Effect of dietary inclusion of ginger meal (*Zingiber officinale Roscoe*) on performance, serum cholesterol profile and carcass quality of broilers

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Abstract

Recent concerns over the use of antibiotics in livestock feed production has generated interest in the use of phytobiotics to improve performance and meat quality of broilers. In this study the effect of dietary inclusion of ginger meal (*Zingiber officinale Roscoe*) on performance, haematology, serum lipid profile and carcass quality of broilers were evaluated. One hundred and eighty day old broiler chicks (Cobb strain) were randomly allocated to 4 treatment group with 3 replicates each. Each group was fed an experimental diets containing air dried ginger rhizome meal at either 0%, 0.2%, 0.4% and 0.6% levels, at starter (0-4 weeks) and finisher (5-8 weeks) stages, in a completely randomized design. 5 birds per treatment were sacrificed and used to evaluate the haematology, performance, carcass characteristics, serum lipid profile and post mortem microbial load on the meat. Results showed no significant ($P>0.05$) effects of dietary ginger meal inclusion on performance parameters but improved carcass yield and quality. 0.4% inclusion of ginger meal significantly ($P<0.05$) increased the HDL cholesterol level (56.72 mg/dL) relative to those fed 0.2% (25.38 mg/dL) while the total lipid, cholesterol, triglycerides and LDL levels were not significantly affected ($P>0.05$). Birds fed diets containing 0.2% ginger meal had haemoglobin content (11.96 g/dl) and PCV (36.68%) values superior to the control (10.16 g/dl and 32.22% respectively) Post mortem microbial load were unaffected by dietary inclusion of ginger up to 0.6% in their diets. Meat tenderness was significantly higher ($P<0.05$) at 0.4% and 0.6% ginger meal levels (8.20) compared to the control (7.40). it is therefore concluded that 0.4 to 0.6 % dietary inclusion of ginger meal in broiler diets will have positive effects on serum lipoprotein level, carcass yield and organoleptic quality of meat.

Keywords: Ginger meal, Broiler, Cholesterol, Lipid profile, Meat quality.

Introduction

Phytobiotics, also called phytogetic feed additives (PFA) are plant derived products added to feed in order to enhance the performance of livestock through the improvement of digestibility, nutrient absorption and elimination of pathogens residents in the animal gut (Balunas and Kinghorn, 2005; Athanasiadou *et al.*, 2007). Recent consumers' expectations in relation to food quality, have led to increasing use PFAs by poultry producers (Gardzielewska *et al.*, 2003). The positive effects of these feed supplements on broiler performance, carcass characteristics and meat quality have been demonstrated

(Schleicher *et al.*, 1998). Evidence also showed that gram positive and gram negative food-borne bacteria, yeast and mould could be inhibited by garlic, onion, cinnamon, cloves, thyme and other spices (Smith-Palmer *et al.*, 1998). PFA, such as ginger (*Zingiber officinale Roscoe*) has been reported to prevent accumulation of lipids including neutral fats and cholesterol (Bamidele and Adejumo, 2012).

The rhizome of *Zingiber officinale* is consumed as a delicacy, medicine, or spice (David, 2009). Ginger contains several bioactive components that has antioxidant (Aeschbach *et al.*, 1994), anti-inflammatory (Minghetti *et al.*, 2007),

anticarcinogenic (Aggarwal *et al.*, 2008) and antibacterial (Sudrashan *et al.*, 2010) properties. Although Zhao *et al.* (2011) reported that feed intake and feed conversion ratio did not differ among laying hens fed dried ginger at 5, 10, 15 and 20 g/kg inclusion levels, Onu (2010) found that 0.25% inclusion of ginger in broiler diets improved FCR although feed intake did not change. Broilers fed diets containing ginger produced higher carcass weights, higher dressing percentages and improved carcass quality (Zhang *et al.*, 2009). Total cholesterol, low density lipoprotein (LDL) cholesterol and very low density lipoprotein (VLDL) cholesterol decreased significantly ($P < 0.05$) in broilers fed aqueous ginger extract, while, high density lipoprotein (HDL) cholesterol concentration increased (Saeid *et al.*, 2010). E-8 β , 17-epoxylabd-12-ene-15, 16-dial isolated from ginger, has been reported to inhibit cholesterol biosynthesis in homogenated rat liver (Tanabe *et al.*, 1993). Reduction of total fat and cholesterol contents and alteration of the lipid profile to a more unsaturated kind were methods for improving the quality of meat health-wise (Hu and Willett, 2002; WHO and FAO, 2003). Achieving this through dietary inclusion of naturally occurring herbs would be a cheap and safe strategy, and amenable to adoption by poultry farmers. The objective of this study was to investigate the effect of dietary inclusion of ginger on performance, serum lipid profile and carcass quality of broilers.

Materials and methods

Experimental diets and birds

About 30kg fresh ginger roots were procured from commercial dealers, and were thereafter washed, sliced and air dried for about 10 days in an open ventilated room, away from sunlight. After drying,

they were milled using a grinding mill machine with sieve size of 0.1 cm and stored in an air tight container under room temperature. Ginger meal and fresh ginger samples were analysed for proximate composition according to AOAC (1990). The metabolizable energy was determined using the method described by Lohdi *et al.* (1970). The ginger meal was incorporated into four experimental diets at 0%, 0.2%, 0.4% and 0.6% levels, respectively, both at starter and finisher phases (Tables 1 and 2). A total of 180 day old Cobb broiler chicks were randomly allotted to four treatment groups. Each treatment group was subdivided into 3 replicates with 15 birds per replicate. Each treatment group was assigned to one of the four diets in a completely randomized design.

Management of broilers

The birds were raised intensively in a deep litter system for 8 weeks. Conventional vaccinations and medications were administered to the birds. Experimental diets and water were offered to the birds *ad libitum*. The birds were weighed at the beginning of the experiment to obtain the initial live-weights and subsequently on weekly basis. Feed intake was determined as the difference between the quantities of feed offered and that left over the following morning. Data obtained were used to compute average daily weight gain, average daily feed intake and feed conversion ratio. The economy of production was estimated as feed cost per kg weight gain.

Slaughter procedure

At the end of the feeding trial, 5 birds were selected at random from each treatment, tagged and kept in separate slaughter pens. They were starved (of feed) for 18 hours (overnight) with unlimited access to water. Thereafter, they were weighed and sacrificed by severing the carotid arteries.

Blood samples were collected individually into ethylene diamine-tetra acetic acid (EDTA) treated bottles for the estimation of haematological parameters. Another set of blood samples were collected into bottles without anticoagulant for determination of serum lipid profile. Thereafter, the birds were dressed and the carcass and organs

weight were taken and expressed as percentage of the live weight. The parameters measured included: head, neck, heart, shanks, liver plus gall bladder, gizzard full, gizzard empty, small intestine, drumstick, and carcass weights. The drumsticks were labelled and aseptically packed in sterile polyethylene bags (Ziploc^R)

Table 1: Ingredient composition of the broiler starter diets

Ingredients (%)	Ginger meal levels (%)			
	T1 (0)	T2 (0.2)	T3 (0.4)	T4 (0.6)
Maize	51.00	50.80	50.60	50.40
Ginger	0.00	0.20	0.40	0.60
Soya Bean Meal	28.00	28.00	28.00	28.00
Fish Meal	4.00	4.00	4.00	4.00
Palm Kernel Cake	5.00	5.00	5.00	5.00
Wheat Offal	8.00	8.00	8.00	8.00
Bone Meal	3.00	3.00	3.00	3.00
Vitamin/Mineral Premix ^a	0.25	0.25	0.25	0.25
Salt	0.25	0.25	0.25	0.25
Lysine	0.25	0.25	0.25	0.25
Methionine	0.25	0.25	0.25	0.25
Total	100.00	100.00	100.00	100.00
Calculated Values				
Crude Protein	21.57	21.58	21.58	21.59
Metabolizable Energy (Kcal/kg)	2778.682771	832764.962758	11	

^aContains the following per kg: vitamin A: 2400000 IU, vitamin D: 1000000 IU, vitamin E: 16000 IU, vitamin K: 800 mg, vitamin B₆: 1000 mg, vitamin B₁₂: 6mg, niacin: 8000 mg, folic acid: 400 mg, pantothenic acid: 3000 mg, biotin: 40 mg, antioxidant: 3000 mg, cobalt: 80 mg, copper: 2000 mg, iodine: 400 mg, iron: 1200 mg, manganese: 1800 mg, selenium: 60 mg and zinc: 14000 mg.

Table 2: Ingredient composition of the broiler finisher diets

Ingredients (%)	Ginger meal levels (%)			
	T1 (0)	T2 (0.2)	T3 (0.4)	T4 (0.6)
Maize	56.00	55.80	55.60	55.40
Ginger	0.00	0.20	0.40	0.60
Soya Bean Meal	18.00	18.00	18.00	18.00
Fish Meal	4.00	4.00	4.00	4.00
Palm Kernel Cake	10.00	10.00	10.00	10.00
Wheat Offal	8.00	8.00	8.00	8.00
Bone Meal	3.00	3.00	3.00	3.00
Vitamin/Mineral Premix ^a	0.25	0.25	0.25	0.25
Salt	0.25	0.25	0.25	0.25
Lysine	0.25	0.25	0.25	0.25
Methionine	0.25	0.25	0.25	0.25
Total	100.00	100.00	100.00	100.00
Calculated Values:				
Crude Protein	18.55	18.57	18.57	18.58
Metabolizable Energy (Kcal/kg)	2843.282836	432829.562822	69	

^aContains the following per kg: vitamin A: 2400000 IU, vitamin D: 1000000 IU, vitamin E: 16000 IU, vitamin K: 800 mg, vitamin B₆: 1000 mg, vitamin B₁₂: 6mg, niacin: 8000 mg, folic acid: 400 mg, pantothenic acid: 3000 mg, biotin: 40 mg, antioxidant: 3000 mg, cobalt: 80 mg, copper: 2000 mg, iodine: 400 mg, iron: 1200 mg, manganese: 1800 mg, selenium: 60 mg and zinc: 14000 mg.

Haematological and Serum Analysis

Haematological parameters (haemoglobin concentration, packed cell volume (PCV), red blood cell (RBC) count, mean cell volume (MCV), mean cell haemoglobin (MCH) content, mean cell haemoglobin concentration (MCHC), platelet concentration, total white blood cell (TWBC) count) were determined using autoblood analyzer (Erma PCE 210, AGD Biomedicals limited, India). The serum samples were analysed for cholesterol, triglyceride and high density lipoprotein (HDL) levels following the spectrophotometric method (Allain *et al.*, 1974), while the low density lipoprotein (LDL) level was calculated (Friedewald *et al.*, 1972).

Determination of Microbial Load

After 10 hours of refrigerated storage (7 ± 1 °C) in aseptically sealed plastic bags (Ziploc[®]) meat samples were taken from each drumstick and transferred into a sterilized plastic bottle for determination of bacterial load. Each sample was used to inoculate a culture plate (nutrient agar), incubated for 2-3 days at 20-30 °C and viewed under an optical (light) microscope with x400 magnification.

Organoleptic Quality Assessment

After 24 hours of refrigerated storage (7 ± 1 °C), the drumsticks were skinned and scored for colour quality using a 3-point rating score (3= normal colour; 2= slightly abnormal; 1= clearly abnormal). About 15 g portion was cut from the same side in each of the drumstick and was immersed in a saturated brine solution (10g/dL) for 30 seconds. Thereafter, samples were packaged individually in double layered transparent polyethylene bags, tied, labelled and boiled under steam for 10 minutes. The cooked samples were allowed to cool to room temperature 32°C and then served to a trained panel of 10 persons.

Each panellist was required to masticate two different samples and score each for tenderness, juiciness, flavour and degree of likeness (hedonic score) using the 9-point Category Rating Scale (AMSA, 1978). Cooking loss was determined following the method described by Bertrand *et al.* (2003) and Aaslyng *et al.* (2003). The remaining drumsticks were then weighed, packaged individually in double layered polyethylene bags and labelled. Samples were boiled in water for 10 minutes, wiped dry using paper towel and weighed again. The loss in weight (during cooking) expressed as a percentage of fresh weight was regarded as percentage cooking loss.

Statistical Analysis

Data were meaned were subjected to descriptive statistics and analysis of variance based on (R Core Team, 2014). Statistically significant means were separated using the Least Significant Difference.

Results and discussion

Proximate composition of ginger

The proximate composition of ginger meal and fresh ginger are shown in Table 3. The ash content (7.08%), crude protein (13.19%) and nitrogen free extract (53.18%) of the ginger meal were close to values reported by Abdallah *et al.* (2013). Metabolisable energy (ME) value of ginger meal (2.60MJ/kg) in this study agreed with that (2.61MJ/kg) of Abdallah *et al.* (2013). The minor variation in values may be due to the differences in variety, environmental condition or processing method employed.

Broiler Performance

Performance of broiler chicken fed diets containing varying levels of ginger meal are shown in Table 4. The inclusion of ginger meal did not significantly ($P>0.05$) affect live-weight, daily weight gain and daily feed intake of broilers. The daily weight gain (g/day) of birds on control diet (41.60)

Table 3: Proximate composition of ginger

Parameters (%)	Ginger meal	Fresh ginger
Moisture Content	20.21	83.45
Ash	7.08	0.94
Crude Protein	13.19	1.52
Crude Fibre	5.95	1.90
Ether Extract	0.39	0.08
Nitrogen Free Extract	53.18	12.12
^a ME(MJ/kg)	2.60	1.74

^aME = Metabolizable Energy, calculated according to Lodhi et al. (1970).

Table 4: Effect of dietary inclusion of ginger meal on broiler performance

Parameters (g)	Ginger meal levels (%)				SEM
	T1 (0)	T2 (0.2)	T3(0.4)	T4(0.6)	
Initial live-weight (Day old)	42.00	43.00	42.00	43.00	0.00
Final live-weight (8 weeks)	2371.69	2429.18	2401.71	2532.24	61.78
Daily weight gain	41.60	42.61	42.14	44.45	7.72
Daily feed intake	106.24	106.55	105.91	107.06	12.86
Feed conversion ratio	2.55	2.50	2.52	2.41	0.05
^a Feed cost/kg weight gain	259.19	261.13	270.29	265.94	5.66
^b Feed cost/kg weight gain	228.55	231.13	240.09	237.02	5.01

Differences were not statistically significant ($P > 0.05$); ^aFeed cost is in Naira for starter phase; ^bfor finisher phase

was similar to those fed 0.2% (42.61), 0.4% (42.14) and 0.6% (44.45) and FCR did not vary across treatment groups. The results are not in agreement with those of Mohammed *et al.* (2012) but similar to those of Dieumou *et al.* (2009). Mohammed *et al.* (2012) reported significant differences ($P < 0.05$) on body weight gain, feed conversion ratio and feed intake when broiler birds were fed diets containing 0.1% and 0.2% ginger. Dieumou *et al.* (2009) fed ginger oils to broilers and found that there were no differences between the birds on the ginger oil diets and the control in terms of feed intake, body weight gain and feed conversion ratio. It is likely that the non-significant differences in weight gain would be due to the non-significant effect on feed intake. Demir *et al.* (2003) and Amooz and Daster, (2009) have indicated that herbs, plant extracts, essential oil and/or the main components of the essential oil did not affect body weight gain, feed intake or feed efficiency in broilers. No

significant differences ($P > 0.05$) were found in the cost of feed per kg weight gain among the treatment groups (Table 4). This is not in line with Minh *et al.* (2010), who reported improved performance and reduced feed cost when dried ginger was supplemented to broiler diets. Ginger, like other spices (e.g. pepper) loses its pungency when stored post milling (Bartley and Jacobs, 2000). Although, the air dried and milled ginger used in this study was stored in air tight containers, it is likely that a significant amount of its potency were lost during storage. Thus, investigating the effect of storage period post milling on broiler performance is necessary.

Results in Table 5 shows that the percentage neck content of the broilers on 0% ginger meal (3.25%) was significantly lower ($P < 0.05$) than the 0.4% ginger meal group (4.13%), but was similar with those of 0.2% and 0.6% groups (3.74% and 3.81% respectively). Birds fed the 0% ginger meal diet (control) were lowest in carcass weight

Ginger meal in broilers' diet

(1876.80g) and dressing percentage (68.19%) while birds fed the 0.4% ginger meal diet were highest (71.55%) in dressing percentage ($P<0.05$). A gradual and progressive increase in drumstick percentage was observed as the inclusion level of ginger meal increased, although the differences were not significant at 95% level of probability. Kamal and Abo Omar (2012) reported no significant differences ($P>0.05$) in all the carcass cuts and organs weight of broilers fed diets containing garlic powder (a herb like ginger) at the rates of 0.2 and 0.4%. The carcass weight and dressing percentages recorded in this study were in agreement with the result of

Zhang *et al.* (2009) who observed that birds fed ginger produced higher carcass weights compared to untreated birds. Inclusion of ginger meal up to 0.6% level had no effect on heart, liver plus gall bladder and intestinal weights relative to the control, suggesting that no adverse physiological reactions were associated with inclusion of ginger meal in the broiler diets. Therefore, inclusion of ginger meal in the broiler diets led to increased lean growth and overall improvement in carcass weight. Zhang *et al.* (2009) had associated improvements in carcass quality of broiler with the antioxidant effect of ginger which enhances protein and fat metabolism.

Table 5: Carcass characteristics and relative organs proportion¹ of broilers fed diets with varying inclusions of ginger meal

Parameters (%)	Ginger meal levels (%)				SEM
	T1 (0)	T2 (0.2)	T3 (0.4)	T4 (0.6)	
Head	2.10	2.12	2.22	2.39	0.24
Neck	3.25 ^a	3.74 ^{ab}	4.13 ^{bc}	3.81 ^{ab}	0.29
Heart	0.48	0.42	0.40	0.41	0.03
Shanks	3.06	3.27	3.60	3.74	0.29
Small Intestine	1.85	2.00	2.16	1.95	0.18
Gizzard Full	3.08	3.14	2.82	3.06	0.29
Gizzard Empty	2.26	2.35	2.23	2.32	0.24
Liver + Gall bladder	1.87	1.98	1.87	1.78	0.08
Drumstick	9.86	10.72	11.44	11.95	0.79
Dressing Percentage	68.19 ^a	68.75 ^{ab}	71.55 ^c	70.87 ^{bc}	0.80
Carcass Weight (g)	1876.80 ^a	2221.40 ^b	2123.8 ^b	2257.40 ^b	68.67

^{a,b,c}Means in the same row bearing different superscripts are significantly different ($P < 0.05$)

¹Percentage of live weight

Haematological Profile and Serum Lipid Content

Table 6 shows that the haemoglobin concentration (11.96g/dl) of 0.2% ginger meal dietary group was significantly higher ($P<0.05$) than the values for other dietary groups ranging from 10.08-10.60 g/dl, whereas values for 0, 0.4 and 0.6% ginger meal dietary groups were similar ($P>0.05$). Similarly, the PCV (36.68%) of 0.2% ginger meal treatment group was

significantly higher ($P<0.05$) than those of other treatments while the PCV of 0, 0.4 and 0.6% treatment groups (32.22, 32.78 and 33.66% respectively) were similar ($P>0.05$). Birds fed control diet were lowest in TWBC ($65.04 \times 10^3 \text{ uL}$) which was significantly lower ($P<0.05$) than those of 0.4% (89.62) and 0.6% (76.78). Data on the effects of dietary inclusion of ginger on haematological profile have been largely inconsistent. Ademola *et al.* (2009) reported

no significant differences ($P>0.01$) in PCV, haemoglobin and RBC but a highly significant difference ($P<0.01$) in TWBC when broiler birds were fed diet containing ginger, garlic and their mixture at rate 1.0, 1.5 and 2.0% inclusion. This is partly in agreement with results from the present study. However, Kehinde *et al.* (2011) reported no significant differences ($P>0.05$) in PCV, haemoglobin, RBC, TWBC and lymphocyte when a gingerized diet was fed to white cockerel chicks at 2 weeks. Increasing lymphocyte count in the blood following increase in white blood cells counts can play an important role in stimulating the immune system of animals (Al-Kassi, 2009). The increase in TWBC and neutrophil counts in 0.4% and 0.6% ginger meal groups, respectively, represents the stimulation of the host's immune system. This suggests that disease

suppressing properties of ginger may be due to its immune stimulatory effects in animals.

There were no significant differences ($P>0.05$) in cholesterol, triglyceride and LDL levels, while a significant difference ($P<0.05$) was observed in HDL level (Table 7). The birds fed 0.4% ginger meal diets had significantly higher ($P<0.05$) HDL (56.72 mg/dL) than those reared on 0.2% (25.38 mg/dL) ginger meal diet. The results in this study was contrary to findings of Saeid *et al.* (2010) who reported significant decrease in total cholesterol, LDL, very low density lipoprotein (VLDL) and increased HDL concentration in broiler chicken fed diets containing 0.4% and 0.6% aqueous ginger extract. This study indicated that birds placed on 0.4% ginger meal had a better health outcome than those on 0.2% ginger meal inclusion.

Table 6: Haematological profile of broilers chickens as affected by different dietary inclusion levels of ginger meal

Parameters	Ginger meal levels (%)				SEM
	T1 (0)	T2 (0.2)	T3 (0.4)	T4 (0.6)	
Haemoglobin (g/dl)	10.16 ^a	11.96 ^b	10.08 ^a	10.60 ^a	0.29
PCV (%)	32.22 ^a	36.68 ^b	32.78 ^a	33.66 ^a	0.89
RBC ($\times 10^6$ /ul)	2.74	2.79	2.62	2.56	0.12
MCV (fL)	121.48	132.6	126.64	133.52	4.79
MCH (pg)	34.26 ^a	40.34 ^b	37.60 ^{ab}	40.02 ^b	1.89
MCHC (g/dL)	29.36	30.38	29.86	29.74	0.69
Platelet ($\times 10^3$ /uL)	24.00	27.10	24.80	25.60	1.17
TWBC ($\times 10^3$ /uL)	65.04 ^a	69.32 ^{ab}	89.62 ^c	76.78 ^b	2.49
Lymphocyte (%)	86.80 ^b	85.60 ^{ab}	86.00 ^{ab}	81.60 ^a	1.56
Neutrophil (%)	13.20 ^a	14.40 ^a	14.00 ^a	19.40 ^b	1.42
Monocyte (%)	-	-	-	-	-
Eosinophil (%)	-	-	-	-	-
Basophil (%)	-	-	-	-	-

^{a,b,c}Means on the same row bearing different superscripts are significantly different ($P < 0.05$)

Gordon *et al.* (1989) reported that high concentration of the relatively large HDL particles correlates with better health condition. Evidence from present study and previous reports strongly suggest hypolipidaemic and hypocholesterolaemic

effects of ginger and its extracts. The hypotriglyceridemic effects in chickens fed herbs were probably due to active ingredients in herbs leading to a decrease in the activity of lipogenic enzymes; thereby reducing re-synthesis (*de novo*) of fatty

acids in liver and subsequently reducing blood LDL cholesterol level (Ciftci *et al.*, 2010). The use of ginger extract has also been reported to reduce cholesterol levels in animals (Galib *et al.*, 2010). According to Crowell, 1999 and Elson *et al.* (1989), active ingredients of medicinal herbs inhibit activity of hydroxymethyl glutaryl

coenzyme A reductase (HMG – CoA) in the liver. This enzyme is a key regulatory enzyme in cholesterol synthesis. Although no significant differences ($P>0.05$) were observed in ether extract contents of meat samples (Table 7), higher inclusion levels of ginger meal, may reduce total lipid contents significantly.

Table 7: Serum lipid profile and meat ether extract of broilers fed diets containing different ginger meal levels

Parameters (mg/dL)	Ginger meal levels (%)				SEM
	T1 (0)	T2 (0.2)	T3 (0.4)	T4 (0.6)	
Cholesterol	123.30	116.90	140.10	118.76	7.82
Triglycerides	83.14	39.54	61.74	59.46	15.04
HDL	42.96 ^{ab}	25.38 ^a	56.72 ^b	42.72 ^{ab}	10.12
LDL	63.70	78.22	75.70	64.16	12.97
Ether Extract (%)	12.32	10.65	15.81	16.38	1.98

^{a,b}Means on the same row bearing different superscript are significantly different ($P < 0.05$)

HDL = High Density Lipoprotein

LDL = Low Density Lipoprotein

Organoleptic Quality and Microbial Load

Table 8 shows organoleptic quality of meat from broilers fed diets with varying levels of ginger meal. Juiciness, flavour and hedonic score showed no significant differences ($P>0.05$) while tenderness varied significantly ($P<0.05$). Meats from 0.4% and 0.6% dietary treatments recorded 8.20 and were more significantly tender ($P<0.05$) than those from 0% treatment group (7.40). Information on organoleptic quality of broilers fed ginger meal supplemented diets is scarce in literature. Odoemelem *et al.* (2013) reported a significant difference ($P < 0.05$) in tenderness, flavour, juiciness and general acceptability of broilers fed diets containing varying levels of scent leaf meal, a spice like ginger. Many herbs, spices and their extract have been added in a variety of foods to improve their sensory characteristics and extend shelf-life (Shahidi *et al.*, 1992). Natural antioxidants have been reported to have no effect on sensory characteristics of meat (Chaves *et*

al., 2008; Janz *et al.*, 2007). Hedonic rating suggests that panellist seemed to like meat from all the groups equally.

There were no significant differences ($P>0.05$) in subjective meat colour evaluation among the treatment groups as shown in (Table 8). Rhizome powder of turmeric (*Curcuma longa* Linn), a member of the Zingiberaceae family, has been extensively used for imparting colour and flavour to foods (Deshpande *et al.*, 1997). The effectiveness of rosemary and oregano extracts to reduce colour loss in some types of meats (Djenane *et al.*, 2002) has been reported. However, ginger inclusion to broiler diets did not affect the meat colour.

There were no significant differences ($P>0.05$) in percentage cooking loss across all the groups treatment (Table 8) suggesting that inclusion of ginger meal in broiler diets had no effect on post-mortem glycolysis or exudation of juice from the meat. Expectedly, during post-mortem aging, the antioxidants in ginger could have imparted its preservative effect which may

Table 8: Effect of dietary inclusion of ginger meal on meat colour, cooking loss, organoleptic rating and bacterial load

Parameters ⁺	Ginger meal levels (%)				SEM
	T1 (0)	T2 (0.2)	T3 (0.4)	T4 (0.6)	
Meat Colour ⁺⁺	2.80	2.80	2.20	2.60	0.21
Cooking Loss (%)	10.65	10.65	13.08	11.59	1.42
Tenderness	7.40 ^a	8.00 ^{ab}	8.20 ^b	8.20 ^b	0.24
Juiciness	6.80	7.20	7.20	7.00	0.32
Flavour	7.20	7.40	7.60	7.80	0.59
Hedonic Score	7.20	7.80	7.80	7.80	0.46
Bacterial Load	+++	+++	+++	+++	-

^{a,b}Means in the same row bearing different superscript are significantly different ($P < 0.05$). The 9 points Category Rating Scale used: Extremely tender/juicy/flavoured = 9; very tender/juicy/flavoured = 8; moderately tender/juicy/flavoured = 7; slightly tender/juicy/flavoured = 6; neither tender/juicy/flavoured, nor tough/dry/unflavoured = 5; slightly tough/dry/unflavoured = 4; moderately tough/dry/unflavoured = 3; very tough/dry/unflavoured = 2; extremely tough/dry/unflavoured = 1. Hedonic Scoring: Extremely liked = 9; very liked = 8; moderately liked = 7; slightly liked = 6; neither liked nor disliked = 5; slightly disliked = 4; moderately disliked = 3; very disliked = 2; extremely disliked = 1. ⁺⁺The 3 points colour score used was: Normal colour = 3; slightly abnormal = 2; clearly abnormal = 1. ⁺⁺⁺ Heavy bacteria growth of *Salmonella* spp.

have a moderating effect on cooking loss. In this study, the muscle samples were not aged as they were tested for cooking losses about 24 hours post-mortem. Results on bacterial load showed a heavy growth of *Salmonella* species in all treatment groups (Table 8). Sudrashen *et al.* (2010) reported that essential oil extracted from ginger resulted in a significant reduction in the bacterial counts of *Staphylococcus*, *Escherichia coli* and *Salmonella* when applied as a decontaminating agent to chicken meat. The different outcomes may be due to the form in which ginger was applied and the prevailing environmental condition. Chrubasik *et al.* (2005) in a review showed that the processing method of ginger product affected its clinical efficacy.

Conclusion

Dietary inclusion of ginger meal in broiler diets within 0.4% and 0.6% inclusion levels in this study had positive effects on serum lipoprotein level and organoleptic quality of meat. It is therefore concluded and recommended that the dietary inclusion of

ginger meal at 0.4% or 0.6% levels in broiler diets should be encouraged and adopted by poultry producers since it significantly increased broilers' serum high density lipoprotein (HDL) level, dressing percentage, carcass weight and meat tenderness. Further research is necessary to investigate the efficacy of ginger meal in prolonging the shelf-life of broiler meat. This may require increasing the level of inclusion in poultry diets.

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