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GROWTH PERFORMANCE, BLOOD INDICES AND INTESTINAL ORGAN DEVELOPMENT OF PULLET CHICKS ADMINISTERED AQUEOUS EXTRACTS OF GUINEA HEN WEED (*PETIVERIA ALLIACEA*)

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ABSTRACT

This study investigated growth performance, intestinal organ development and blood indices of pullet chicks administered aqueous extracts of *Petiveria alliacea* root and leaves. A total of 288 day-old Isa brown pullets were randomly allotted into two groups administered aqueous extract of different parts of *Petiveria alliacea* (root and leaf) at four concentration levels (0, 15, 30 and 45 $g.l^{-1}$) making a total of 8 treatments. Each treatment was replicated three times with 12 birds per replicate. The experiment was arranged in a 2 × 4 factorial experimental layout in a completely randomized design. There were similarities ($P > 0.05$) in feed intake, feed conversion ratio, weight gain and final weight across all treatments. Lowest ($P < 0.05$) water intake was recorded in pullet chicks maintained on 30 $g.l^{-1}$ leaf extract (2726.90 ml/bird). Birds maintained on 30 $g.l^{-1}$ and 45 $g.l^{-1}$ concentration of extraction had the highest ($P < 0.05$) caeca weight (0.75 % of body weight). Birds administered root extract and leaf extract at 30 g. l^{-1} and 45 $g.l^{-1}$ concentration levels recorded higher ($P < 0.05$) white blood cell count compared to other treatments. Highest ($P < 0.05$) lymphocyte differential was recorded in birds raised on 45 $g.l^{-1}$ root extract. Lowest ($P < 0.05$) serum uric acid was recorded in pullet chicks administered 45 $g.l^{-1}$ root extract (3.07 $mg.dl^{-1}$), while serum cholesterol was lowered ($P < 0.05$) in all administered levels of extracts of *Petiveria alliacea* when compared to the control birds. The study concluded that administration of aqueous root extract of *Petiveria alliacea* at 45 $g.l^{-1}$ concentration level best enhanced immunity, reduced serum urea and cholesterol in pullet chicks without impairing their growth.

Key words: growth performance; blood indices; pullet chicks; *Petiveria alliacea* root; *Petiveria alliacea* leaf

INTRODUCTION

Poultry production represents one of the largest sub-sectors of the Nigerian agricultural industry (Bamiro *et al.*, 2006). Gradual growth of the poultry industry can be attributed to systemic and timely application of innovative sciences (Alabi and Samuel, 2002).

Commercial layers capable of producing remarkable amount of eggs during their life-time has been developed through improvement in genetic make-up, modification of diet and improvement

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in management practices (Alabi and Samuel, 2002). The major aim of egg-type chicken production is to raise a disease-free stock to attain optimal body weight and egg production in return for each unit of feed intake (Asrat *et al.*, 2018). According to Holik (2015), the basis for good egg production is a successful rearing phase. This means that management, health and growth performance of pullet chicks at early age, despite accounting for a small portion of the bird's life, have significant impact on subsequent egg production performance. Poor nutrition at early age was reported to limit growth potential (Henderson *et al.*, 2008) and induce poor performance as a result of increased susceptibility to diseases in chickens (Noy and Sklan, 1999; Dibner *et al.*, 1998). For commercial egg-type chickens having the genetic potential to rapidly attain peak of egg production, good body reserves and health status is necessary to achieve satisfactory performance in the laying house (Summers, 2008). Therefore, appropriate health maintenance practices and proper feeding management are necessary right from the early stage of growth to produce healthy and excellent egg-producing laying stock.

Blood is a key index in evaluating physiological, pathological and nutritional state of avian species (Hauptmanova *et al.*, 2006; Olorode *et al.*, 2007). Dietary intake has been identified as a major factor affecting blood composition (Aletor, 1989; Aletor and Egberongbe, 1992). Relative comparison of blood constituent compositions with normal standardized values could be used to predetermine the metabolic status of an animal as well as feed utilization and quality (Babatunde *et al.*, 1992).

Antibiotics have been used in poultry production as growth promoters and for therapeutic purposes against many diseases facing the poultry industry. However, recently the use of antibiotic drugs has been restricted due to emergence of antibiotic resistant microorganisms and harmful drug residues in food products (Castanon, 2007; Diarra and Malouin, 2014; Dhama *et al.*, 2015). Also, increasing awareness of the public on food safety has led to high demand of antibiotic-free food products of poultry sources (Biswas *et al.*, 2010). These trends necessitated researchers to find sustainable alternatives to the use of antibiotics for general health maintenance, immunomodulation, growth enhancement and therapeutic purposes (Diarra and Malouin, 2014). The use of herbal plant has emerged as one of the viable alternatives to antibiotic drugs (González-Lamothe *et al.*, 2009). Considering feed efficiency, weight gain and improved liveability in poultry production, the use of herbal plants have shown some promising results (Mishra and Singh 2000; Deepak *et al.*, 2002; Jahan *et al*., 2008).

Petiveria alliacea belonging to the plant family *phytolaccacea* is a perennial herb that grows widely in tropical regions (Lopes-Martins *et al.*, 2002). The root and leaves has been used in folk medicine against various diseases (Kim *et al.*, 2006) and as antispasmodic, sedative, diuretic, anti-helminthic, menstrual promoting, stimulant, analgesic, anti-inflammatory and anti-cancerous agent (Lopes-Martins *et al.*, 2002). *Petiveria alliacea* has also been reported to possess broad range of antimicrobial properties (Illnait-Zaragozí *et al.*, 2014; Ekunseitan *et al.*, 2016). Phytochemical screening of the plant showed presence of Terpenoid, Flavonoid, Tannin, Alkaloids, Phytate, Phenols, Antioxidant, Saponin, Oxalate and Carotenoids (Ekunseitan *et al.*, 2016). Few studies have been conducted recently, investigating the growth response of growing pullets (Muhammad *et al.*, 2018) and broiler chickens (Odetola *et al.*, 2019) to *Petiveria alliacea* root and leaf meal. However, the potential of extracts from fresh roots and leaves of *Petiveria alliacea* on growth performance and health of poultry species is yet to be explored. Therefore, this study was conducted to evaluate the growth performance, intestinal organ development and blood indices of pullet chicks administered aqueous extract of *Petiveria alliacea*.

MATERIAL AND METHODS

Ethical Statement

This study was performed in accordance with the ethical guidelines of Animal Welfare Committee, College of Animal Science and Livestock Production, Federal University of Agriculture, Abeokuta, Nigeria.

Experimental Site

The experiment was conducted at the Poultry Unit of Livelihoods Support and Development Centre (SLIDEN AFRICA), Alabata road, Abeokuta, Ogun State, Nigeria.

Harvesting and Extraction of *Petiveria alliacea*

Fresh roots and leaves of *Petiveria alliacea* were harvested from Kotopo Area of Abeokuta, Nigeria. They were rinsed thoroughly with clean water to remove sand and other dirt. Aqueous extraction of *Petiveria alliacea* was done as described by Nodu *et al.* (2016). 15 g, 30 g and 45 g of roots and leaves were weighed individually and each was blended separately in 1 litre of water for 120 seconds. After blending, each mixture was filtered to remove root and leaf particles using appropriate sieve. The filtrates were supplied to birds separately as drinking water according to the treatment groups. Volume of filtrates supplied to birds at all period of administration was enough to meet and exceed daily water requirement of the birds.

Table 1. Percentage composition of experimental diet

Ingredients	%
Maize	50.00
Soya bean meal	10.00
Fish meal (72 % CP)	1.70
Groundnut cake	20.00
Wheat offal	15.00
Oyster shell	1.00
Bone meal	1.50
Lysine	0.15
Methionine	0.15
Common salt	0.25
Premix	0.25
Total	100.00
Determined Analysis (%)	
Dry matter (%)	88.70
Crude Protein (%)	21.80
Crude Fibre (%)	5.00
Ether extracts (%)	3.74
Ash (%)	6.00
Metabolisable energy (MJ.kg^{-1})	11.91

Premix (Composition per kg diet): Vit. A (I.U.) 2,800,000; Vit. E (mg) 16,000; Vit. K (mg) 800; Vit. B_1 (mg) 1,200; Vit. B_2 (mg) 1,600; Vit. B_6 E.E4 (mg) 30; Folic Acid (mg) 0.4; Niacin (mg) 20,000; D Cal Pan (mg) 4,400; Co (mg) 120; Cu (mg) 3,200; I (mg) 600; Se (mg) 48; Zn (mg) 24,000; Fe (mg) 16,000; Mn (mg) 40,000; Choline Chloride (mg) 120,000; Antioxidant (mg) 48,000.

Management of Experimental Birds

Two hundred and eighty eight, 1-day-old Isa-brown pullet chicks were used for the experiment. The chicks were brooded altogether for 14 days. After balancing for weight at 15 days of age, the chicks were arranged in a 2 × 4 factorial experimental layout consisting of two groups administered extract of different parts (root or leaves) at different concentration levels (0, 15, 30 and 45 g.l^{-1}). The experiment consisted of 8 treatments replicated three times each with 12 birds per replicate. Prepared aqueous extract of root or leaves of *Petiveria alliacea* at the stated concentration levels were offered to birds in each treatment as drinking water on two consecutive days per week throughout the experimental period. The experiment lasted between 15 to 56 days of age. All treatments receiving aqueous extract of root or leaves *Petiveria alliacea* were free of antibiotic drugs. Experimental birds were raised in a deep litter system with housing temperature ranging between 32 °C (89.6 °F) and 21 °C (69.8 °F) since brooding until the end of the experiment. Birds in all treatments were fed *ad libitum* a formulated starter diet in a mash form (Table 1).

Data Collection

Performance Characteristics

Data on initial body weight, feed intake, water intake, body weight gain, final weight, feed conversion ratio and mortality rate were collected.

$$\text{Daily feed intake (g)} = \text{Feed given (g)} - \text{Feed leftover (g)}$$

$$\text{Daily water intake (ml)} = \text{Volume of water supplied (ml)} - \text{Volume of water left (ml)}$$

$$\text{Average daily feed intake (g)/bird} = \frac{\text{Daily feed intake of the replicate (g)}}{\text{Number of birds in the replicate}}$$

$$\text{Body weight gain (g)} = \text{Final body weight (g)} - \text{Initial body weight (g)}$$

$$\text{Average body weight gain (g)/bird} = = \frac{\text{Final body weight of replicate (g)} - \text{Initial body weight of replicate (g)}}{\text{Number of bird in the replicate}}$$

$$\text{Feed conversion ratio} = \frac{\text{Feed consumed (g)}}{\text{Body weight gain (g)}}$$

$$\text{Mortality (\%)} = \frac{\text{Number of dead birds/Replicate}}{\text{Total number of birds in the replicate}} \times 100$$

Determination of Haematological and Blood Biochemical Indices

Blood Collection

At the end of the study (56 days of age), two millilitres (2 ml) of blood was drawn twice from the brachial vein of two birds in each replicate of all treatments into two different labelled bottles for haematological and serum biochemistry investigations. The blood samples for haematological parameters were collected into bottles pre-treated with ethylene diamine tetraacetate (EDTA), an anticoagulant. Blood samples for biochemical indices was collected into another sample bottle containing no anticoagulant.

Haematological Indices

The haematological indices examined include: Red Blood Cell (RBC), white blood cell (WBC), leucocyte differential count (lymphocytes, monocytes, heterophils, eosinophils, basophils), Packed cell volume (PCV) and haemoglobin (Hb) concentration. RBC and WBC counts were determined using Neubaur chamber method, as described by Lamb (1981). PCV was determined using haematocrit reader according to Benson *et al.* (1989). Haemoglobin was estimated using cyanomethaemoglobin method (Dayyal, 2016).

Serum Biochemical Indices

Serum total protein was determined by the Biuret method (Reinhold, 1953) using a commercial kit (Randox Laboratories Ltd, U.K), while albumin and globulin values were measured by bromocresol green method (Doumas and Biggs, 1971). The serum creatinine and urea nitrogen were estimated by de-proteinisation and Urease-Berhelot colorimetric methods using a commercial kit (Randox Laboratories Ltd, U.K). Free cholesterol was determined using a commercial kit (Quimica Clinica Applicada, S.A).

Intestinal Organ Weight

At the end of the study (56 days of age) two birds with body weights close to the replicate's mean weight were selected from each replicate of all treatments, starved for 12 hours and slaughtered. The gastrointestinal tract was carefully isolated from the carcass. The oesophagus, crop, proventriculus, gizzard, small intestine, large intestine, caecum and liver were separated. Weights of each separated organs were measured using an electronic sensitive weighing scale and expressed as a percentage of live bodyweight.

Table 2. Main effects of aqueous extract of different parts (root and leaf) and concentration of extraction of *Petiveria alliacea* on growth performance of pullet chicks (3 – 8 weeks)

	Plant Part			Concentration of extraction				
Parameters	Root	Leaf	SEM	0 g.l^{-1}	15 g.l^{-1}	30 g.l^{-1}	45 g.l^{-1}	SEM
Initial weight (g/bird)	82.22	82.30	0.04	82.24	82.21	82.28	82.32	0.06
Final weight (g/bird)	412.90	412.74	1.23	410.20	415.47	413.31	412.29	1.57
Total weight gain (g/bird)	330.68	330.43	1.22	327.96	333.26	331.03	329.97	1.54
Weight gain (g/bird/day)	7.87	7.86	0.03	7.81	7.94	7.88	7.86	0.04
Total feed intake (g/bird)	1116.36	1119.46	1.11	1118.35	1117.96	1117.20	1118.14	1.76
Average feed intake (g/bird/day)	26.58	26.65	0.03	26.63	26.62	26.60	26.63	0.04
Feed conversion ratio	3.37	3.39	0.01	3.41	3.35	3.38	3.39	0.02
Total water intake (ml/bird)	3007.62	2870.79	63.72	3150.00^{a}	2942.80^{ab}	2797.50^{b}	2866.40^{b}	73.75
Average daily water intake (ml/bird/day)	71.61	68.35	1.52	75.00^{a}	70.07^{ab}	66.61^{b}	68.25^{b}	1.76
Mortality (%)	0.69	1.39	1.04	2.77	1.38	0.00	0.00	0.79

SEM: Standard error of mean.

$^{a, b}$ Means in the same row not sharing common superscript are significantly ($P < 0.05$) different.

Statistical Analysis

The experiment was arranged in a 2 × 4 factorial experimental layout and data collected were subjected to a completely randomized design. Significant differences among treatment means were determined using a Duncan's Multiple Range Test (Statistical Analysis Software; SAS, 2010).

RESULTS

The main effects of aqueous extract from different parts (root and leaf) and concentration of extraction of *Petiveria alliacea* on growth performance of pullet chicks (3 – 8 weeks of age) are presented in Table 2. Water intake was significantly affected by concentration of extraction. The highest water intake (75.00 ml) was recorded in the control group, while pullets maintained on 30 g.l^{-1} or 45 g.l^{-1} concentration of extraction demonstrated statistically similar and least values of water consumption (66.61 and 68.25 ml, respectively).

The interactive effect of aqueous extract from different parts (root and leaf) and concentration of extraction of *Petiveria alliacea* on growth performance of pullet chicks (3 – 8 weeks of age) is presented in Table 3. Only water intake was significantly ($P < 0.05$) influenced by the interaction of extracts from different parts (root and leaf) and concentration of extraction of *Petiveria alliacea*. The control groups had significantly ($P < 0.05$) higher water intake compared with pullet chicks administered 30 g.l^{-1} concentrations of leaf extract.

The main effects of aqueous extract from different parts (root and leaf) and concentration of extraction of *Petiveria alliacea* on haematological indices and some serum metabolites of pullet chicks at 8 weeks of age are presented in Table 4. Birds offered aqueous root extract had significantly ($P < 0.05$) higher lymphocyte value (67.79 %) compared to birds administered leaf extract (65.75 %). Uric acid was significantly ($P < 0.05$) higher in serum of birds administered leaf extract (4.35 mg.dl^{-1}) compared to root extract (3.95 mg.dl^{-1}). White blood cell count increased significantly ($P < 0.05$) with increase in concentration of extraction, although only numerical difference was observed between 30 g.l^{-1} and 45 g.l^{-1} concentrations of extraction. Pullets in the control group showed higher ($P < 0.05$) value of heterophil compared to birds offered with other concentrations of extraction. Furthermore, lymphocyte value increased significantly ($P < 0.05$) along with increase

Table 3. Interactive effect of aqueous extract of different parts (root and leaf) and concentration of extraction of *Petiveria alliacea* on growth performance of pullet chicks (3 – 8 weeks)

Plant part	Root				Leaf				
Concentration of extraction	0 g.l^{-1}	15 g.l^{-1}	30 g.l^{-1}	45 g.l^{-1}	0 g.l^{-1}	15 g.l^{-1}	30 g.l^{-1}	45 g.l^{-1}	SEM
Parameters									
Initial weight (g/bird)	82.19	82.11	82.25	82.31	82.28	82.30	82.30	82.34	0.08
Final weight (g/bird)	409.00	415.55	414.39	412.64	411.39	415.39	412.22	411.94	2.37
Total weight gain (g/bird)	326.81	333.44	332.14	330.33	329.11	333.08	329.92	329.61	2.33
Weight gain (g/bird/day)	7.78	7.94	7.91	7.87	7.84	7.93	7.85	7.85	0.06
Total feed intake (g/bird)	1114.81	1115.25	1116.53	1118.86	1121.89	1120.67	1117.86	1117.42	2.04
Average feed intake (g/bird/day)	26.54	26.55	26.58	26.64	26.71	26.68	26.62	26.61	0.05
Feed conversion ratio	3.41	3.34	3.36	3.38	3.41	3.36	3.39	3.39	0.02
Total water intake (ml/bird)	3132.60^{a}	3094.30^{ab}	2868.10^{ab}	2935.50^{ab}	3167.40^{a}	2791.40^{ab}	2726.90^{b}	2797.30^{ab}	93.86
Average daily water intake (ml/bird/day)	74.59^{a}	73.67^{ab}	68.29^{ab}	69.89^{ab}	75.42^{a}	66.46^{ab}	64.93^{b}	66.60^{ab}	2.23
Mortality (%)	2.77	0.00	0.00	0.00	2.77	2.77	0.00	0.00	1.04

SEM: Standard error of mean.

$^{a, b}$ Means in the same row not sharing common superscript are significantly ($P < 0.05$) different.

Table 4. Main effects of aqueous extract of different parts (root and leaf) and concentration of extraction of *Petiveria alliacea* on haematological indices and some serum metabolites of pullet chicks at 8 weeks of age

	Plant Part			Concentration of extraction				
Parameters	Root	Leaf	SEM	0 g.l^{-1}	15 g.l^{-1}	30 g.l^{-1}	45 g.l^{-1}	SEM
Haematological indices								
Pack Cell Volume (%)	25.06	25.06	0.81	24.68	25.83	24.73	24.98	1.19
Haemoglobin (g.dl^{-1})	8.31	8.42	0.33	8.43	8.60	8.27	8.15	0.49
Red Blood Cell (× 10^{12}.L^{-1})	2.07	2.00	0.08	2.05	2.03	2.02	2.03	0.13
White Blood Cell (× 10^{9}.L^{-1})	11.11	11.05	0.29	9.78^{c}	10.75^{b}	11.87^{a}	11.92^{a}	0.17
Heterophil (%)	29.79	31.17	0.73	33.17^{a}	29.92^{b}	30.50^{b}	28.33^{b}	0.86
Lymphocyte (%)	67.79^{a}	65.75^{b}	0.68	63.67^{c}	67.08^{b}	67.33^{b}	69.00^{a}	0.74
Eosinophil (%)	0.50	0.92	0.17	0.67	0.67	0.67	0.83	0.26
Basophil (%)	0.83	1.08	0.22	1.33	1.17	0.67	0.67	0.30
Monocyte (%)	1.08	1.08	0.26	1.17	1.17	0.83	1.17	0.37
Serum metabolites								
Total protein (g.dl^{-1})	4.56	4.56	0.15	4.37	4.68	4.50	4.68	0.19
Albumin (g.dl^{-1})	2.39	2.41	0.08	2.40	2.47	2.33	2.40	0.11
Globulin (g.dl^{-1})	2.17	2.15	0.12	1.97	2.22	2.17	2.28	0.16
Uric acid (mg.dl^{-1})	3.95^{b}	4.35^{a}	0.18	4.85a	4.25^{b}	4.13^{b}	3.37^{c}	0.16
Creatinine (mg.dl^{-1})	2.46	2.58	0.26	2.48	2.48	2.50	2.62	0.38
Glucose (mg.dl^{-1})	123.12	123.19	3.34	123.73	123.43	122.40	123.07	4.94
Cholesterol (mg.dl^{-1})	153.77	155.22	9.19	200.43^{a}	143.78^{b}	141.93^{b}	131.83^{b}	6.06

SEM: Standard error of mean.
$^{a, b, c}$ Means in the same row not sharing common superscript are significantly ($P < 0.05$) different.

in concentration of extraction, ranging from 63.67 % in control birds to 69.00 % in birds maintained on 45 g.l^{-1} concentration level. The increase in concentration of extraction significantly ($P < 0.05$) decreased uric acid level from 4.85 mg.dl^{-1} in control birds to 3.37 mg.dl^{-1} in birds raised on 45 g.l^{-1} concentration of extraction. Serum cholesterol level was significantly ($P < 0.05$) higher in the control birds compared with other concentration levels.

The interactive effect of aqueous extract of different parts (root and leaf) and concentration of extraction of *Petiveria alliacea* on haematological indices and some serum metabolites of pullet chicks at 8 weeks of age is presented in Table 5. There was significant ($P < 0.05$) increase in white blood cell count as concentration of extraction increased for both groups maintained on root and leaf extracts, although values recorded at 30 g.l^{-1} or 45 g.l^{-1} concentration levels were statistically similar. Values recorded for heterophil varied between 26.67 % in birds administered 45 g.l^{-1} root extract and 34.33 % in the control birds (0 g.l^{-1} root extract). Lymphocyte value was significantly ($P < 0.05$) higher in birds administered root extract compared with values recorded for birds administered leaf extract at each concentration. Moreover, lymphocyte values increased along with increase in concentration of extraction of both plant parts. Uric acid level ranged from 3.07 mg.dl^{-1} in birds administered 45 g.l^{-1} concentration of root extract to 4.90 mg.dl^{-1} in birds offered 0 g.l^{-1} concentration of leaf extract (control). Serum cholesterol was significantly ($P < 0.05$) higher in the control birds compared to birds maintained on other concentrations levels of both root and leaf extract.

The main effects of aqueous extract from different parts (root and leaf) and concentration of extraction of *Petiveria alliacea* on intestinal organ weights of pullet chicks at 8 weeks of age are presented in Table 6. The control birds showed the lowest ($P < 0.05$) caeca weight, while birds maintained on 30 g.l^{-1} or 45 g.l^{-1} concentration of

Table 5. Interactive effect of aqueous extract of different parts (root and leaf) and concentration of extraction of *Petiveria alliacea* on haematological indices and some serum metabolites of pullet chicks at 8 weeks of age

Plant part	Root				Leaf				
Concentration of extraction	0 g.l^{-1}	15 g.l^{-1}	30 g.l^{-1}	45 g.l^{-1}	0 g.l^{-1}	15 g.l^{-1}	30 g.l^{-1}	45 g.l^{-1}	SEM
Parameters									
Haematological indices									
Pack Cell Volume (%)	24.67	26.00	24.67	24.90	24.70	25.67	24.80	25.07	1.87
Haemoglobin (g.dl^{-1})	8.27	8.60	8.13	8.23	8.60	8.60	8.40	8.07	0.75
Red Blood Cell (× 10^{12}.L^{-1})	2.13	2.03	2.03	2.07	1.97	2.03	2.00	2.00	0.19
White Blood Cell (× 10^{9}.L^{-1})	9.83^{c}	10.70^{b}	12.03^{a}	11.87^{a}	9.73^{c}	10.80^{b}	11.70^{a}	11.97^{a}	0.24
Heterophil (%)	34.33^{a}	28.83^{bc}	29.33^{bc}	26.67^{c}	32.00^{ab}	31.00^{ab}	31.67^{ab}	30.00^{bc}	0.97
Lymphocyte (%)	63.00^{e}	68.83^{ab}	69.00^{ab}	70.33^{a}	64.33^{de}	65.33^{d}	65.67^{cd}	67.67^{bc}	0.60
Eosinophil (%)	0.33	0.33	0.33	1.00	1.00	1.00	1.00	0.67	0.31
Basophil (%)	1.33	1.00	0.33	0.67	1.33	1.33	1.00	0.67	0.44
Monocyte (%)	1.00	1.00	1.00	1.33	1.33	1.33	0.67	1.00	0.57
Serum metabolites									
Total protein (g.dl^{-1})	4.20	4.83	4.57	4.63	4.53	4.53	4.43	4.73	0.29
Albumin (g.dl^{-1})	2.30	2.53	2.33	2.40	2.50	2.40	2.33	2.40	0.16
Globumin (g.dl^{-1})	1.90	2.30	2.23	2.23	2.03	2.13	2.10	2.33	0.24
Uric acid (mg.dl^{-1})	4.80^{a}	4.00^{bc}	3.93^{bc}	3.07^{d}	4.90^{a}	4.50^{ab}	4.33^{abc}	3.67^{dc}	0.19
Creatinine (mg.dl^{-1})	2.43	2.37	2.43	2.60	2.53	2.60	2.57	2.63	0.60
Glucose (mg.dl^{-1})	123.33	123.07	122.33	123.77	124.13	123.80	122.47	122.37	7.80
Cholesterol (mg.dl^{-1})	194.87^{a}	148.07^{b}	141.63^{b}	130.50^{b}	206.00^{a}	139.50^{b}	142.23^{b}	133.17^{b}	8.44

SEM: Standard error of mean.

$^{a, b, c, d, e}$ Means in the same row not sharing common superscript are significantly ($P < 0.05$) different.

Table 6. Main effects of aqueous extract of different parts (root and leaf) and concentration of extraction of *Petiveria alliacea* on intestinal organ weights of pullet chicks at 8 weeks of age

	Plant Part			Concentration of extraction				
	Root	Leaf	SEM	0 g.l^{-1}	15 g.l^{-1}	30 g.l^{-1}	45 g.l^{-1}	SEM
Organs (% of body weight)								
Oesophagus	0.41	0.41	0.01	0.40	0.42	0.43	0.41	0.01
Crop	0.96	0.89	0.04	0.92	0.94	0.96	0.88	0.05
Small intestine	5.30	5.57	0.24	5.76	5.59	5.25	5.13	0.31
Large intestine	0.34	0.33	0.01	0.32	0.33	0.34	0.34	0.02
Caeca	0.68	0.69	0.04	0.58^{b}	0.67^{ab}	0.75^{a}	0.75^{a}	0.04
Proventriculus	0.69	0.72	0.03	0.70	0.72	0.70	0.71	0.05
Empty gizzard	2.31	2.22	0.05	2.32	2.20	2.24	2.29	0.07
Liver	2.05	2.01	0.04	2.02	2.00	2.03	2.07	0.06

SEM: Standard error of mean.

$^{a, b}$ Means in the same row not sharing common superscript are significantly ($P < 0.05$) different.

Table 7. Interactive effect of aqueous extract of different parts (root and leaf) and concentration of extraction of *Petiveria alliacea* on intestinal organ weights of pullet chicks at 8 weeks of age

Plant part	Root				Leaf				
Concentration of extraction	0 g.l^{-1}	15 g.l^{-1}	30 g.l^{-1}	45 g.l^{-1}	0 g.l^{-1}	15 g.l^{-1}	30 g.l^{-1}	45 g.l^{-1}	SEM
Organs (% of body weight)									
Oesophagus	0.39	0.42	0.43	0.41	0.41	0.41	0.42	0.40	0.01
Crop	0.93	1.03	1.02	0.88	0.91	0.86	0.91	0.88	0.08
Small intestine	5.51	5.28	5.12	5.30	6.02	5.90	5.39	4.97	0.41
Large intestine	0.32	0.35	0.35	0.32	0.32	0.31	0.34	0.35	0.02
Caeca	0.59	0.65	0.72	0.79	0.58	0.70	0.78	0.72	0.05
Proventriculus	0.73	0.66	0.72	0.65	0.66	0.78	0.68	0.78	0.06
Empty gizzard	2.35	2.16	2.31	2.42	2.29	2.25	2.17	2.16	0.10
Liver	2.05	2.04	2.02	2.09	1.99	1.97	2.04	2.05	0.10

SEM: Standard error of mean.

extraction had similar and highest caeca weights.

The interactive effect of aqueous extract from different parts (root and leaf) and concentration of extraction of *Petiveria alliacea* on intestinal organ weights of pullet chicks at 8 weeks of age are presented in Table 7. The interaction had no significant ($P > 0.05$) influence on all intestinal organ weights examined.

DISCUSSION

The similarities in growth performance observed in this study indicated that aqueous extract from root and leaf of *Petiveria alliacea* offered to pullet chicks constitutes main important phytochemicals. Phytochemicals have been reported as bioactive non-nutritive compounds (Liu, 2013) and, therefore, may have no substantial contribution to growth performance. There is also suggestion that aqueous extract from root and leaf of *Petiveria alliacea* at concentration levels up to 45 g.l^{-1} contains minimal level of anti-nutritional phytochemicals, since there was no detrimental effect on growth of pullet chick. Similarly, Odetola *et al.* (2019) reported no significant difference in all growth parameters examined when broiler birds were fed diets supplemented with graded levels of *Petiveria alliacea* root meal at 500 g, 1000 g, 1500 g, 2000 g and 2500 g.100 kg^{-1} of feed. However, Muhammad *et al.*, (2018) found improvement in growth performance of growing pullets fed diet containing 1000 mg of *Petiveria alliacea* root meal per kilogram of feed. Disparity in these results may be attributed to the stage of growth of the pullet chicks and mode of application of *Petiveria alliacea.*

The reduced water consumption observed in pullet chicks maintained on the extracts from root and leaf of *Petiveria alliacea* might not be a factor of taste, since chickens have been reported to have few taste receptors with sweet taste receptor missing and bitter taste receptor very few (Berkhoudt, 1985; Roura *et al.*, 2013). Odour and appearance were stated as important factors in determining what birds consume, like other mono-gastric animals (Baldwin, 1976; Mellor, 2000). Hence, the lowered water intake can be credited to water discolouration and characteristic strong odour of *Petiveria alliacea* resulting from the presence of sulfurate compounds (De Sousa *et al.*, 1990).

Similarities in PCV, Hb and RBC of birds in all treatments signified that administration of aqueous extract of *Petiveria alliacea* did not trigger anaemic or polycythaemia conditions in birds. Therefore, it supported normal physiological functions of the body. All values recorded in this study fell within the range ($2.0 - 3.5 \times 10^{12}$.L^{-1}, 6.5 – 13 g.dl^{-1} and 22 – 43 % for RBC, Hb and PCV respectively) earlier reported by Santoso *et al.* (2017).

The increase in white blood cell count and lymphocyte differential can be considered as a result of enhancement in the immune system instigated

by the experimental plant. This boost ability of the birds to fight against foreign bodies, thereby, strengthening the resistance to diseases (Alegre and Clavo, 2007). *Petiveria alliacea* was reported to possess immune-stimulating properties due to the presence of dibenzyl trisulfide (Quadros *et al.*, 1999; Rosner *et al.* 2001). Randle *et al.* (2018) also stated that water extract of *Petiveria alliacea* stimulated lymphocyte, interferon and interleukin production. This result is synonymous to the findings of Sobayo *et al.* (2018), who reported an increase in the lymphocyte count of broiler birds fed 100 ppm or 500 ppm dietary inclusion of *Petiveria alliacea* root and leaf meal. Higher lymphocyte differential observed in pullet chicks administered root extract indicated that root extract tends to promote production of antibodies and cytotoxic cells compared to leaf extract. Values recorded for white blood cell count fell within the range ($5.0 – 15.00 \times 10^9.L^{-1}$) reported by McDonald (1996).

The concentration dependent reduction in serum uric acid level caused by the administration of aqueous extract of root and leaf of *Petiveria alliacea* in this study suggested that the extracts promoted protein utilization, owing to the fact that high serum uric acid level signals poor dietary protein utilization (Oduguwa and Ogunmodede, 1995; Awosanya *et al.*, 1999). This also indicated improved renal functionality (Oni *et al.*, 2018). This corresponds to the finding of Sobayo *et al.* (2018), who observed low serum uric acid concentration in broilers fed 500 or 1500 ppm dietary inclusion of *Petiveria alliacea*.

The observed decrease in serum cholesterol level may suggest inhibition of fatty acid synthesis by *Petiveria alliacea*. The organosulfur compounds present in *Petiveria alliacea*, similar to those in garlic and onion (Randle *et al.*, 2018), are responsible for its characteristic garlic odour. These compounds have been found to inhibit squalene epoxidase, which is involved in the synthetic pathway of cholesterol (Khan *et al.*, 2007). Elson and Qureshi (1995) also stated that extracts from plants may lower blood cholesterol in chickens by inhibiting 3-Hydroxy-3-methylglutaryl coenzyme A (HMG-CoA) reductase, the enzyme involved in cholesterol synthesis. This result is similar to the finding of Stanacev *et al.* (2011), who reported hypocholesterolaemic effect in blood serum of garlic-treated broilers.

Also, Oleforuh-Okoleh *et al.* (2015) opined that serum cholesterol was reduced when broiler chickens were administered aqueous extract of ginger and garlic. However, Odetola *et al.* (2019) reported an increase in serum cholesterol of broiler chickens fed 2500 g of *Petiveria alliacea* root meal per 100 kg of feed. This discrepancy may arise from variations in preparation methods, which may affect the stability of active organo-sulphur compounds (Poojary *et al.*, 2017). Similarities in weight of oesophagus, crop, gizzard, proventriculus, small intestine, large intestine and liver indicated that the administration of aqueous extract from root and leaves of *Petiveria alliacea* at all tested concentrations did not interfere with normal development of these organs. Improvement in the caeca weight, recorded in this study, could be a result of physiological adjustment to increased biological activities within the caeca. The caeca has been found to be a site for fermentation and further digestion of feed, for utilization and absorption of water and nitrogenous components, for microbial action and as a site for production of immunoglobulins (Clench and Mathias, 1995). Therefore, the antimicrobial (Kim *et al.*, 2006; Ekunseitan *et al.*, 2016) and immunomodulatory (Williams *et al.*, 2007; Santander *et al.*, 2012) activities of *Petiveria alliacea* might have enchanced biological processes within the caeca and, thus, the consequent adjustment in weight. Similarly, Rougiere and Carre (2010) reported a rise in the activity within the caeca and subsequent increase in the caeca weight by inclusion of 15 % sunflower hulls into the diet of broiler chickens.

CONCLUSION

It is concluded that aqueous root extract of *Petiveria alliacea* at 45 $g.l^{-1}$ concentration level best enhanced immune cell proliferation and reduced serum uric acid and cholesterol content in pullet chicks without compromising their growth.

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