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Original Research

Performance, slaughter traits and serum corticosterone levels in COBB500 broiler chickens fed lycopene-supplemented diets during heat period

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ABSTRACT

Poultry farmers in the tropics suffer great losses in broiler production especially during the post brooding phase as a result of heat stress occasioned by high ambient temperature. This study therefore, investigated the ameliorative effects of synthetic lycopene dietary supplement on growth performance, slaughter traits and serum corticosterone (CORT) levels of COBB500 broiler chickens reared during heat period. A total of 120 birds were selected at 4th week of rearing and allotted into a control group (C) and three experimental groups designated as T1, T2 and T3. Each group had 3 replicates. The four groups were fed the same starter diet for 4 weeks and then differently on finisher diet supplemented with lycopene at 0mg/kg feed (control), 5mg/kg (T1), 10mg/kg (T2), and 15mg/kg (T3) for 3 weeks. Data obtained were analyzed for statistical differences using ANOVA. The results showed that lycopene supplementation increased feed intake significantly ($p<0.05$) in the birds under groups T1 and T3. Final body weights and weight gain were statistically similar across the groups but numerically improved in the lycopene-supplemented broilers. While the thigh muscle weight increased significantly ($p<0.05$) across the groups with increasing supplementation, feed conversion ratio (FCR) decreased optimally (2.03) at 15mg/kg supplementation level leading to improved general performance. The supplement also decreased serum CORT concentration significantly ($p<0.05$) at 5mg/kg level. Therefore, lycopene can be supplemented in diets at 5mg/kg feed as an anti-stress and performance enhancer in COBB500 broiler chickens reared under hot climate.

Keywords: Growth performance, COBB500 broilers, serum corticosterone, lycopene, heat stress.

INTRODUCTION

Broiler chickens are specifically selected for rapid growth and high feed efficiency (Bohler *et. al.*, 2021). Even though adequate warmth is required for normal development of chicks during brooding, high ambient temperature above the thermoneutral zone of the birds is a challenge at both the brooding and finishing phases (Jag, 2006). The finishing phase is particularly critical in this regard as the broilers would have grown enough feather coverage coupled with increasing metabolic heat production due to high caloric intake (Dawson & Whittow, 2000; Bohler *et. al.*, 2021). The high body heat production together with high environmental temperature above the thermo-neutral range of 12°C to 26°C (Holik, 2009), surpasses the thermoregulatory capacity of the birds leading to heat stress which may be detrimental to health, wellbeing and survival of broiler chickens. Heat stress disrupts the normal physiological equilibrium or homeostasis in affected animals (Lara and Rostagno, 2013) and leads to coping strategies that negatively impact health, development, and productivity. Some of the negative responses of broiler chickens to heat stress include; reduced feed intake, poor feed conversion ratio, poor weight gain and growth performance (Mack *et al.*, 2013; Liu *et al.*, 2016), poor broiler meat quality (Gogoi *et al.*, 2021) and sometimes high mortality rate (Kirunda *et al.*, 2001; Mack *et al.*, 2013). Elevated serum level of CORT has also been reported (Tankson *et. al.*, 2001; Garriga *et. al.*, 2006; Costa-Pinto & Palermo-Neto, 2010). These adverse effects of heat stress on performance have reportedly been depriving broiler farmers of their expected economic gains. For instance, an estimated $128 to $165 million annual economic losses to heat stress have been reported in the US poultry industry (St-

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Pierre *et. al.* 2003). Considering the losses from tropical regions worldwide, this will automatically have negative impacts on global economy and food security (Bohler *et. al.*, 2021). Supplementation of various anti-stressors, antioxidants and growth promoters in feeds or water, among other measures, are being used as means of ameliorating the negative effects of heat in birds.

Lycopene is a potent antioxidant naturally available in tomato, watermelon, pink guava and pawpaw (Ambreen *et al.,* 2013). Lycopene from natural sources has been effectively studied in broiler chickens for improving growth performance indices (Hosseini-Vashan *et al*., 2016), reducing broiler meat cholesterol (Englmaierová *et al*., 2011), ameliorating oxidative stress by improving antioxidant enzymes activities (Hosseini-Vashan *et al*., 2016; Sahin *et al*., 2011; 2016) and modulating stress-related nuclear transcription factors (Sahin *et al*., 2011; 2016). The synthetic form of lycopene has equally been used as supplement in diet-based therapy in reducing oxidative damage of DNA and lymphocytes (Alshatwi *et al*., 2010). Lycopene has numerous double bonds which are responsible for its scavenging ability and protection against free radicals (Naz *et al.,* 2014). Its singlet oxygen quenching ability has been reported to be better than α- and β-carotene, lutein and α tocopherol (Rivero *et al.,* 2001; Perkins-Veazie & Collins, 2004). It is efficiently absorbed owing to its lipophilic characteristics (Rao & Agarwal, 1999), and its assimilation depends on chylomicron micelles mediated mechanism which facilitates its movement from gastrointestinal tract towards body tissues (Naz *et al.,* 2013). The isomeric form of lycopene is another factor that affects its absorption. The *trans*-isomeric form is less adsorbed as compared to *cis*-isomeric configuration (Collins *et al.,* 2005; Rupasinghe & Clegg, 2007). Presence of fat, together with the *cis*-isomeric form, facilitates lycopene absorption. Following its absorption, lycopene resides in body tissues including the adipose tissues, liver, prostate and adrenal glands (Rupasinghe & Clegg, 2007). Dietary supplementation of lycopene in managing heat stress in COBB500 broiler chickens has not been well reported. The study therefore, investigated the ameliorative effects of synthetic lycopene dietary supplement on growth performance, slaughter characteristics and serum CORT concentration of COBB500 broiler chickens.

MATERIALS AND METHODS

EXPERIMENTAL LOCATION AND DESIGN

The experiment was performed in the poultry unit of the experimental farm of the Faculty of Veterinary Medicine, Usmanu Danfodiyo University, Sokoto, Sokoto State. One hundred and twenty COBB500 broiler chicks of mixed sexes were used for this study. They were randomly allotted into 4 groups (**control, T1, T2, and T3**), and fed the same starter diet during the brooding phase (day old to 4 weeks of age). During the finishing phase, they were fed with finisher diets supplemented with lycopene at 0, 5, 10, and 15mg/kg feed representing the control, T1, T2 and T3, respectively for 3 weeks. They were reared in an open pen under deep litter system and vaccinated against Newcastle Disease and Infectious Bursa Disease. The lycopene was purchased online from Neolife Products® through jumia.com.ng and was delivered at the Faculty of Veterinary Medicine, Usmanu Danfodiyo University, Sokoto State. The diet compositions are presented below.

SAMPLE AND DATA COLLECTION

From the commencement of the study at 4th week, data were collected on performance indices including feed intake and body weight weekly. At the end of the 7th week, the birds were weighed and data on final body weight, weight gain and feed conversion ratio were obtained. For CORT hormone assay and slaughter traits, six (6) chickens per group were selected (2 chickens per replicate) and about 1ml of blood was sampled from each bird through the wing veins into plain bottles. They were allowed to clot and then centrifuged to obtain serum for hormone analysis. CORT hormone was assayed using Accu-bind® Elisa Kits sourced from California, USA. Instructions of the manufacturer were strictly followed. The six (6) selected chickens were exsanguinated using Halal method, defeathered manually and the carcasses were then eviscerated ensuring that gut contents didn't splash on the carcasses. Live and dressed weights were taken and recorded. Organs (heart, liver, gizzard, proventriculus, spleen, small intestine and large intestine) as well as cut parts (lumbar, breast, neck, thigh and wings) were separated, weighed and their weights, expressed as a percentage of live weight, were recorded accordingly.

DATA ANALYSIS

Data obtained were subjected to analysis of variance (ANOVA) at 5% probability using GraphPad prism InStat version 3.0 statistical software (d, Software, Inc., San Diego, CA USA). The results were presented in tables and bar chart.

RESULTS

The results of growth performance indices of the broiler chickens are presented in Table II. It was noted that lycopene supplementation improved performance indices. Mean final body weight varied upwardly from 1.75kg in the control group to 1.94kg, 1.85kg and 2.03kg in T1, T2 and T3, respectively. A similar trend was noticed in body weight gain which increased from 0.8kg in the control group to 1.00kg, 0.91kg and 1.10kg in T1, T2 and T3, respectively. However, both parameters were statistically similar across the groups. Feed intake however, differed significantly ($p<0.05$) T1 (2.50kg) and T3 (2.23kg) but it was

Table I. Composition of starter and finisher experimental diets

Feedstuffs	Starter diet (0-4 weeks)	Finisher diets supplemented with lycopene Control (0mg/kg)	T1 (5mg/kg)	T2 (10mg/kg)	T3 (15mg/kg)
Maize	42.03	50.34	50.34	50.34	50.34
Soybean	12.66	8.55	8.55	8.55	8.55
GNC	25.31	17.11	17.11	17.11	17.11
Wheat offal	15.00	19.00	19.00	19.00	19.00
Bone meal	2.50	2.50	2.50	2.50	2.50
Limestone	1.50	1.50	1.50	1.50	1.50
Salt	0.25	0.25	0.25	0.25	0.25
Lysine	0.20	0.20	0.20	0.20	0.20
Methionine	0.25	0.25	0.25	0.25	0.25
***Premix**	0.30	0.30	0.30	0.30	0.30
Lycopene (mg/kg)		0.0	0.0005	0.001	0.0015
Total	**100.00**	**100.00**	**100.0005**	**100.001**	**100.0015**
Calculated values					
Crude protein (%)	**23.00**	**19.00**	**19.00**	**19.00**	**19.00**
Energy (kcal/kg)	**2753.73**	**2753.73**	**2780.21**	**2780.21**	**2780.21**

*Premix to supply Vitamin D (2,000mg), Vitamin K_3 (2,000mg), Vit. B_{12} (10,000mg), pantothenic acid (10,000mg), niacin (26,000mg), folic acid (1,000mg), biotin (100,000mg), choline (150,000mg), manganese (10,000mg), zinc (50,000mg), cobalt (250mg), iron (40,000mg), copper (6,000mg), iodine (500mg), selenium (100mg).

KEY: 5GNC: Groundnut cake, T1, T2, T3: Treatments 1, 2 and 3, mg/kg: milligram per kilogram

statistically similar in the control (2.1kg) and T2 groups (2.13kg). Results of feed conversion ratio showed that lycopene caused improvement in feed-to-carcass conversion by reducing FCR values from 2.62 in control group to 2.5, 2.34 and 2.03 in T1, T2 and T3, respectively. The optimal value (2.03) was obtained at 15mg/kg supplementation level.

Table III presents the results of slaughter traits of the COBB500 broiler chickens fed lycopene-supplemented diets. It was noted that carcass traits did not differ significantly across the groups except the thigh weight which increased significantly with increasing lycopene supplementation levels.

The result of serum CORT levels in the experimental birds is presented in Fig. 1. The results showed that the highest serum CORT concentration (2.23ng/mL) was recorded in the control group. In comparison to the control group, it was noted that lycopene supplementation significantly ($p<0.05$) reduced serum CORT concentrations in all the supplemented groups but it was increasing from the 1.62ng/mL in T1 to 1.94ng/mL and 2.15ng/mL in the groups T2 and T3 respectively.

DISCUSSIONS

From the results on indices of growth performance of the COBB500 broiler chickens presented in Table II, the least feed intake was recorded in the control group. In line with earlier reports (Al-Fataftah *et. al.,* 2007; Attia *et al.,* 2009; Mack *et al.,* 2013; Liu *et. al.,* 2016), when birds are exposed to heat stress, their feed intake reduces. Feed intake is suppressed in birds by signaling to the appetite center in the hypothalamus through the peripheral thermal receptors (Al-Fataftah *et. al.,* 2007). This physiological response is necessary in order to minimize metabolic heat generation as a coping strategy against heat stress (Dawson & Whittow, 2000). Therefore, supplementation of any agent that can ameliorate stress and improve performance is necessary at this stage of rearing. In this study, lycopene caused significant ($p<0.05$) increase in feed intake at 5mg/kg supplementation level, where the highest value was obtained. This implied that lycopene effectively enhanced feed intake in the broilers fed on diets supplemented at 5mg/kg level. Similar findings (increased feed intake) were reported by Lira *et. al.,* (2010) in broiler chickens and Sahin *et. al.* (2006a) in Japanese quails following lycopene supplementations. Several other studies have reported effectiveness of lycopene in the management of stress conditions (Liu *et al*., 2005; Matos *et al*., 2006; Scolastici *et al*., 2008; Mackinnon *et al.* 2011). However, Englmaierová *et al*., (2011) reported in contrary that supplementing lycopene alone didn't increase feed intake in broiler chickens. Although final body weight, weight gain and feed

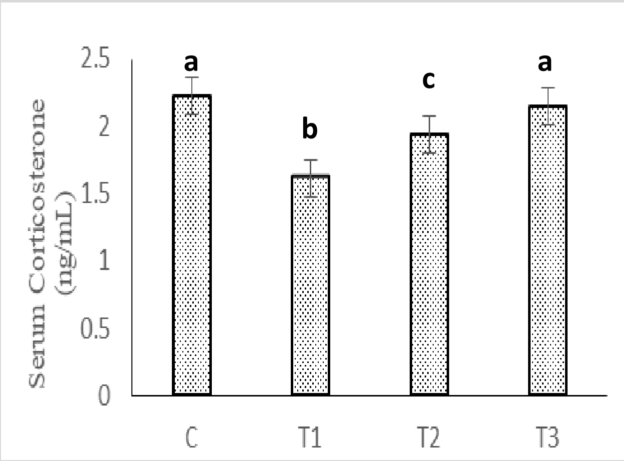

Figure 1. Serum Corticosterone level of COBB500 broiler chickens fed lycopene-supplemented diets
Key: C=Control, T1, T2, T3 received lycopene-suppllemented fed at 5 mg/Kg, 10 mg/Kg and 15 mg/Kg respectively. Chart with different superscripts (a, b, c) are significantly (p<0.05) different diets

conversion ratio (FCR) values were statistically similar across the groups, the slight weight gain in the lycopene-supplemented groups resulted in lowering FRC values in these groups.

This may be attributed to stress ameliorative effect of lycopene supplementation as weight gain are not expected to be significantly improved in birds due usual reduced feed intake occasioned by heat stress. Al-Fataftah *et. al.*, (2007) and Liu *et. al.*, (2016) have reported that high ambient temperature depresses feed intake with resultant decrease in body weight gain. This indicates anti-stressor efficacy of lycopene as it improved overall performance indices by increasing feed intake, final body weight, and weight gain and decreasing FCR. Weight gain varies across the groups ranging between 0.8kg and 1.10kg in control and T3 groups respectively. Feed conversion ratio was best in group T3 (2.03) compared to other treatment groups (T2: 2.5 and T3: 2.34) and the control (2.62). Being an index of performance, lowest value of FCR implies excellent conversion of feed to body tissues.

Table II. Performance indices of COBB500 broiler chickens fed lycopene-supplemented diets

Performance indices	**Control (0mg/kg)**	**T1 (5mg/kg)**	**T2 (10mg/kg)**	**T3 (15mg/kg)**	**SEM**
Mean initial weight (kg/bird)	0.95	0.94	0.94	0.93	0.01
Mean final weight (kg/bird)	1.75	1.94	1.85	2.03	0.05
Mean weight gain (kg/bird)	0.80	1.00	0.91	1.10	0.12
Mean feed intake (kg/bird)	2.10^{a}	2.50^{c}	2.13^{a}	2.23^{b}	1.10
Feed Conversion Ratio	2.62	2.50	2.34	2.03	0.13

abc: means in the same row with different superscripts are significantly (p<0.05) different.

Table III. Slaughter traits of COBB500 broiler chickens fed lycopene-supplemented diets

Parameters	**Control**	**T1**	**T2**	**T3**	**SEM**
Live weight	1750	1940	1850	2030	0.05
Dress weight	1600	1800	1700	1850	0.03
% Dress weight	91.42	92.78	91.89	91.13	0.19
Thigh	2.76^{a}	3.27^{c}	3.81^{c}	4.74^{b}	1.10
Wings	1.10	1.08	1.06	1.10	0.01
Neck	1.09	1.10	1.27	1.05	0.65
Breast muscle	5.00	5.53	5.83	5.79	0.03
Lumber	3.81	2.76	2.65	2.63	0.01
Gizzard	1.14	1.16	1.14	1.10	0.05
Heart	0.11	0.12	0.12	0.12	0.01
Small intestine	0.16	0.18	0.23	0.17	0.12
Large intestine	0.17	0.16	0.18	0.16	0.03
Spleen	0.10	0.11	0.11	0.10	0.01
Proventriculus	0.13	0.12	0.12	0.12	0.01
Liver	0.12	0.14	0.12	0.15	0.12

abc: means in the same row with different superscripts are significantly (p<0.05) different.

As presented in table III, the results on slaughter traits of the COBB500 broiler chickens fed lycopene-supplemented diets showed that there were no significant differences in all organs and cut parts of the broiler chickens across the groups except the thigh weight. It was noted that with increasing lycopene supplementation levels, thigh weights increased significantly ($p<0.05$) across the groups. This may be due to effects of restricted movement and more resting normally exhibited by birds as part of behavioral measures of managing heat condition (Mack *et al.*, 2013) coupled with heat ameliorative effects of lycopene. Mean final body weight varied upwardly from 1.75kg in the control group to 1.94kg, 1.85kg and 2.03kg in T1, T2 and T3, respectively. A similar trend was noticed in body weight gain which increased from 0.8kg in the control group to 1.00kg, 0.91kg and 1.10kg in T1, T2 and T3, respectively. However, both parameters were statistically similar across the groups. Feed intake however, differed significantly ($p<0.05$) T1 (2.50kg) and T3 (2.23kg) but it was statistically similar in the control (2.1kg) and T2 groups (2.13kg).

From the result of serum CORT levels in the broilers presented in Fig.1, it was observed that the highest serum concentration (2.23ng/mL) of the stress hormone was recorded in the control group where lycopene was not supplemented in the diet. This impliedly showed higher release of the stress hormone and the finding conforms with the report of Attia *et al.* (2009) that release of CORT is stimulated by stress conditions. At 5mg/kg supplementation level, lycopene significantly ($p<0.05$) decreased serum CORT concentration in the broilers under group T1 compared to other groups. However, the effect was not sustained beyond 5mg/kg lycopene-feed supplementation. As lycopene dosage increased from 5mg/kg to 15mg/kg, serum CORT levels also increased. This may be attributed to reduced feed intake recorded at 10 mg/kg and 15mg/kg lycopene-feed supplementation levels. Since the lycopene was supplemented in the feed, reduction in feed intake might had led to reduction in lycopene intake and bioavailability. More so according to Jian *et al.* (2005), lycopene carotenoids need to form a complex with proteins within the acidic pH of stomach, to facilitate its passage through intestinal lumen. And then, the resultant lycopene-protein complex will breakdown for lycopene to join chylomicron in blood stream to reach target tissue through the hepatic pathway (Jian *et al.*, 2005; Gao *et al.*, 2008). Therefore, the decrease in feed intake recorded in groups T2 and T3 might have also reduced the bioavailability of adequate dietary proteins required for complexing and passage of lycopene carotenoids within the gut to the target tissues and organs of the birds in the two groups. These findings may imply that appropriate quantity of lycopene carotenoids was bioavailable to COBB500 broiler chickens fed at 5mg/kg supplementation compared to other groups. Therefore, further studies focusing on lower dosages and bioavailability of the supplement may be necessary to ascertain the assumptions.

CONCLUSION AND RECOMMENDATIONS

In conclusion, lycopene supplementation in diets at 5mg/kg feed ameliorated the negative effects of heat stress in COBB500 broiler chickens. Based on the findings of this study, lycopene is therefore recommended at 5mg/kg supplementation level as anti-stressor, antioxidant and growth enhancer.

CONFLICT OF INTEREST

There was no conflict of interest among the authors.

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