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Original Research Article

Oral administration of aqueous bamboo leaf extract: effect on performance, haematological indices and blood oxidative status of broilers

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Abstract

The growing concerns over antibiotic resistance and the need for safer alternatives in broiler production make exploring natural additives like plant extracts imperative to enhance broiler health and performance. This study evaluated the effect of aqueous bamboo leaf extract (BLE) in drinking water on broiler chickens' performance, haematological indices, and blood oxidative status. Ninety-six Ross 308 one-day-old broilers were randomly assigned to four treatments: T1 (Control, ordinary water), T2 (antibiotics (Tetranor 5% at 5 g per litre of water)), T3 (50 ml BLE per litre of water) and T4 (100 ml BLE per litre of water), each with four replicates of six birds. Performance data were recorded weekly over 8 weeks, and blood samples were collected on day 56 for haematological and oxidative status analysis. Data were analysed using SAS (2000) with means separation via Tukey's test. Results showed that broilers that consumed water containing 100ml/L BLE had the highest ($p < 0.05$) live weight (LW) of 1078.20 g and weight gain (WG) of 1029.19 g at the starter phase. At the finisher phase, broilers in the 100ml BLE group had the highest ($p < 0.05$) LW (2695.42 g) and zero mortality, whereas the control group recorded the lowest LW (1672.95 g). The feed conversion ratio (FCR) was improved ($p < 0.05$) in broilers that had access to water containing 100 ml/L BLE at both phases. Haematological analysis revealed increased ($p < 0.05$) packed cell volume and haemoglobin concentrations in the 100 ml/L BLE group. Oxidative stress markers showed lower ($p < 0.05$) malondialdehyde levels for broilers in the 100 ml/L BLE group than those in the control group. Superoxide dismutase was reduced ($p < 0.05$) for broilers given ordinary water and those given antibiotics but increased for broilers with 100 ml/L BLE. In conclusion, including BLE at 100 ml/L in drinking water enhanced weight gain, FCR, and survival rate while reducing oxidative stress, indicating a promising natural alternative for improving broiler health and performance.

Keywords: broiler; bamboo leaf extract; weight gain; PCV; haemoglobin; malondialdehyde; superoxide dismutase

INTRODUCTION

The consumption of chicken meat has contributed to improving diet quality among developed and developing countries since it contains high protein content and other nutrients such as vitamins and minerals (FAO, 2010). The chicken meat is an important component of the human diet and is a good source of cheap animal protein (Cohen et al., 2007). It is known that intensive broiler production under commercial conditions is often connected with the

use of antibiotics due to their effect in inhibiting bacterial activity and growth-promoting effect (Bacanli and Başaran, 2019; Liu et al., 2020). Reports from documented surveys reveal that antibiotic use in animals doubles that of humans across the globe and a high percentage of animals raised for food, particularly poultry, are being treated with synthetic antibiotics (Aarestrup, 2012; Pavlov et al., 2018). This indicates that the challenges emanating from the use of antibiotics resulting in antibacterial resistance and harmful accumulation of antibiotic residues persist. The continuous misuse of antibiotics in chickens has resulted in the deposition of antibiotic residues in poultry meat, leading to the mutant development of multi-drug resistance microbial strains causing diverse and severe adverse effects (Rokka et al.,2013; Chang et al., 2015).

This occurrence has triggered increased attention to the potential risks associated with health and the environment due to the continuous use of antibiotics (Gadde et al., 2017). This development has also increased the search for suitable alternatives to antibiotics that are cheap to source and without harmful residual effects. Phytogenic plants, usually called phytobiotics, can serve as effective feed additives in poultry production due to their inherent bioactive constituents (Ognik et al., 2020). These natural plants are non-toxic and without harmful residues playing a key role as growth promotants by exhibiting antibacterial and antioxidant properties (Alagawany et al., 2019; AbdEl-Hack et al., 2020). The phytogenic plants can be utilised in the form of herbal extract, seeds and plant parts due to their wide range of natural compounds with functional biomolecules (Jakhetia et al., 2010). Bamboo (*Bambusa vulgaris*) belongs to this plant group and is a fast-growing natural resource, cheaply available and climate-friendly (Habibi, 2019). The bamboo leaves have been reported to possess active phytoconstituents such as flavonoids and polyphenols capable of inhibiting bacterial proliferation (Hu et al., 2000; Singh et al., 2010).

Bamboo leaves serve as natural herbal ingredients containing active substances like vitamin C and flavonoids contained in flavones C-glycoside form which can be obtained through simple extraction (Mulyono et al., 2012; Baguistan et al., 2017). Bamboo leaf extract (BLE) has been documented in the literature to be active against various pathogens. Tao et al. (2018) reported that bamboo leaf extracts exhibited a strong antibacterial effect against harmful pathogens such as *Escherichia coli*, *Salmonella enterica* and *Staphylococcus aureus*. It has also been reported to exhibit antioxidant properties thereby reducing the risk of disease infection and resulting in improved growth (Ni et al., 2013). Previous studies have also revealed that BLE has antioxidant and free radical scavenging properties due to the functional activities of flavonoids and phenolic acids (Guo et al., 2008; Singh et al., 2010; Kimura et al., 2022). Based on these properties, we hypothesised that administering BLE obtained through an economical and simple extraction process may positively influence broiler chickens' performance, haematological and blood oxidative status. In addition, studies investigating the effect of BLE administration on broilers are rare which is the reason for the dearth of information for its use in broiler production. Therefore, this study was designed to investigate the effect of oral administration of BLE on performance, blood oxidative status and haematological indices of broilers.

MATERIALS AND METHODS

Experimental site

The experiment was carried out at the Poultry Unit of the Teaching and Research Farm, School of Agriculture, Epe Campus, Lagos State University. The tropical climate has an average temperature of 26.30 °C and precipitation of about 1990 mm per annum (https: //en.climate-data.org/africa/nigeria/lagos/epe-46640/). The position on latitude and longitude is 6°35′2.83″ N and 3°59′0.10″ E respectively (https://latitude.to/map/ng/nigeria/cities/epe).

Collection and preparation of bamboo leaf extracts

The bamboo leaf extract (BLE) was prepared from fresh bamboo leaves collected from the bamboo (*Bambusa vulgaris*) plants within the premises of Lagos State University, Epe Campus. They were air-dried at room temperature and chopped into pieces. The chopped bamboo leaves were poured into the boiled water at the rate of 15 grams of bamboo leaves to one litre of boiled water. It was allowed to cool and macerate for 48 hours after which the extracts were filtered and the leaf particles removed. Then, the extracts were stored in bottles at room temperature before usage.

Phytochemical constituent and total antioxidants of BLE

The BLE was analysed for phytochemical composition and total antioxidant capacity (Table 1). The phytochemical constituents, tannin,

saponin, alkaloid, flavonoids and total phenols were determined according to standard procedures by Edeoga et al. (2005). The total antioxidant capacity was determined using a 2,2-diphenyl-1-picrylhydrazyl (DPPH) assay according to the method by Mimica-Dukic et al. (2004).

Table 1. Selected phytochemical and total antioxidants of BLE

Composition	Quantity (mg/ml)
Tannin	8.96
Saponin	10.24
Alkaloids	21.68
Flavonoids	63.22
Total phenol	6.18
Total antioxidant†	11.08

† = % DPPH scavenged

Experimental animals' management, design and treatments

The experiment was carried out in compliance with ethical procedures for Animal Research by the Nigeria Institute of Animal Science in Nigeria (NIAS-NREP-2017) and with the approval of the Animal and Plant Research Ethics Committee (APREC) of Lagos State University. The day-old chicks were procured from Agric International Technology and Trade Limited (AGRITED) hatchery in Ibadan Nigeria and before the arrival of the birds, the brooding pens were cleaned, disinfected and pre-heated to regulate the temperature of the day-old chicks. Wood shavings were provided as bedding on the floor, and the feeders and drinkers were cleaned, disinfected, and made available for feeding and providing water. The recommended vaccination schedules were also adhered to. The temperature range

Table 2. Gross composition of experimental diets

Ingredients (%)	Starter (0–28 days)	Finisher (29–56 days)
Maize	51	60
Soya bean meal	19	19
Groundnut cake	14	10
Fish meal	2	1
Wheat offal	10	6
Oyster	1	1
Bone	2	2
Lysine	0.25	0.25
Methionine	0.25	0.25
Premix*	0.25	0.25
Salt	0.25	0.25
Total	**100**	**100**
Determined nutrients		
Metabolisable energy (kcal/kg) **	2965	3067
Crude protein (%)	22.65	19.42
Fat (%)	4.10	3.89
Fiber (%)	3.84	3.33
Calcium (%)	1.30	1.22
Phosphorus (%)	0.51	0.47
Lysine (%)	1.29	1.13
Methionine (%)	0.59	0.54
Ash (%)	3.02	2.57

*Starter premix: vit. A10,000,000 IU, vit. D 32,500,000 IU, vit. E 23,000 mg, vit. K3 2,000 (mg), vit. B1 1,800 (mg), vit. B2 5,500 (mg), niacin 27,500 (mg), pantothenic acid 7,500 (mg), vit. D6 3,000 (mg), vit. B12 (15 mg), folic acid (750 mg), biotin H2 60 mg, chlorine chloride 300,000 mg, cobalt 200 mg, copper 3,000 mg, iodine 1,000 mg, iron 20,000 mg, manganese 40,000 mg, selenium 200 mg, zinc 30,000 mg.
*Finisher phase: vit. 8,500,000 IU, vit. D3 1,500,000 IU, vit. E 10,000 mg, vit K3 1,500 mg, vit. B1 1,600 mg, vit. B2 4,000 mg, niacin 20,000 mg, pantothenic acid 5,000 mg, vit. D6 1,500 mg, vit. B12 10 mg, folic acid 500 mg, biotin H2 750 mg, chlorine chloride 175,000 mg, cobalt 200 mg, copper 3,000 mg, iodine 1,000 mg, iron 20,000 mg, manganese 40,000 mg, selenium 200 mg, zinc 30,000 mg.
**Calculated using the formulae, ME = 26.7 (% dry matter) + 77(% ether extract) – 51.22 (% crude fibre) Nutrient Requirements of Poultry, NRC (1994)

was 30.24 ± 1.45 °C while the prevailing humidity was 66.93 ± 2.13%. A total of 96 day-old broiler chicks (Ross 308) purchased from the hatchery were grouped into four treatments using a completely randomised design into 16 pens. Each treatment had 24 birds consisting of 4 replicates of 6 per replicate. The birds were raised for 8 weeks split into starter (1–4 weeks) and finisher (5–8 weeks) phases. Diets were formulated at each phase (Table 2) to meet the nutrient requirements of the birds according to the nutrient requirement guide (Ross Nutrition Specification, 2016). The treatments were bamboo leaf extracts free i.e., ordinary water (T1; Control), antibiotics (T2; Tetranor 5% (contains the active ingredient Oxytetracycline Hydrochloride and was obtained from Jubaili Agrotec Limited, Nigeria) at 5 g per litre of water)), 50 ml of bamboo leaf extracts per litre of water (T3; 50 ml BLE) and 100 ml of bamboo leaf extracts per litre of water (T4; 100 ml BLE). Throughout the experimental period, antibiotics were not administered in water or added to the feed of the other treatments except that specified for antibiotics.

Growth performance

The initial live weight of the birds per pen (n = 4 per treatment) was measured and the subsequent weight changes were recorded weekly while the final weight was recorded at the end of the 8th week (56th day). The difference between initial weight (IW) and final weight (FW) was calculated to determine the weight gain (WG). The difference between the feed offered and leftovers was calculated to obtain the feed intake (FI). The feed consumed was divided by the weight gain to obtain the feed conversion ratio (FCR) and mortality was monitored and recorded during the trial and expressed in percentage.

Haematological indices

On the 56th day, three birds per replicate were selected and 2.5 ml of blood was collected from the brachial wing veins into vials containing ethylenediamine tetra-acetic(EDTA) for the analysis of haematological indices. The packed cell volume (PCV), haemoglobin (Hb), white blood cell (WBC) and red blood cell (RBC) were determined according to Lamb (1991). The mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH), and mean corpuscular haemoglobin concentration (MCHC) were calculated according to Bush (1991).

Blood oxidative status

On the 56th day, 3 ml of blood was collected into plain bottles for the analysis of indices of blood oxidative status. Superoxide dismutase (SOD) was assayed according to standard protocols in which the serum was diluted before SOD assay. The erythrocyte pellets were lysed in 5 times the volume of cold water and centrifuged at 12,000 × *g* for 5 min to pellets the erythrocyte membranes. Exactly 0.2 ml of diluents was added to 2.5 ml of 0.05 M carbonate buffer, pH 10.2 to equilibrate in the spectrophotometer. Then 0.3 ml of freshly prepared 0.3 mM adrenaline was added to the mixture and was rapidly mixed by inversion. The changes in absorbance at 480 nm on the spectrophotometer were monitored at intervals for 30 seconds for 150 seconds (Sun et al., 1988). Glutathione peroxidase (GPx) was determined by measuring glutathione-s-transferase activity. The reaction was allowed to run for 3 minutes and the absorbance was read against the blank at every successive 30 seconds at 340 nm (Paglia and Valentine, 1967). The method of Sinha (1972) was used to determine the catalase activity, absorbance changes were recorded at 570 nm, catalase activity was calculated by plotting the standard curve and the concentration of the remaining hydrogen peroxide was extrapolated from the curve. For the malondialdehyde (MDA) assay, the sample transferred to a disposable test tube (13 × 100 mm) was reacted with 2.0 ml of Thiobarbituric-Trichloroacetic-Hydrochloric acid (TBA-TCA-HCL) (1:1:1) reagent (TBA 0.3%. 0.25 N HCL, and 15% TCA). The mixture was vortex-mixed and incubated in a boiling bath at 95 °C for 15 minutes to develop colour. Then samples were cooled on the ice for 10 min, vortex mixed again and centrifuged for 10 min, at 2500 × *g* at 4 °C. The absorbance of the resulting supernatant solution was determined at 532 nm against a reference blank and the Malondialdehyde (MDA) content was calculated (Carbonneau et al., 1991).

Statistical analysis

All data collected were subjected to a one-way analysis of variance using SAS (2009). The significant means were separated using Tukey's test of the same software. A significant difference was considered at $p < 0.05$.

RESULTS

Effect of aqueous BLE inclusion in drinking water of broiler chicken on performance at starter and finisher phase

Table 3 shows the performance of broilers given aqueous BLE in drinking water at the starter and finisher phases. In the starter phase, the result shows that the live weight (LW), WG, mortality and FCR were

Table 3. Performance of broiler chickens given aqueous BLE in drinking water at starter and finisher phase

Parameters	Control	Antibiotics	50 ml BLE	100 ml BLE	SEM	p-value
Initial weight (g)	50.13	50.05	50.03	49.73	0.10	0.177
Day 28						
Live weight (g)	801.91^{b}	744.20^{b}	751.20^{b}	1078.20^{a}	43.94	0.004
Weight gain (g)	751.78^{b}	694.15^{b}	701.70^{b}	1029.19^{a}	43.96	0.004
Feed intake (g)	1296.30	1353.65	1424.06	1423.83	32.92	0.491
FCR	1.72^{ab}	1.97^{ab}	2.13^{a}	1.39^{b}	0.09	0.013
Mortality (%)	0.25^{b}	1.75^{ab}	2.50^{a}	0.25^{b}	0.25	0.014
Day 56						
Live weight (g)	1672.95^{b}	1961.00^{ab}	2082.67^{ab}	2695.42^{a}	142.53	0.055
Weight gain (g)	871.04	1216.80	1331.47	1616.55	110.25	0.103
Feed intake (g)	4235.62	4437.86	4770.50	4390.20	100.44	0.307
FCR	5.31^{a}	3.99^{ab}	3.96^{ab}	2.69^{b}	0.37	0.072
Mortality (%)	0.50^{b}	0.25^{b}	2.25^{a}	0.00^{b}	0.28	0.004

$^{a–b}$ Means on the same row having different superscripts are significantly different
SEM = Standard error of the mean
BLE = Bamboo Leaf Extract
FCR = Feed conversion ratio

significantly ($p < 0.05$) affected by the inclusion of BLE in the drinking water. Broilers that had access to water containing 100 ml BLE had higher ($p < 0.05$) LW (1078.20 g) and WG (1029.19 g) than other treatments. Broilers given water containing 100 ml/L BLE had better ($p < 0.05$) FCR than the 50 ml/L BLE group but were statistically similar to those given ordinary water and antibiotics. Broilers in the control group and those given water containing 100 ml/L BLE had lower ($p < 0.05$) mortality (0.25 %) than those given water containing 50 ml/L BLE but were statistically similar to those given antibiotics. It was also observed that FI was not ($p > 0.05$) affected by the inclusion of aqueous BLE in the drinking water of broilers. At the finisher phase, the LW of the broiler chickens was affected ($p < 0.05$) in which the group with access to 100 ml/L BLE had a higher ($p < 0.05$) LW (2695.48 g) than those in the control group (1672.95 g). However, it was similar to the groups given antibiotics and 50 ml/L BLE. There was no significant ($p > 0.05$) effect of BLE inclusion in drinking water on the weight gain and the feed intake of the broilers across all treatments. Broiler chickens in the 100 ml/L BLE group had better ($p < 0.05$) FCR than those in the control group while it is similar to those given antibiotics and those given water containing 50 ml/L BLE. The mortality rate was affected ($p < 0.05$) and the broilers given water containing 50 ml/L BLE had higher ($p < 0.05$) mortality (2.25 %) compared to the rest of the treatments. However, no mortality occurred in the group of broilers given water containing 100 ml/L BLE.

Effect of aqueous BLE inclusion in drinking water of broiler chicken on haematological indices

Table 4 indicates the haematological indices of broilers given aqueous bamboo leaf extract (BLE) in drinking water. The result shows that the PCV of broilers given water containing 100 ml/L BLE was significantly higher ($p < 0.05$) compared to those in the control group but similar to the group of broilers given antibiotics and 50 ml/L BLE. The haemoglobin content of broilers given water containing 100 ml/L BLE and those given antibiotics was significantly higher ($p < 0.05$) than those given water containing 50 ml/L BLE but statistically similar to those in the control group. The red blood cell counts of broilers in the control group were significantly higher ($p < 0.05$) than those given water containing 50 ml/L BLE but were similar to the group of broilers given antibiotics and those in the 100 ml/L BLE group. Broilers in the control group had a higher ($p < 0.05$) WBC count than those given antibiotics and those given water containing 50 ml/L BLE but similar to those given 100 ml/L BLE in water whereas the WBC count of broilers given antibiotics was similar to those given 50 ml/L BLE in drinking water. Lymphocyte counts of broilers given antibiotics were higher ($p < 0.05$) compared to those that had access to water containing 50 ml/L and 100 ml/L BLE but similar to those in the control group whereas the lymphocytes of broilers given 50 ml/L of BLE in drinking water were also similar to those given 100 ml BLE. However, there were no significant ($p > 0.05$) differences in heterophils, eosinophils, basophils, monocytes, MCV, MCH and MCHC across the four treatments.

Table 4. Haematological indices of broilers given aqueous BLE in drinking water

Haematological indices	Control	Antibiotics	50 ml BLE	100 ml BLE	SEM	P-value
Packed cell volume (%)	34.33^{b}	41.00^{ab}	38.33^{ab}	43.33^{a}	1.23	0.023
Haemoglobin (g/L)	138.70^{ab}	149.30^{a}	114.70^{b}	152.70^{a}	0.53	0.014
Red blood cell (× 10^{12}/L)	3.50^{a}	3.03^{ab}	2.93^{b}	3.10^{ab}	0.79	0.025
White blood cell (× 10^{9}/L)	19.43^{a}	13.73^{c}	15.73^{bc}	16.93^{ab}	0.68	0.001
Heterophil (%)	32.67	32.67	37.00	34.00	0.96	0.369
Lymphocytes (%)	70.00^{ab}	71.33^{a}	60.33^{c}	62.67^{bc}	1.58	0.004
Eosinophils (%)	2.00	0.67	2.00	1.33	0.29	0.330
Basophils (%)	0.33	0.33	0.00	0.33	0.13	0.802
Monocytes (%)	1.33	1.67	1.63	1.67	0.26	0.956
Mean corpuscular volume (fl)	120.29	130.80	116.90	124.13	2.74	0.347
MCH (pg)	39.69	44.84	39.40	40.81	1.15	0.300
MCHC (g/L)	330.30	342.80	334.00	328.10	0.32	0.433

$^{a–c}$ Means on the same row having different superscripts are significantly different
BLE = Bamboo leaf extract, SEM = Standard error of the mean, MCH = Mean corpuscular haemoglobin, MCHC = Mean corpuscular haemoglobin concentration

Table 5. Blood oxidative status of broilers orally administered aqueous BLE

Parameter	Control	Antibiotics	50 ml BLE	100 ml BLE	SEM	P-value
MDA (U/L)	13.30^{a}	7.55^{ab}	10.57^{ab}	5.40^{b}	2.34	0.037
SOD (U/L)	0.36^{b}	0.59^{b}	1.53^{ab}	2.95^{a}	0.37	0.022
GPx (U/L)	13.83	15.57	11.77	11.40	1.61	0.829
CAT (U/L)	0.43	0.24	0.20	0.35	0.39	0.119

^{ab} Means on the same row having different superscript are significantly different
BLE = Bamboo leaf extract, SEM = Standard error of the mean

Effect of aqueous BLE inclusion in drinking water of broiler chicken on blood oxidative status

Table 5 presents the effect of aqueous BLE inclusion in the drinking water of broiler chicken on blood oxidative status. The result shows that MDA and SOD were affected ($p < 0.05$) by the inclusion of aqueous BLE while GPx and CAT were not affected ($p > 0.05$) by the treatment. Broilers given ordinary water had higher ($p < 0.05$) MDA than those given 100 ml/L BLE in drinking water but similar to those given antibiotics and those given 50 ml/L BLE in drinking water. The groups of broilers given ordinary water and antibiotics had lower ($p < 0.05$) SOD than those given water having 100 ml/L BLE but similar to those given water containing 50 ml/L BLE.

DISCUSSION

Performance

At the stater phase, the broilers given water containing 100 ml/L BLE had higher FW and WG than other treatments. The increased FW and WG observed for this group of broilers could be due to the presence of flavonoids in the extract. It has been observed that flavonoids act as growth hormones due to their hydroxyl groups of aglycone (Havsteen, 2002). Li et al. (2017) also reported an increased body weight of broilers by 17.60% when fed a diet supplemented with 2.5 g/kg of bamboo leaf flavonoids (BLFs). The results obtained in this study are similar to the report of Shen et al. (2019a) who also discovered linear and quadratic increases in the final body weight of broiler chickens fed diets supplemented with BLE. There was no significant difference in the FI of the broiler chickens across treatment. However, the birds given water with the aqueous BLE at 50 ml/L and 100 ml/L in drinking water consumed slightly more feed than birds in the control and antibiotic groups at the end of the starter phase. The slight increase in feed intake could be due to the influence of BLE's phytochemical constituent, which stimulates feed intake. Wang et al. (2016) reported that the flavonoid and polyphenol content of marigold and broccoli extract improves feed palatability which promotes FI resulting in better performance. The FCR was best for broilers given water containing 100 ml/L of BLE but was worst for broilers given 50 ml/L of BLE in drinking water. It has been reported that the bioactive compounds of BLE can increase digestive enzymes' activities, resulting in improved nutrient utilisation (Dhama et al., 2015). The poor FCR

observed for the group of broilers given 50 ml/L BLE could be due to the lower quantity of BLE with a low concentration of flavonoids which could not elicit improved digestion. Reduced mortality observed for the group of broilers given water containing 100 ml/L BLE suggests that BLE could serve as an immune booster. The constituent secondary metabolites of BLE including tannins, flavonoids, and saponins are potent antioxidants that reduce the risk of disease development (Abbas et al., 2016).

At the finisher phase, broilers that were given 100 ml/L of BLE in drinking water had increased FW. This is similar to the report of Oloruntola et al. (2018) who observed increased weight for broilers fed a diet containing pawpaw leaf meal than those fed a control diet at day 42. The FI was not significantly affected but FCR was improved for broilers given 100 ml/L BLE as observed at the starter phase. The better FCR obtained for the group of broilers given 100 ml/L of BLE is due to the positive effect of bioactive compounds in BLE. Imasuen et al. (2014) also observed improved FCR for broilers given heat-treated pumpkin leaf extract as a supplement due to the positive effect of bioactive compounds. No mortality was observed for broilers given water containing 100 ml/L of BLE however, mortality was higher for broilers given water containing 50 ml/L BLE. This observation indicates that the inclusion of BLE in the drinking water of broilers at 50 ml/L was not sufficient to support increased immunity against disease infection. It is therefore pertinent to state that the ability of phyto-additives to exhibit their inherent attribute is a function of the inclusion levels.

Haematology

The result of haematology shows that the PCV of broilers given 100 ml/L BLE in drinking water was significantly higher compared to those in the control group but similar to the group of broilers given antibiotics and those in the 50 ml/L BLE group. The increase in PCV suggests adequate nutrient availability and utilisation by the birds. The range of PCV found in this study is 34.33–43.33% which is higher than the range (28–35%) reported by Onyishi et al. (2017) for broilers aged five to seven weeks. Haemoglobin content of broilers given water containing 100 ml/L BLE and those given antibiotics was significantly higher than that of those given 50 ml/L BLE in drinking water but the broilers in the control group had intermediate haemoglobin content. This observation indicates that 100 ml/L of BLE in broilers' drinking water could promote the birds' well-being like the addition of antibiotics. It has been reported that medicinal plants can be used as feed supplements for both nutritional and therapeutic purposes to improve health status (Oloruntola et al., 2018). The red blood cell count of broilers in the control group was significantly higher than those in the 50 ml/L BLE group but RBC was intermediate for the group of broilers given antibiotics and 100 ml/L BLE group. This suggests that the constituents of the 100 ml/L of BLE do not impair the health status of the birds since it is similar to those in the control group. Assessing of circulating red blood cells is crucial in identifying anaemia (Peters et al., 2011). The result obtained in this study indicates that the broilers in the control, antibiotics, and 100 ml/L BLE group are not suffering from anaemia.

Broilers in the control group had higher WBC counts than those given antibiotics and 50 ml/L BLE group but statistically similar to those given water containing 100 ml/L BLE while the WBC count of broilers given antibiotics was similar to those given 50 ml/L BLE in drinking water. The reduced WBC observed for the group of broilers given 50 ml/L BLE in drinking water could be due to the presence of phytochemicals in BLE while the increased WBC count observed in the control group could be due to the presence of foreign organisms such as bacteria and viruses. Leucocytes are cells of the immune system involved in defending the body against both infections and disease (Dinauer and Coates, 2008). Lymphocyte counts were reduced in the group of broilers given water containing 50 ml/L and 100 ml/L of BLE. The reduced lymphocyte observed for this group of broilers suggests that the broilers may not be facing health challenges because the rise in circulating lymphocytes could be triggered in response to invading antibodies. There was no significant difference in Heterophil, MCV, MCH and MCHC across the four treatments. The values of MCH and MCHC obtained were within the normal range as reported by Bounous and Stedman (2000) which suggests the good health status of the birds.

Blood oxidative status

The result of blood oxidative status shows that the inclusion of 100 ml/L BLE in the drinking water of broilers significantly reduced the MDA. The reduced MDA observed for broilers given 100 ml/L BLE of aqueous BLE in drinking water suggests that the extract inclusion was effective in reducing oxidative stress. The MDA is known to be one of the lipid peroxidation metabolites, indicating the degree of oxidative stress (Shen et al., 2019b). The reduction in observed MDA is associated with the potent

bioactive constituents of BLE such as flavonoids. Shen et al. (2019b) reported that the antioxidative property of flavonoids is exhibited by their capacity to transfer electron free radicals, chelate metals catalysts, activate antioxidant enzymes, and inhibit oxidases. It is therefore reasonable to suggest that the flavonoids in BLE play a major part in improving antioxidant enzyme activities. The increased MDA observed in other treatments and especially in the control group is due to the oxidation of poly-unsaturated fatty acid which causes lipid peroxidation as a result of an imbalance between reactive oxygen species and the body's neutralising ability (Devasagayam et al., 2003). The SOD was higher for broilers orally administered aqueous BLE at 100 ml/L in drinking water than those broilers in the control group and those given antibiotics. This suggests that the birds in the 100 ml BLE group were not experiencing oxidative stress as a result of the functionality of SOD which is reported to be a potent endogenous enzymatic antioxidant (Niu et al., 2017). Oxidative stress is a key factor leading to cardiovascular diseases, such as atherosclerosis, hyperlipidemia, inflammation and other chronic diseases (Cachofeiro` et al., 2008). The observation in the current study implies that the inclusion of BLE in the water of broilers at 100 ml/litre could prevent the bird from experiencing these diseases arising from oxidative stress. It is worth mentioning that SOD activities in blood increases as the level of BLE inclusion in water increases. The increase in the activity of SOD in response to the inclusion of aqueous BLE in the drinking water of broilers is connected to the plant-derived bioactive constituent of bamboo leaf such as polyphenols. Mhillaj et al. (2019) explained that a variety of electrophilic compounds including polyphenol and plant-derived constituents trigger the nuclear factor erythroid 2-related factor 2 pathway response which serves as a factor that upregulates antioxidant enzymes and regeneration of direct antioxidants.

From the result of the present study, the GPx and CAT of broilers across all treatments were observed to have no significant difference. However, there is a numerical decrease in the values of GPx of broilers administered water containing 50 ml/L and 100 ml/L BLE compared to that of the control and the antibiotics group which may be due to the suppressive effect of SOD on GPx activity as a result of high SOD observed for broiler given water containing 50 ml/L and 100 ml/L BLE. It has been earlier reported by Seven et al. (2009) that the suppression of GPx activity in the blood may depend on SOD upregulation. The CAT activity was not significantly different across treatments, however, the CAT for broilers given 50 ml/L and 100 ml/L BLE in drinking water was numerically lower than that of the control group which could also be associated with the concentration of hydrogen peroxide (H_2O_2). It has been reported in the literature that there exists an interrelationship between the level of H_2O_2 and the activity of GPx (Zelinová et al., 2013). Therefore, it could be stated that aqueous BLE inclusion in the drinking water of the broiler provides a protective mechanism against oxidative stress by decreasing free radicals rather than increasing the antioxidant enzyme activity of GPx and CAT.

CONCLUSION AND RECOMMENDATION

Including 100 ml/L aqueous BLE in the drinking water of broilers resulted in higher LW and WG at the starter phase and better FCR at the finisher phase compared to the control. Mortality did not occur in the group of broilers given water containing 100 ml/L BLE similar to the control group. The inclusion of aqueous BLE in the drinking water for broilers at 100 ml/L increased the PCV compared to the control group. Including BLE in broilers' drinking water at 50 ml/L resulted in a lower WBC count than the control group. The inclusion of aqueous BLE in drinking water given to broiler birds at 100 ml/L increased the level of SOD and reduced the level of MDA compared to the control group. Therefore, it is recommended that aqueous BLE inclusion in the drinking water of broilers at 100 ml/L can improve their performance, reduce mortality and improve health status. Including 100 ml/L BLE in drinking water of broilers can also reduce oxidative stress resulting in oxidative stability

CONFLICT OF INTEREST

The authors declared no conflicts of interest concerning the research, authorship, and publication of this article.

ETHICAL COMPLIANCE

The authors have followed ethical standards in conducting the research and preparing the manuscript.

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