Tropical Animal & Poultry Science

Publisher: Tropican Animal Research Services, Armidale NSW, Australia. www.tropican.com.au. Email: trop.sci@gmail.com.
ISSN: 2208-8431

Growth performance, carcass quality and haemato-biochemical profile of broiler chickens fed Turmeric (*Curcuma longa* L) rhizome powder in a hot and humid environment.

A.A. Odunsi*[1], M.A. Haruna[1], A.O. Akinwumi[1], T.O. Akande[2], O.A. Morakinyo[1], O.R. Olalere[1] and C.O. Olatunji[1]

[1]Department of Animal Nutrition and Biotechnology, Faculty of Agricultural Sciences, Ladoke Akintola University of Technology, Ogbomoso, Nigeria
[2]Department of Animal Sciences, Obafemi Awolowo University, Ile Ife, Nigeria
*[1]Corresponding author: aaodunsi@lautech.edu.ng

Abstract

This study investigated the effect of dietary Turmeric (*Curcuma longa* L) Rhizome Powder (TRP) on growth performance, carcass quality and haemato-biochemical profile of broiler chickens. The trial was carried out in an open-sided and naturally ventilated broiler house under conditions of high ambient temperature and humidity prevalent in the tropics. A total of 200 day-old Arbor Acre broiler chicks were randomly allotted into five dietary treatments comprising of four replicates in each treatment. Five diets containing varying levels of TRP at 0, 2.5, 5.0, 7.5 and 10 g/kg were fed during the starter (1-28d) and finisher (29-49d) phases. The ambient temperature and relative humidity were monitored during the experimental period. Data on growth performance (daily weight gain (DWG) and daily feed intake (DFI) were measured while feed-to-gain ratio (FGR) was computed during the starter, finisher and combined starter/ finisher phases. Carcass cut-up parts, meat composition and blood profile were determined at the end of the finisher phase. Data collected were subjected to one-way analysis of variance and treatment means separated using Duncan Multiple Range Test at $P<0.05$. At 1-28d, DFI and DWG were not significantly ($P>0.05$) influenced whereas FGR improved with supplementation and the best response was for broilers on 7.5gTRP/kg diet. At 29-49d, increase in TRP decreased ($P<0.05$) feed intake, increased ($P<0.05$) DWG and ($P<0.05$) FGR. At 1-49d, DFI was similar ($P>0.05$) while DWG and FGR were positively enhanced ($P<0.05$) with TRP. Improvement in DWG for broilers fed 2.5g/kg, 5.0g/kg, 7.5g/kg and 10g/kg TRP over the control group were 4.66, 4.88, 7.10 and 8.43% respectively while, 6.18, 6.56, 8.49 and 10.04% were recorded for FGR respectively. Inclusion of TRP significantly improved (up to 6.1%) the carcass dressing percentage of birds fed 10g/kg TRP over the control group. Abdominal fat increased ($P<0.05$) with increase in TRP. Supplementation of TRP in broiler diets improved the sensory attributes of the meat giving a better flavour, colour, tenderness and overall acceptability. The crude protein, ether extract and dry matter contents of broiler meat increased significantly with increase in TRP level. Birds on 0gTRP/kg diet had the least ($P<0.05$) values for packed cell volume (26.0%), haemoglobin (6.95g/dl) and mean corpuscular haemoglobin (23.39pg), while those on 10g/kg TRP had the least ($P<0.05$) values for white blood cell and red blood cell. Turmeric rhizome powder had significant ($P<0.05$) influence on all parameters measured for serum biochemical indices except the albumin. The use of supplemental TRP in broiler diets demonstrated significant growth enhancement following its cushioning effects against thermal stressors in a hot and humid environment.

Adoptable findings
In Nigeria and some other parts of the tropics, commercial broiler chicken meat is considered to be of poorer taste than the local poultry meat. Supplementing commercial poultry diets with spices may improve the quality of the meat but such plant extracts are also known to contain antiobiotic properties. It is important to assess such extracts from the dual points of view as spice and as antibiotic agents.

Key words: Arbor Acres broiler chicks, Growth Performance, Turmeric, Carcass, Blood

---

Introduction

There has been an increase in commercial broiler production in Nigeria due to a significant rise in the number of eateries and fast food outlets making use of dressed broiler chickens. However, the climate of Nigeria is generally hot throughout the year with slight differences between wet season (summer) and rainy (winter) months. The annual mean temperature and relative humidity in Nigeria has been recorded as 32.8±3.37^{o}C and 61.98±24.8% respectively (Eludoyin, 2011; Oyewole *et al*., 2014; Olorunmaiye *et al*., 2016). The high temperature and humidity most times lead to thermal stress, which Eludoyin *et al.*, (2014) had shown to be on the increase from year 2000 at most weather stations in Nigeria. Heat stress is particularly detrimental to broiler productivity in tropical and sub-tropical regions of the world. Exposing broilers to high ambient temperature affects feed intake, and consequently loss of body weight and cause adverse physiological changes in the animals (Olanrewaju *et al.,* 2016). Current commercial broiler hybrids with high performance attributes require high-energy diets, which allow the maximum expression of their genetic potential. However, in order to counteract the effect of high ambient temperature, poultry producers make use of feed additives in addition to other measures (Gous and Morris, 2005). Herbal feed additives are added to animal feed to improve their nutritive value, boost animal performance by increasing their growth rate, and enhance feed conversion efficiency as well as lower mortality in poultry birds (Durrani *et al.,* 2006; Andriyanto *et al.,* 2016). Recently, turmeric (Baghban *et al.,* 2016) has been employed to achieve the above-mentioned objectives and also alleviate the effect of heat stress in broiler chickens.

Turmeric (*Curcuma longa* L.) is a rhizomatous herbaceous perennial plant of the ginger family, *Zingiberaceae*. It is native to tropical South Asia but is now widely cultivated in all the tropical and subtropical regions of the world. Globally, the world production level for turmeric is between 11-16 tons per year, India accounts for over 78%, followed by China and Myanmar in Asia, while Nigeria is the fourth largest producer of turmeric with about 3% of the global annual production (Yusuf, 2016).

The deep orange-yellow powder known as turmeric is prepared from boiled and dried rhizomes of the plant. It has been extensively used as spice, food preservative and coloring material. The plant has also been recognized as a pharmaceutical crop for production of standardized therapeutic extracts or molecules (Yusuf, 2016). Turmeric has beneficial effects on many biological reactions including anti-inflammatory, antioxidant, anti-carcinogenic, anti-mutagenic, anticoagulant, antifertility, anti-diabetic, antibacterial, antifungal, antiprotozoal, antiviral, anti-fibrotic, anti-venom, hypotensive and hypo-cholesteremic activities (Chattopadhyay *et al*., 2004). Several authors (Samarasinghe *et al.,* 2003; Durrani *et al*., 2006; Zainali *et al.,* 2009; Abd Al-Jaleel, 2012; Mahmoud, 2015) had reported that turmeric powder improved growth performance and nutrient metabolism, enhanced feed-to-gain ratio, supported a higher relative weight of breast and thigh portions, but reduced abdominal fat of broiler chickens. Sugibarto *et al.* (2011) and Emadi *et al*. (2007) inferred that turmeric powder had significant effect on blood values of broilers while Ashayerizadeh *et al*., (2009) did not observe any significant changes. Furthermore, (Hosseini-Vashan *et al.,* 2015; Baghban *et al.,* 2016) highlighted the thermal stress reducing effect of turmeric in broiler diets, whereas Hosseini-Vashan *et al.* (2012) concluded that turmeric supplementation in diets improved the antioxidant status without affecting performance and immune system of heat-stressed broilers.

Therefore, the present study was carried out with the aim of investigating the effects of supplemental dietary turmeric rhizome powder on growth performance, carcass quality and haemato-biochemical profile of broiler chickens under a humid tropical environment characterized by high temperature and relative humidity.

Materials and Methods

The experiment was carried out at the Poultry Research unit of Ladoke Akintola University of Technology Teaching and Research Farm, Ogbomoso, Nigeria where turmeric rhizomes were also harvested from the farm plots. Harvested turmeric rhizomes were sliced and blanched with water at 60^{0}C for five minutes after which they were sun dried for seven days. Dried turmeric rhizomes were grinded with electric blender to make powdered turmeric rhizome powder (TRP). Two basal diets were formulated for the broilers at two stages of growth (as shown in Table 1): for the starter (1-28 days) and finisher (29-49 days) phases and TRP was added to the diets at the inclusion rates of 0, 2.5, 5.0, 7.5, and 10gTRP /kg diet to make five dietary treatments each for the starter and finisher phases. A total of 200 unsexed day-old Arbor Acres broiler chicks were purchased and randomly distributed into the five dietary groups. Each treatment contained 4 replicates of 10 birds. The birds were raised on a deep litter system under intensive management and were supplied with feed and water *ad-libitum* and all necessary routine management practices were carried out. The trial was carried out in an open-sided and naturally ventilated broiler house under conditions of high ambient temperatures and relative humidity. A standard wet and dry bulb thermometer was hanged centrally inside the poultry house for monitoring temperature and humidity between 12.00am and 2.00pm daily.

Data were collected daily on feed intake (DFI) and weight gain (DWG) while feed-to-gain ratio (FGR) and mortality rate were computed, respectively. At the 49^{th} day of the trial, sixteen chickens (male and female) per treatment were sacrificed for blood collection, carcass and organ evaluation, and meat quality analysis. The birds were slaughtered and properly bled by hanging their legs and turning down their necks and then scalded in water at 60°C. After de-feathering, the plucked weight was recorded and was followed by evisceration to get dressed carcass weights. The weights of the cut-up parts (thigh, breast, neck, wings, back and drumsticks), organs (heart, kidney, lungs, liver, spleen, gizzard and intestines), and the abdominal fats were recorded. From the sacrificed and dissected carcasses, samples of the breast and drumstick muscles were divided into two parts and rinsed individually in distilled water. A part of the divided breast and drumstick was packed in labelled transparent double layer polythene bag, boiled in water bath at 80^{o}C for 20minutes. The other part was also prepared and grilled in a microwave oven for 20minutes. Both boiled and grilled samples were allowed to cool to room temperature, coded with random numbers, arranged on white enamel plates and presented to a ten member panellist for sensory evaluation. Each panellist was required to provide organoleptic scores, one sample per treatment with ranked preference in the following categories: colour, juiciness, flavour, tenderness and overall acceptability. A nine-point hedonic scale was used with 1 referring to extremely dislike and 9 as extremely like (Cross, *et al.*, 1987). Members of the panel were told not to chew gum or drink water for at least 3 hours before the commencement of the test. They were also asked to rinse their mouths with water after each sample and to allow an interval of not less than 2 minutes in-between samples. Samples of the uncooked meat (drumstick) were also used to determine the crude protein, ether extract and moisture contents according to AOAC (2006). In addition, meat samples from the breast and drumstick portions were weighed, cooked or grilled, residual moisture removed and reweighed. The differences in weight were recorded as weight loss (Cross *et al.*, 1987) from where percentage-cooking loss was calculated.

$$\% \text{ Cooking loss} = \frac{\text{Raw weight (g)} - \text{cooked weight (g)}}{\text{Raw weight}} \times 100$$

At the point of slaughter, blood samples were collected through the wing veins into labelled sterile universal bottles containing ethylene-diamine-tetra-acetic acid (EDTA) as anticoagulant and used to determine the haematological components (packed cell volume, red blood cell, haemoglobin, white blood cell, mean cell volume, mean cell haemoglobin, and mean cell haemoglobin concentration) within an hour of sample collection following standard procedures described by Dacie and Lewis (1991). Blood samples were also transferred into labelled sterile bottles without anticoagulant and used to determine the biochemical components (total protein, total cholesterol, albumin, globulin, urea, serum glutamate oxaloacetate transaminase (SGOT) and serum glutamate pyruvate transaminase (SGPT).

Dried samples of diets and TRP were analysed for proximate composition using the methods described by AOAC (2006). The data collected were subjected to one-way analysis of variance (ANOVA) using the General Linear Model procedure of SAS (2012) to determine treatment effects. Significant mean differences were determined using Duncan Multiple Range Test of the same package

Results and Discussion

The study was carried out between July and September when the weather was quite hot, humid and rainy. In Nigeria, the wet season (summer) is usually from April to October while the dry season (winter) is from November to March. The poultry house temperature was approximately 30.5^oC +/- 2^oC during the finisher period and average ambient relative humidity was 73% +/- 2%. Leeson *et al.*, (1992) stated that the optimum temperature range in which broilers are able to optimise their maximum genetic potential is between 12.7 and 26.7^oC, whereas Olanrewaju *et al.* (2016) had classified temperature above 26^oC as high for broiler chickens.

The analysed TRP contained 8.05% moisture content, 9.67% crude protein, 3.91% fat, 5.57% crude fibre, 8.25% ash and 64.55% total carbohydrates. This is indicative of a good source of protein, carbohydrates and minerals due to the high ash content.

Growth performance of broiler chickens fed varying supplemental levels of TRP during the starter, finisher and combined phases are shown in Table 2. At the starter phase, DFI and DWG were not significantly ($P>0.05$) influenced, whereas FGR improved with supplementation and the best response was obtained from broilers on 7.5gTRP/kg diet. At the finisher phase, increase in TRP decreased ($P<0.05$) DFI, increased ($P<0.05$) DWG and improved ($P<0.05$) FGR. At 1-49days, DFI was similar ($P>0.05$) while DWG and FGR were significantly improved with increase in TRP. The improvement in DWG for broilers fed 2.5g/kg, 5.0g/kg, 7.5g/kg and 10g/kg TRP over the control group was 4.66, 4.88, 7.10 and 8.43% respectively while, 6.18, 6.56, 8.49 and 10.04% were recorded for FGR respectively. The improvement in DWG and FGR supported previous reports (Abd Al-Jaleel, 2012; Hanan, 2015; Mahmoud, *et al.*, 2015), but was at variance with Hosseini-Vashan *et al.* (2012) who reported that TRP had no effect on performance of heat-stressed broiler chickens. The improvement in DWG and FGR as the inclusion rate of TRP increased could be attributed to optimal antioxidant activity of turmeric that stimulates protein synthesis by enzymatic system (; Zainalli *et al.*, 2009; Hanan, 2015) and reduction of lipid peroxidation (Baghban *et al.*, 2016). The noted improvements may also be due to the active components of turmeric (curcuminoids and curcumin) that enhance digestion and absorption of dietary nutrients (Hussein, 2012; Baghban *et al.*, 2016). Earlier report (Rajput *et al.*, 2012) showed that TRP had the ability to stimulate secretion of digestive juices and improve the gastro-intestinal conditions, which could contribute to an increase in nutrient utilization, in addition to its anti- microbial effects. The high ambient temperature that birds on control diet were exposed to without supplemental turmeric might also have impacted on their performance in terms of feed intake, weight gain, feed conversion efficiency and physiological responses (Abu-Dieyeh, 2006).

Table 1:Gross composition of diets (g/kg)

Ingredients (kg)	Starter (1-28d)	Finisher (29-49d)
Maize	521.0	571.0
Soya bean meal	270.0	230.0
Groundnut cake	80.0	40.0
Wheat offal	50.0	86.0
Fish meal (72%)	30.0	25.0
Dicalcium Phosphate	30.0	30.0
Oyster shell	10.0	10.0
Lysine	2.0	2.0
Methionine	2.5	2.5
Broiler Premix*	2.5	2.5
Salt	2.0	2.0
Total	1000	1000
Analysed Composition (g/kg)		
Crude Protein	227.0	204.0
Ether Extract	32.5	45.1
Crude Fibre	30.0	50.0
Ash	80.0	80.0
Dry Matter	925.0	925.0
Nitrogen Free Extract	555.0	546.0

*Premix Composition (per kg diet): Vit. A (12,000,000IU), Vit K (2000mg), Vit D3 (2,500,000IU), VitB2 (6000mg), Vit B6 (4500mg), Pantothenic acid (15,000mg), Folic acid (1500mg), Biotin (50mg), Choline chloride (300,000mg), Cobalt (500mg), Copper (5000mg), Iodine (1000mg), Iron (20,000mg), Manganese (80,000mg), Selenium (1000mg), Zinc (50,000mg), Antioxidant (125,000mg).

The effect of supplemental TRP in broiler diets during the hot summer months on carcass yield, cut-up parts, abdominal fat, organs and offal weights are shown in Table 3. Carcass dressing percentage, wing and back were significantly higher ($P<0.05$) in birds fed TRP diets compared to the control. The values for neck, breast, drumstick and thigh portions were not significantly ($P>0.05$) influenced but higher numerical values were recorded for broilers fed TRP. The improved carcass traits could be attributed to the presence of beneficial phytochemicals such as curcumin, methylcurcumin, and other active compounds (Nanung *et al.,* 2013) in turmeric. Our findings agreed with those of Andriyanto *et al.* (2016) and Adegoke *et al.* (2016) who reported that turmeric powder increased carcass quality and dressing percentage, exemplified by the quality breast and thigh portions of broilers while Rahmatnejad *et al.* (2009) did not record any significant changes. The general aim in the feeding of turmeric diet was to cause a decrease in the abdominal fat contents (Samarasinghe *et al.*, 2003; Durrani *et al.*, 2006; Zainali *et al.,* 2009; Zhongze, 2009; Hosseini-vashan *et al.,* 2012; Andriyanto *et al.*, 2016;). It was postulated that curcumin decrease the activity of the enzymes acting as rate limiting enzymes in lipogenesis such as acetyl coA carboxylase, which is the rate limiting enzyme in fatty acid synthesis. However, our result and those of Adegoke *et al.* (2016) did not support that notion. Possibly, turmeric cultivar, diet content, level of curcumin in diet and broiler strain may be possible reasons for the increment in abdominal fat content recorded here. Changes in organ weights (Table 3) were only significant for heart, spleen and large intestine while kidney, lung, gizzard, liver, small intestine and caecum were not significantly influenced, which were somewhat similar to observations by Ashayerizadeh *et al.* (2009) and Adegoke *et al.* (2016).

Table 2: Effects of maize-soybean based diets supplemented with Turmeric rhizome powder on growth performance (g/kg) of broiler chickens during starter, finisher and combined starter/ finisher phases

	0	2.50	5.0	7.5	10.0	SEM
Starter phase (1-28d)						
Daily feed intake, g	71.9	71.8	71.7	70.7	70.1	3.62
Daily weight gain, g	33.0	34.6	34.7	36.7	33.3	1.15
Feed: Gain	2.18^{c}	2.07^{b}	2.07^{b}	1.93^{a}	2.11^{c}	0.13
Finisher phase (29-49d)						
Daily feed intake, g	175.9^{a}	171.8^{c}	171.3^{c}	172.8^{b}	171.8^{b}	4.12
Daily weight gain, g	61.2^{b}	64.1^{b}	64.1^{b}	63.9^{c}	69.7^{a}	3.02
Feed: Gain	2.87^{a}	2.68^{b}	2.67^{b}	2.74^{b}	2.49^{c}	0.25
Combined phase (1-49d)						
Daily feed intake, g	116.5	114.6	114.4	114.5	113.7	1.18
Daily weight gain, g	45.1^{c}	47.2^{b}	47.3^{b}	48.3^{a}	48.9^{a}	0.65
Feed: Gain	2.59^{a}	2.43^{b}	2.42^{b}	2.37^{b}	2.33^{b}	0.19

SEM: ^{a,b,c,d} Treatments on the same row with different superscripts are significantly different (p<0.05)

Table 3: Carcass, cut-up parts, organ and offal yield of broiler chickens fed supplemental levels of Turmeric powder (percentage of live weight)

			Diet(g/kg)			
Parameters	0	2.5	5.0	7.5	10.0	SEM
LW (g/bird)	2267^{c}	2303^{b}	2300^{b}	2317^{b}	2393^{a}	17.4
Dressed %	69.2^{c}	71.1^{bc}	71.1^{bc}	73.9^{a}	73.4^{a}	0.69
Cut up Parts %						
Breast	23.6	24.0	25.4	24.8	23.6	0.28
Thigh	10.5	10.9	10.6	10.9	10.6	0.09
Drumstick	9.92	10.6	10.2	10.5	10.7	0.14
Back	12.1^{b}	15.0^{a}	12.3^{b}	12.5^{b}	13.2^{a}	0.22
Wing	7.28^{b}	7.40^{b}	7.39^{b}	8.22^{a}	8.17^{a}	0.08
Neck	4.53^{b}	4.68^{b}	4.62^{b}	5.24^{a}	5.13^{a}	0.05
Abdominal fat	0.62^{c}	1.41^{b}	1.07^{b}	1.58^{a}	1.69^{a}	0.76
Organs (%)						
Kidney	0.55^{ab}	0.40^{ab}	0.28^{b}	0.34^{ab}	0.65^{a}	0.09
Lungs	0.65	0.56	0.65	0.53	0.65	0.15
Heart	0.66^{a}	0.48^{b}	0.65^{a}	0.67^{a}	0.71^{a}	0.17
Spleen	0.14^{a}	0.13^{a}	0.14^{a}	0.09^{b}	0.12^{ab}	0.02
Gizzard	3.68	3.66	4.05	3.66	3.72	0.46
Liver	2.66^{b}	2.28^{b}	3.15^{a}	2.61^{b}	3.06^{a}	0.26
Offals %LW						
Small intestine	2.93^{b}	2.84^{b}	3.00^{a}	2.77^{b}	3.11^{a}	0.13
Large intestine	0.18	0.14	0.13	0.15	0.14	0.07

a, b and c: Treatment means on the same row with different superscripts are significantly different (P<0.05).
LW = live weight

The data on water loss and meat composition presented in Table 4 showed that percentage loss due to cooking was not significant (P>0.05) while roast loss was significant (P<0.05). Meat from the broiler chickens on 10g/kg TRP had the highest roast loss of 41.9%. The dry matter, ether extract and crude protein of the meat obtained from the breast muscle of the experimental broiler chickens all showed significant variations. Crude protein values were significantly (P<0.05) higher for broilers on 2.5 and 7.5g/kg TRP (Daneshyar *et al.*, 2011) while the high ether extract value was at variance with Daneshyar *et al.*, (2011). The high ether extract obtained in this trial might have been a function of the high abdominal fat deposit in the broilers fed turmeric powder diet.

Table 4: Dry matter, crude protein, ether extract content and water loss of meat from broiler chickens fed supplemental levels of Turmeric powder (g/kg)

		Diets (g/kg)				
Parameters, %	0	2.5	5.0	7.5	10	SEM
Dry Matter	36.6^{b}	39.1^{a}	36.7^{b}	39.1^{a}	37.8^{b}	2.99
Crude Protein	20.1^{b}	24.2^{a}	21.2^{b}	26. 9^{a}	22.3^{b}	2.37
Ether extract	9.92^{b}	9.80^{b}	10.6^{a}	11.3^{a}	10.1^{ab}	0.89
Water Loss						
Cook Loss	24.4	28.5	24.9	25.8	24.4	0.71
Roast Loss	36.1^{b}	35.3^{b}	36.1^{b}	32.3^{b}	41.9^{a}	0.98

a, b and c: Treatment means on the same row with different superscripts are significantly different (P<0.05)

Table 5: Effect of maize-soybean diets supplemented with turmeric rhizome (*Curcuma longa*) powder on sensory evaluation of processed meat of broiler chickens

	Diets (g/kg)					
Parameters	0	2.5	5.0	7.5	10	SEM
Boiled:						
Colour	6.17^{b}	5.47^{b}	7.29^{a}	7.71^{a}	7.47^{a}	0.28
Flavour	4.57^{bc}	4.71^{b}	4.00^{c}	4.29^{c}	4.86^{a}	0.23
Tenderness	4.71	4.40	5.41	4.91	5.14	0.26
Juiciness	4.34^{b}	4.57^{b}	4.43^{b}	4.71^{a}	4.86^{a}	0.22
Texture	5.43	4.43	5.86	5.57	5.14	0.22
Overall Acceptability	5.56^{b}	5.29^{b}	6.29^{a}	6.43^{a}	6.48^{a}	0.20
Roasted:						
Colour	6.57^{b}	6.86^{b}	6.88^{b}	7.14^{a}	7.71^{a}	0.22
Flavour	3.57	3.86	3.57	4.00	3.86	0.22
Tenderness	3.57^{c}	6.00^{a}	7.14^{a}	5.43^{b}	6.71^{a}	0.26
Juiciness	4.29	3.57	4.57	4.86	4.71	0.22
Texture	5.14^{c}	5.43^{c}	5.86^{b}	6.43^{b}	7.14^{a}	0.61
Overall Acceptability	5.86^{c}	6.23^{b}	6.86^{a}	6.29^{b}	6.43^{b}	0.15

$^{a, b, c \text{ and } d}$ Treatments on the same row with different superscripts are significantly different (p<0.05).

The haematological indices (Table 6) showed that birds fed the control diet had the least (P<0.05) values for packed cell volume (26.0%), haemoglobin (6.95g/dl) and mean corpuscular haemoglobin (23.39pg) compared to broilers fed diets supplemented with TRP. However, broilers fed 10g/kg TRP had the least (P<0.05) values for white blood cell and red blood cell compared to those on the control diet. Though the highest values for PCV, MCV and MCHC were observed in birds fed 10g/kg TRP, the values obtained are within standard ranges recommended by Mitruka and Rawnsley (1977) and agreed with the findings of Emadi *et al.* (2007), Kumari *et al.* (2007) and Mahejabin et al. (2015). Though the method of turmeric administration in this study differs from those of Sugiharto et al., (2011) who offered turmeric extract orally, but the results from both studies were in concurrence. Turmeric rhizome powder had significant (P<0.05) influence on all parameters measured for serum biochemical indices except the albumin (Table 7) however, Ashayerizadeh *et al.*, (2009) observed no significant differences in the concentration of serum total protein, albumin, glucose, globulin, total cholesterol, SGPT and SGOT of broilers fed TRP. The different physiological reactions to turmeric supplementation across various studies may be ascribed to form of administration, exposure to heat, level of inclusion and possibly broiler strain used for the different studies.

Table 6:Effect of maize-soybean diets supplemented with turmeric rhizome (*Curcuma longa*) powder on haematology of broiler chickens

	Diets (g/kg)					
Parameters	0	2.5	5.0	7.5	10	SEM
Packed cell volume, %	26.0^{c}	28.5^{b}	28.1^{b}	28.0^{b}	30.2^{a}	1.57
White blood cell, x10^{3}/L	20.9^{d}	31.5^{a}	28.0^{b}	22.4^{c}	17.9^{d}	1.17
Red blood cell, x10^{9}/L	3.00^{b}	3.15^{b}	3.55^{a}	2.73^{b}	2.70^{b}	0.60
Haemoglobin, g/dl	6.95^{b}	7.90^{a}	8.05^{a}	7.35^{b}	8.70^{a}	0.96
MCHC, %	26.9^{b}	27.8^{a}	28.8^{a}	26.8^{b}	29.2^{a}	1.79
MCH, Pg	23.4^{c}	26.7^{b}	24.4^{c}	27.9^{b}	32.6^{a}	4.62
MCV, Fl	86.9^{b}	94.2^{b}	86.4^{b}	105.5^{a}	112.1^{a}	16.66

$^{a, b\ and\ c}$ Treatments on the same row with different superscripts are significantly different ($p<0.05$).
MCHC = Mean Corpuscular Haemoglobin Concentration; MCH = Mean corpuscular Haemoglobin
MCV = Mean Corpuscular Volume

Table 7:Effect of maize-soybean diets supplemented with turmeric rhizome (Curcuma longa) powder on serum biochemistry of broiler chickens

Parameters	0	2.5	5.0	7.5	10	SEM
Total Protein, mg/dl	3.70^{a}	3.35^{c}	3.32^{c}	3.50^{ab}	3.65^{a}	0.28
Globulin, mg/dl	2.30^{ab}	2.10^{c}	2.16^{c}	2.25^{b}	2.40^{a}	0.17
Albumin, mg/dl	1.40	1.25	1.16	1.25	1.25	0.15
Total cholesterol, mg/dl	87.0^{a}	85.0^{a}	77.7^{b}	77.0^{b}	84.0^{a}	6.85
Urea, mg/dl	28.5^{a}	28.1^{a}	24.9^{b}	31.2^{a}	29.5^{a}	3.67
SGOT, μ/dl	417.5^{b}	367.5^{c}	375.6^{c}	417.0^{b}	486.5^{a}	59.71
SGPT, μ/dl	19.5^{ab}	16.0^{c}	21.7^{a}	16.0^{c}	20.5^{a}	3.33

$^{a, b\ and\ c}$ Treatments on the same row with different superscripts are significantly different ($p<0.05$).
SGOT = Serum Glutamate Oxaloacetate Transaminase; SGPT = Serum Glutamate Pyruvate Transaminase

Conclusion

Considering the results obtained in the current study, it could be concluded that dietary inclusion of turmeric powder positively enhanced growth performance, carcass yield, meat quality and maintained blood status of broiler chickens. In addition, turmeric powder (10g/kg) ameliorated the attendant hot and humid environmental conditions as revealed by the better growth performance of broiler chickens fed supplemental turmeric powder over the control group.

References

A.O.A.C (2006) Association of Official Analytical Chemists. Official methods of analysis, 18th Edition Washington, D. C. USA.

Abd Al-Jaleel, R. A. (2012) Use of turmeric (Curcuma longa) on the performance and some physiological traits on the broiler diets. Iraqi Journal of Veterinary Medicine. 36: 51-57

Abu-Dieyeh, Z. H. M (2006) Effects of high temperature per se on growth performance of broilers. Int. J. Poultry Sci., 5: 19-21

Adegoke , A. V., Abanikanda, I. A., Sanwo, K. A., Egbeyale, L. T and Abiona, A. A. (2016) Dietary addition of Turmeric (Curcuma longa) rhizome powder and Cayenne pepper (*Capsicum frutescens*) powder on carcass traits of broiler chickens. Proc. 41st Conference of Nigerian Society for Animal Production, March 20-24, 2016, Federal University of Agriculture Abeokuta, Ogun State, Nigeria pp 371-374.

Andriyanto, F. A, Dedi N. A, Pramesti N, Gusti H. S, Ridi A, Diah N. P, Aulia A.M and Wasmen M. (2016) Improved productivity and health performances of broiler chickens administered with Jamu ginger, curcuma and turmeric. Int. J. Poult. Sci., 15: 487-492.

Ashayerizadeh, O., Dastar, B., Shams S. M., Rahamatnejad, E., and Ashayerizadeh, A. (2009). Influence of prebiotic and two herbal additives on interior organs and haematological indices of broilers. J Anim. Vet. Adv. 8(9):1851-1855.

Baghban, K. P., Daneshyar, M and Najafi, R (2016) Effects of cinnamon (*Cinnamomum zeylanicum*) and Turmeric (*Curcuma longa*) powders on performance, enzyme activity and blood parameters of broiler chickens under heat stress. Poultry Science Journal 4 (1): 47-53

Chattopadhyay, I., Biswas K., Bandyopadhyay U. and Banerjee R. K. (2004) Turmeric and curcumin: Biological actions and medicinal applications. Current Science. 87: 44-53

Cross, H.R., Moen, R. and Stanfield, S. (1987) Guidelines for cookery and sensory evaluation of meat. Meat Science Association (ed), Chicago, USA.

Dacie, J.V. and Lewis, S.M. (1991). Practical haematology, 7th Edn, Edinburgh: Churchill Livingstone, England, 37-85

Daneshyar, M., Alizadeh Ghandkanlo, M., Sabzi Bayeghra, F., Farhangpajhoh, F. And Aghaei M. (2011) Effect of dietary turmeric supplementation on plasma lipoproteins, meat quality and fatty acid composition in broilers, South African Journal of Animal Science, 41(4): 420-428

Durrani F. R., Ismail, M, Sultan, A, Suhail1, S. M., Chand, N and Durrani, Z (2006) Effect of different levels of feed added Turmeric (*Curcuma longa*) on the performance of broiler chicks, Journal of Agricultural and Biological Science V 1(2): 9-11

Eludoyin, O. M (2011) Air temperature and relative humidity areal distribution over Nigeria. Ife Research Publications in Geography 10: 134-145

Eludoyin, O. M., Adeleke, I.O., Webster, R and Eludoyin, A.O. (2014) Air temperature, relative humidity, climate regionalization and thermal comfort of Nigeria. International Journal of Climatology 34: 2000-2018

Emadi, M., Kermanshahi, H and Maroufyan, E (2007) Effect of varying levels of turmeric rhizome powder on some blood parameters of broiler chickens fed corn-soybean meal based diets. Int. J. Poult. Sci. 6:345-348

Gous, R.M and T.R. Morris, (2005) Nutritional interventions in alleviating the effects of high temperatures in broiler production. World's Poult. Sci. J., 61: 463-475.

Govindarajan V. S. and Stahl W. H. (1980) Turmeric- Chemistry, technology, and quality. Crit. Rev Food Sci Nut. 12:199-301.

Hanan E. Al-Mashhadani (2015) Effect of different levels of Turmeric (*Curcuma longa*) supplementation on broiler performance, carcass characteristic and bacterial count. Egyptian Poultry Science Journal. 35(I): 25 -39

Hosseini-Vashan, S. J., Golian, A and Yaghobfar, A (2015) Effects of turmeric rhizome powder and source of oil in diet on blood metabolites, immune system and antioxidant status in heat stressed broiler chickens. Journal of Livestock Science and Technologies 3 (2): 13-20.

Hosseini-Vashan, S.J., Golian, A., Yaghobfar, A., Zarban, A., Afzali, N. and Esmaeilinasab, P. (2012) Antioxidant status, immune system, blood metabolites and carcass characteristic of broiler chickens fed turmeric rhizome powder under heat stress, African Journal of Biotechnology Vol. 11(94): 16118-16125.

Hussein S. N. (2012) Effect of Turmeric (*Curcuma longa*) powder on growth performance, carcass traits, meat quality, and serum biochemical parameters in broilers. Journal of Advanced Biomedical and Pathobiology Research, 3: 25-32.

Kumari, P., M.K. Gupta, R. Ranjan, K.K. Singh And R. Yadava. (2007) Curcuma longa as feed additive in broiler birds and its pathophysiological effect. IJEB. 45: 272-27

Leeson, S., Summers, J. D and Caston, L. J (1992) Response of broilers to feed restriction or diet dilution in the finisher period. Poultry Science, 71: 2056-2064.

Mahejabin, N., Mostofa, M., Akter, F., Das, S And Alam, M. (2015) Effects of neem, turmeric and papaya leaf extract mixture on growth performance of broilers, International Journal of Natural and Social Sciences, 2(2):17-21.

Mahmoud M. A., Mayada R. F. & Kuldeep D. (2015) Nutritional and biological effects of Turmeric (*Curcuma longa*) supplementation on performance, serum biochemical parameters and oxidative status of broiler chicks exposed to endosulfan in the diets. Asian Journal of Animal and Veterinary Advances, 10: 86-96

Mitruka, B.M. and Rawnsley, H.M. (1977) Clinical biochemical and haematological reference values in normal experimental animals. Masson Publications U.S.A. Incorporation, 88: 140 – 143.

Nanung, D. D. (2013) Turmeric (*Curcuma longa linn*.) supplementation as an alternative to antibiotics in poultry diets, WARTAZOA Vol. 23 No. 1

Olanrewaju, H. A., Purswell, J. L., Collier, S. D and Branton, S. L. (2016) Interactive effects of ambient temperature and light sources at high relative humidity on growth performance and blood physiological variables in broilers grown to 42 day of age. Int. J. Poult. Sci., 15: 394-400.

Olorunmaiye, J. A and Awolola, O. O (2016) Models of hourly dry bulb temperature and relative humidity of key selected areas in Nigeria for engineering applications. Nigerian Journal of Technology 35: 360-369.

Oyewole, J. A., Thompson, A. M., Akinpelu, J. A and Jegede, O. O (2014) Variation of rainfall and humidity in Nigeria. Journal of Environment and Earth Science 4: 29-37

Rahmatnejad E, Roshanfekr H, Ashayerizadeh O, Mamooee M, and Ashayerizadeh A. (2009) Evaluation of the effect of several non-antibiotic additives on growth performance of broiler chickens. J Anim Vet Adv. 8:1670-1673.

Rajput, N., Muhammad, N., Yan, R., Zhong, X. and Wang, T. (2012) Effect of dietary supplementation of curcumin on growth performance, intestinal morphology and nutrients utilization of broiler chicks. Journal of Poultry Science. 50: 44-52.

Samarasinghe, K., Wenk, C., Silva, K. And Gunasekera, J. (2003) Turmeric (Curcuma longa) root powder and mannanoligosaccharides as alternatives to antibiotics in broiler chicken diet. Asian-Aust. J. Anim. Sci. 16:1495-1500.

SAS (2012) Statistical Analysis System, version 8.1, SAS Institute Incorporation Cary, NC, USA.

Sugiharto, I., Widiastuti, E. and Prabowo, N. S. (2011) Effect of turmeric extract on blood parameters, feed efficiency and abdominal fat content in broilers, J. Indonesian Trop. Anim. Agric. 36(1): 21-26

Wuthiudomler, M., Grisanapan, W., Luanratana O and Caichompoo. W. (2000) Anti-fungal activities of plant extracts. South East Asian Journal of Tropical Medicine. Public Health. 31(1):178-182.

Yusuf, V. A. (2016). Turmeric; 'Golden Crop' neglected by Nigerian farmers. Daily Trust Newspaper, www.dailytrust.com.ng/news/agriculture/turmeric-crop- neglected by Nigerian farmers/135235.html.

Zainali, A., Riasi, A., Kermanshahi, H., Farhangfar, H and Ziaie, H. (2009). Effect of sodium selenite and turmeric powder on growth performance, carcass quality and blood antioxidant metabolites of heat stressed broiler chickens. Anim. Sci. Res. J. 19(2): 69-85.

Zhang, J., Hu, Z., Lu, C., K. Bai, K., Zhang, L and Wang, T. (2015). Effect of various levels of dietary curcumin on meat quality and antioxidant profile of breast muscle in broilers. J. Agric. Food Chem., 63: 3880-3886.

Zhongze, H. (2009). Effect of curcumin on fat deposition and its mechanism in different breeds of chickens. Anhui Agric Sci Bull. 15:107.