TP, ALB, GLO, ALP and Urea across the dietary treatment group. The ALT, AST and CR value of the birds fed on GT is significantly ($p<0.05$) with the least value in birds fed control. The inclusion of the natural antioxidants at the two inclusion levels have significant ($p>0.05$) effect on the serum parameters except ALT and Urea. The birds fed natural antioxidants at the inclusion level of 0.5g/kg has a higher ($p<0.05$) TP, ALB, GLO, ALP, and CR value than the one at inclusion level of 1.0g/kg.

Effect of different natural antioxidants on physical properties of broiler chicken

Table 8 shows the effect of treatment of different natural antioxidants on physical properties of broiler chicken. The result shows that the natural antioxidant had significant ($p<0.05$) effect on the physical properties parameters. The birds fed on RS had the lowest ($p<0.05$) cooking loss value compare to others in the treatment groups. The birds fed on control had the highest ($p<0.05$) value for thermal shortening, cold shortening, drip loss and ph. There were no significant ($p>0.05$) difference in the inclusion level, except on thermal and cold shortening. The interaction (The natural antioxidants vs inclusion) shows no significant ($p>0.05$) difference, except on thermal and cold shortening.

Table 7: Effect of natural antioxidants on Serum of broiler chicken

	TP (g/dL)	ALB (g/dL)	GLO (g/dL)	ALP (U/L)	ALT (U/L)	AST (U/L)	CR (mg/dL)	UREA (mg/dL)
Natural antioxidants								
CT	2.78^{c}	1.47^{c}	1.31^{c}	13.71^{c}	19.14^{c}	92.89^{d}	1.09^{c}	3.82^{c}
RS	3.53^{a}	1.87^{a}	1.66^{a}	17.40^{a}	23.28^{b}	101.58^{c}	1.09^{c}	4.44^{a}
BP	2.49^{d}	1.32^{d}	1.17^{d}	12.27^{d}	18.52^{c}	101.25^{c}	1.18^{b}	3.80^{c}
GT	3.23^{b}	1.71^{b}	1.52^{b}	15.91^{b}	27.81^{a}	120.99^{a}	1.50^{a}	4.29^{b}
CM	3.37^{b}	1.78^{b}	1.59^{a}	16.62^{b}	24.98^{b}	112.70^{b}	1.00^{c}	3.91^{c}
SEM	0.07	0.04	0.03	0.33	0.81	1.29	0.05	0.05
P-value	*	*	*	*	*	*	*	*
Inclusion level								
0.5	3.26^{a}	1.72^{a}	1.54^{a}	16.07^{a}	23.57	102.79^{b}	1.26^{a}	4.07
1.0	2.93^{b}	1.55^{b}	1.38^{b}	14.43^{b}	22.62	113.02^{a}	1.09^{b}	4.09
SEM	0.05	0.03	0.02	0.23	0.57	0.91	0.04	0.03
P-value	*	*	*	*	NS	*	*	NS
Interactions between natural antioxidants and inclusion levels								
P-value	*	*	*	*	*	*	*	*

abc Means along the same column with different superscripts are significantly different (p <0.05) SEM - Standard Error of Mean * Significant, NS- Non Significant, AST – Aspartate aminotransferase, ALT - Alanine aminotransferase CR-Creatine, ALP-Alkaline phosphate, TP-total protein, GLO- Globulin. ALB-Albumin. *P<0.05

Table 8: Effect of different natural antioxidants on Physical properties of broiler chicken

	Cooking Loss (g)	Thermal shortening (cm)	Cold shortening (cm)	Drip Loss (g)	pH
Natural antioxidants					
CT	39.30^{a}	47.82^{a}	39.29^{a}	3.87^{a}	7.0^{a}
RS	34.14^{c}	44.32^{bc}	23.72^{c}	2.86^{b}	6.20^{c}
BP	38.03^{ab}	35.88^{c}	31.74^{b}	2.87^{b}	6.55^{b}
GT	36.23^{b}	45.88^{b}	26.26^{c}	2.06^{c}	5.95^{d}
CM	34.65^{c}	32.96^{d}	13.91^{d}	1.81^{d}	5.96^{d}
SEM	0.60	1.08	2.14	0.20	0.19
P-value	*	*	*	*	*
Inclusion levels					
0.5	36.65^{a}	38.63^{b}	25.15^{a}	2.31^{a}	6.37^{a}
1.0	35.86^{b}	46.90^{a}	21.19^{b}	2.14^{b}	6.13^{b}
SEM	0.42	0.77	1.51	0.14	0.01
P-value	NS	*	*	NS	NS
Interactions between natural antioxidants and inclusion levels					
P-value	NS	*	*	NS	NS

^{abcd} Means along the same column with different superscripts are significantly different (p <0.05) SEM - Standard Error of Mean. *P<0.05, NS- Non Significant.

Effect of different natural antioxidants on lipid profile of broiler chicken.
The effect of treatment of natural antioxidants on lipid profile of broiler chicken is shown in Table 9. The natural antioxidants has no significant ($p>0.05$) effect on the lipid profile. The birds fed on BP have the highest CHO compared to other treatment group. The value of TAG of the birds fed on CT and BP has the highest ($p<0.05$) compared to other treatment group. The HDL of the birds fed on CT, GT and CM has higher value. The LDL of the birds fed on BP has the highest ($p<0.05$) value across the treatment group. The MDA of the birds fed on control (no natural antioxidant) has the highest significant ($p<0.05$) effect compare to other treatment group. The natural antioxidants have significant ($p<0.05$) effect on the lipid profile.

Effect of natural antioxidants on organoleptic properties of broiler chicken.
The main effect of natural antioxidants on organoleptic properties of broiler chicken is shown in Table 10. All the parameters examined were significantly ($p<0.05$) influenced by the dietary treatment. The colour of broiler meat from birds fed with GT and BP were moderately light ($p<0.05$) compared to those fed with RS and the combination CM. The mean value of juiciness was highest ($p<0.05$) for meat of broiler chicken fed with BP and control CT. The mean values of apparent adhesion were highest ($p<0.05$) for meat of broiler chicken fed with RS (6.70). The mean values of residue after chewing were highest ($p<0.05$) for the meat of broiler chicken fed with RS and CT. Birds fed with BP has the highest ($p<0.05$) acceptability. The interaction (The natural antioxidants vs inclusion) shows a high significant ($p>0.05$) difference at 1.0g/kg inclusion level on all the lipid profile parameters except on CHO and LDL.

Table 9: Effect of natural antioxidant on lipid profile of broiler chicken

	CHO (mg/dL)	TAG (mg/dL)	HDL (mg/dL)	LDL(mg/dL)	MDA (U/L)
Natural antioxidants					
CT	125.8^{b}	89.76^{a}	47.24^{a}	60.62^{d}	15.08^{a}
RS	102.15^{d}	47.69^{d}	19.66^{d}	72.96^{b}	12.45^{b}
BP	140.00^{a}	82.84^{b}	29.44^{c}	94.00^{a}	9.63^{d}
GT	106.35^{d}	33.66^{d}	38.27^{b}	61.35^{d}	9.69^{d}
CM	115.59^{c}	62.28^{c}	37.50^{b}	65.64^{c}	11.37^{c}
SEM	4.48	4.58	1.66	5.18	0.85
P-value	*	*	*	*	*
Inclusion levels					
0.5	118.06^{a}	57.75^{b}	31.44^{b}	75.08^{a}	10.26^{b}
1.0	115.9^{b}	63.49^{a}	34.94^{a}	68.28^{b}	12.52^{a}
SEM	2.01	2.29	0.83	2.58	0.42
P-value	*	*	*	*	*
Interactions between natural antioxidant and Inclusion level					
P-value	*	*	*	*	*

abcd Means along the same column with different superscripts are significantly different ($p < 0.05$), SEM - Standard Error of Mean * Significant, NS- Non Significant, TAG- Tri-glyceride, CHO- Glucose, HDL- high density lipoprotein, LDL- low density lipoprotein, MDA- Malondialdehyde. *P<0.05

Table 10: Effect of natural antioxidants on organoleptic properties of broiler chicken

	Colour	Flavour	Juiciness	Ease of fragmentation	Apparent Adhension	Residue after chewing	Overall Acceptability
				Natural antioxidants			
CT	6.20^{b}	7.00^{a}	6.80^{a}	7.20^{a}	5.80^{c}	6.30^{b}	7.20^{a}
RS	5.90^{c}	7.10^{a}	5.90^{b}	7.00^{a}	6.70^{a}	6.20^{b}	7.00^{b}
BP	6.40^{b}	6.50^{b}	6.90^{a}	7.00^{a}	6.20^{b}	5.30^{c}	7.60^{a}
GT	6.80^{a}	6.50^{b}	5.90^{b}	6.80^{b}	5.90^{c}	6.00^{a}	6.80^{c}
CM	5.90^{c}	6.20^{c}	6.20^{a}	6.80^{b}	6.20^{b}	5.80^{c}	7.20^{a}
SEM	0.17	0.19	0.19	0.19	0.26	0.27	0.22
P-value	*	*	*	*	*	*	*
				Inclusion level			
0.5	6.36^{a}	6.76^{a}	6.56^{a}	6.84^{b}	5.80^{b}	5.22^{b}	7.28^{a}
1.0	6.10^{b}	6.45^{b}	5.95^{b}	7.05^{a}	6.70^{a}	6.70^{a}	7.00^{b}
SEM	0.12	0.13	0.14	0.13	0.18	0.19	0.15
P-value	*	*	*	*	*	*	*
				Interactions between Natural antioxidant and inclusion levels			
P-value	*	*	*	*	*	*	*

abc Means along the same column with different superscripts are significantly different ($p<0.05$) SEM - Standard Error of Mean. *P<0.05, NS- Non Significant

DISCUSSION

Dressing percentage is a better index of total edible meat after the visceral organs; blood and feathers have been removed (Ugwu and Onyimonyi, 2008). This indicated that birds on the antioxidants, especially those with the CM (RS + BP + GT) have more edible meat mostly at 0.5g/kg level and follow by GT and RS in the feed compare to the control. Ikeme (1990) have earlier reported that bled weight, defearthered weight and dressed weight followed the same trend with the pre-slaughtered weight, which is contrary to the result of this research. This result was in contrary with Al-Kaisse (2009), who reported that use of herbal plants had no effect on the percentage of dressing weight.

It was observed from this study that BP, GT and CM (RS + BP + GT) showed increased pH with decreased cooking loss in GT, BP, RS and CM. The pH directly influence the meat quality attributes like tenderness, colour and juiciness. The amount of glycogen in the muscle prior to slaughter and the rate of its conversion into lactic acid are important determinant of pH. Barbut (1993) reported that low pH in poultry meat is associated with low WHC and consequently an increased cooking loss, drip loss, and decreased tenderness. It was mentioned by Alshelmani *et al*., (2016b) that a rapid decrease of muscle pH, while the carcass temperature is still high, may cause denaturation of the proteins in the muscles. Hence, the meat colour becomes pale. In addition, pale meat may attribute to a decrease in the WHC.

The internal organ weights in this study is consistent with the finding of Jimoh *et al.* (2012).This might implies that the natural antioxidants did not adversely affect the bird's organ. This study suggested that as farmers are getting increased live weight of birds, the consumers are also

benefiting from eating lean and functional or nutraceutical meats. Also, consumption of meat from these birds will improve consumer's health and wellness rather than increasing their health risk.

This study showed that treatment groups fed BP and GT had significantly ($p<0.05$) lowered WBC, RBC and Hb as compared with the control group. These observations are correlated with the data published by Avallone *et al.* (1996). The reduction of the parameters (WBC, RBC and Hb) may be due to the activity of BP and RS which may act on oestrogen hormone. Al-Kassie *et al.* (2011) reported that oestrogen hormone decreases erythrocyte formation and this agree with our results.Broilers chicks fed with the CM had significantly better total protein, globulin and albumin than the other dietary groups for serum protein. Adedeji (1992) reported serum protein to be a means of replacement of tissue proteins, buffer in acid-base balance and transporter of constituents of blood such as vitamins, iron, copper, hormones, lipids and enzymes. This result is in consonance with AL-Baghdadi (2011) who also observed no significance effect of RS extract on serum protein of layers.

The significant differences ($p< 0.05$) in TP, and cholesterol level across the treatments was in accordance with Gholami-Ahanquaran *et al*. (2016), who reported that total protein in chickens fed aflatoxin plus turmeric increased significantly. A decrease in total protein level may indicate severe malnutrition, disorders associated with mal-absorption such as celiac or hepartic disease which interferes with protein metabolism (Stuart, 2011).
The significant panellists result on colour, tenderness, juiciness and texture shows that consumer preference was adversely influenced unlike the result of Ojediran and Emiola (2018). Consumers reject products in which the colour departs from the normal appearance (Qiao *et al*., 2001). According to Lawrie (1998), flavour could be influenced with the age of the animal while juiciness depends largely on the fat content of the carcasses (Lawrie, 1998). Intramuscular fat and water holding capacity of meat is directly related to juiciness. Akinwumi *et al.* (2013) reported that quail meat has the least water loss during cooking compared to other poultry birds which makes it more juicy and tender than others. This might be responsible for the significant effect on tenderness, texture and juiciness.

CONCLUSION

Based on the results obtained from the study, it can be concluded that the natural antioxidants had no influence on the carcass characteristics of broiler chicken. The inclusion level at 0.5g/kg improved the dressing percentage above 1.0g/kg The combination of the antioxidants greatly improved the thigh and drumstick above others while 0.5g/kg favoured breast meat above 1.0g/kg The various natural antioxidants had various effect on the internal organs with no particular trend. However, the liver was significantly reduced with CM. The CM (BP+GT+RS) of the antioxidants also improved the physical properties, haematology and serum properties of the broiler chicken.

RECOMMENDATION

The use of natural antioxidants is hereby advocated to have improved carcass characteristics and quality.

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