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Growth Performance, Carcass Characteristics, Haematological and Histological Indices of Broiler Finisher Birds Reared on Varying Levels of Alum Treated Litter

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ABSTRACT

The study aimed to determine the growth performance, carcass characteristics, haematological and histological indices of broiler finisher birds reared on varying levels of alum treated litter. A total of 300 mixed sex of broiler birds at 4 weeks of age were allotted to 4 treatments groups in a completely randomized design (CRD)with 5 replicates of 15 birds each. Treatment 1 served as the control, while treatments 2, 3 and 4 contained (200g, 400g, and 600g) of alum per 5kg liter respectively. Results showed that the body weight gain, ADWG, FCR, feed intake and ADFI values were higher ($p<0.05$) in favor of the treatment groups (T2, T3 and T4). Treatment groups had better ($p<0.05$) carcass and organ quality than the control group. In hematology results, it was only the values for WBC were significant ($p<0.05$) across the treatment and the value was highest ($p<0.05$) in control birds. Furthermore, histological indices determined were not significant ($p>0.05$). It was therefore,concluded that the treatment of broiler litter with alum up to 600g/5kg litter had no adverse effect on their performance and can be employed as a litter management protocols for improving performance in broiler production.

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INTRODUCTION

Increased per capita income, rapid urbanization, changing lifestyles, shifting eating habits and population growth all contributes to an increase in the demand for poultry products. Poultry, such as broiler chicken, is the least expensive source of farm animal protein and can satisfy the increasing human demands for food products of animal origins globally (Farrell, 2013). The production of broilers, which have a reduced fat content, increased protein content, and a balanced amino acid composition, is one of the fastest means of producing large amounts of high-quality animal protein for human consumption, according to Sleman et al. (2015).

However, poultry industry is still faced with several ecological problems despite its contribution to the global demand for meat. One of such ecological issues is litter ammonia gas emission. Ammonia is a product of microbial decomposition of N_2-rich compounds such as uric acid (Munk et al., 2017). It has been confirmed that the accumulation of ammonia in pens has some negative impacts on the environment, health of birds and farm attendants (Salim et al., 2014, Attia et al., 2020). Ammonia gas pollutes the environment and helps to create climate change by the formation of nitrous oxide in the atmosphere. In addition, elevated ammonia levels in poultry houses can hurt hens by reducing their development rate, feed efficiency, and egg production. Ammonia gas can also impair respiratory systems of birds by worsening tracheitis and air sacculitis and thereby making them more susceptible to long-lasting respiratory ailments such as Newcastle disease, E. coli infection and increasing incidence of kerato conjunctivitis (Tasistro et al., 2007)

However, litter management strategy that can be employed to maintain good litter quality and decrease the excessive litter emission of ammonia gas is litter treatment with alum. Aluminum sulfate has been used to treat poultry litter to lessen the formation and volatilization of ammonia gas from the litter. Aluminum sulfate is a salt with chemical formula $Al_2 (SO4)_3$ Incorporation of aluminum sulfate into the litter will help to acidify it and change the volatile ammonia to ammonium ions ($NH4^+$), which is not volatile. Alum has been used as a profitable means of reducing ammonia emission within the poultry pens (Gilmour et al., 2004). Sahoo et al. (2017) treated litter with alum and observed that the nitrogen content of the litter from the treated groups was higher than that of the control group. According to the authors' explanation, the acidic composition of the litter prevented the free ammonium ion from being converted to ammonia, causing more nitrogen to be retained in the litter. Alum applications have been demonstrated to reduce NH_3 concentrations in poultry houses, which improves chicken performance. This includes improved weight gain, better feed conversion, reduced mortality rates, and higher earnings for poultry producers (Moore, 2011). In contrast to non-treated groups, Madrid et al. (2012) found that adding alum to new litter (wood shaving) at a rate of 0.25 kg/m^2 for five days (37-42) dramatically lowered indoor ammonia concentrations and Do et al. (2005) obtain similar findings for a multi-flock litter. Due to the myriads of negative impacts of ammonia gas on farm animal productivity, human beings and as well as the environment, the study was designed to investigate the the effect of variying levels of alum treated litter on growth performance, carcass characteristics, hematological and histological indices of finisher broiler birds.

MATERIALS AND METHODS

Ethical Consideration

The research was done in line with the ethical provisions of the Committee (No: EOE281SORE02.10.08.2022) on the use of farm animals for research at the University of Nigeria, Nsukka.

Location and Duration of Study

The experiment took place at the Avian Unit of the Teaching and Research Farm, Department of Animal Science, University of Nigeria, Nsukka. Nsukka is located at longitudes 6˚25'N and latitude 7˚24'E and at an altitude of 430 m above sea level. The relative humidity ranges from 56.01% to 103.83%, which is normal for a humid tropical environment. The average maximum temperature is between 33 °C and 37 °C (Energy Centre, UNN 2008). The research lasted for four weeks.

Characteristics of Aluminum Sulfate

The aluminum sulfate that was tested is a salt with the chemical formula $Al_2 (SO4)_3$ and was purchased from Joe Chem. Chemical Store Nsukka. The aluminum sulfate was stored in a dry, cool and temperate environment.

Management of Experimental Animals and Alum Application

A total of 300 mixed sex (Anak strain) broiler birds were used. They birds were assigned randomly to 4 treatments groups in a completely randomized experimental setup with 5 replicates of 15 chickens at 4 weeks old. Treatment 1 was used as the control (the litter did not contain any alum), while treatments 2, 3, and 4 contained, respectively, 200 g, 400 g, and 600 g of aluminum sulfate /5kg litter. The birds were housed in a deep litter system. During the treatment of the litter with the aluminum sulfate, gloves were worn to prevent skin irritation and burns by the alum. Furthermore, 50% out of the quantity aluminum sulfate used to treat the litter in each replicate in T2, T3 and T4 was spread on the bare floor first, while the remaining 50% was then mixed homogenously with the litter (new wood shavings) and gently spread. The reason for this is that microbial activity is higher beneath the litter than the top. Fresh drinking water and dietary treatments were provided continuously to the birds throughout the feeding trial. To avoid breathing in alum dust, goggles and a mask were also used. Overall flock prophylactic administration and routine vaccination were given also. A stress pack was administered to the birds via drinking water at 100 g/50 liters (according to manufacturer's recommendation) to boost appetite and energy supply immediately the birds arrived. The room temperature was monitored with the use of thermometer, and the lighting was provided using a 200v watt bulb.

Experimental diets: The experimental diet was formulated to satisfy the nutritional needs of the birds and is shown in (Table 1). The proximate compositions of the experimental diet were done using the procedures of AOAC (2012).

Table 1. The Percentage compositions and chemical content of experimental diet

Ingredients (%)	Finisher
Maize	38.25
Wheat offal	13.00
Soybean meal	8.00
Groundnut cake	14.00
Palm kernel cake	20.00
Fish meal	2.00
Bone meal	4.25
Vitamin premix	0.25
Methionine	0.25
Lysine	0.25
Total	100
Calculated composition	
Crude protein (%)	20.00
Metabolizable Energy (Mcal/ KgME)	3000
Crude fiber (%)	5.85
Crude fat (%)	4.20
Chemical composition (%)	
Crude matter	90.20
Crude fiber	5.05
Crude protein	20.10
Crude fat	4.21
Crude ash	5.85
Nitrogen Free Extract	54.99

Data Collection

Growth Performance Parameters

Weigths of the birds were taken at the beginning of the study. The average life weights of all the birds in each replicate were weighed at the end of every week throughout the trial period using a 6 kg electronic sensitive weighing scale. The average daily weight gain per bird was calculated using the live weight increase. From the first day the feeding trial started and to the end, feed intake was chronicled. Weighing of the diet before giving it to the birds allowed us to determine how much was consumed. To calculate the daily feed intake, the difference between the feed that was delivered the day before and the leftover feed in the feeding trough the following morning was divided by the number of birds in each replicate. Feed conversion ratio was obtained by dividing the amount of feed consumed by the birds by their increase in body weights,. The average daily feed intake was calculated by dividing the feed intake by the number of days the feeding trial lasted. By dividing the body weight gained by the birds by the number of days the study lasted, the average daily weight gain was calculated.

Carcass and Organ Evaluation

A total of 5 birds per replication were chosen at random for carcass analysis on the last week of the study. Before being killed, the birds were starved for 12 hours while receiving plenty of water. Each bird was individually weighed before being killed by an external throat cut and let to bleed to death. The slain birds were scalded in moderately hot water for a short period of time before having their feathers gently and painstakingly removed to prevent skin tearing. Each bird was plucked and then its weight was recorded. The defeathered birds were swiftly split up and the gastrointestinal tracts were carefully removed. The eviscerated carcasses were then meticulously dissected. The weight of the animal's head, neck, shanks, drumsticks, thigh, wing, breast, and back were taken. Each organ was weighed separately on an electronic balance.

Haematological Evaluation

Three birds were randomly chosen from each replication after the feeding trial (which lasted for 28 days). Using sterilized needles, blood samples (3ml) were taken from the wings and emptied into a labeled, sterilized bottle containing ethylene diamine tetra acetic acid (EDTA). The procedures outlined by Mitruka and Rawnsley (1977) were used to evaluate the hemoglobin concentration (Hb) and pack cell volume (PCV). With the help of an automated Idexx Vet Test Chemistry Analyzer, the total white blood cell (WBC) and red blood cell (RBC) counts were measured (IDEXX Labouratories, Inc.). The mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH) and mean corpuscular haemoglobin concentration (MCHC) were also calculated using the formula below:

MCHC = Haemoglobin (g/ 100 ml) x 100/PCV

MCH = Haemoglobin (g/ 100 ml)/ RBC counts

MCV = 10 x PCV (%)/RBC counts.

Statistical Design and Analysis

Data generated were subjected to one way ANOVA using a statistical package SPSS, (2003) Windows version 8.0. Mean differences were separated using Duncan′s New Multiple Range Test (Duncan, 1955) as outlined by Obi (2002).

The statistical model used to test the effect of treatments on the determined variables was:

$X_{ij} = \mu + T_i + E_{ij}$

X_{ij} = individual observation

μ = population mean

T_i = treatment effect

E_{ij} = experimental error

RESULTS

Growth performance

Table 2 and Figure 1-3 shows the effect of varying levels of alum treated litter on growth performance of broiler birds. Average daily weight gain of T2 and T3 were the same, but lower than the value of 49.66 observed for those T4 and higher than the value of 41.07 recorded for those on control treatment. The same trends were noted in total body weight gain, feed intake and average daily feed intake. Feed conversion value of T2 and T3 were the same (p>0.05), but significantly lower than the value of 3.04 recorded in T1 and higher than the value of 2.71 recorded in T4.

Table 2. Growth performance of broiler finisher birds reared on varying levels of alum treated litter for 28day

Parameters	Initial body weight (g/birds)	Body weight gain (g/bird)	Feed intake (g/bird)	ADWG (g/bird)	ADFI (g/bird)	FCR (g/g)
T1	1220.00	1150.00^{c}	3519.96^{c}	41.07^{c}	125.7^{c}	3.06^{a}
T2	1210.00	1286.70^{b}	3696.12^{b}	45.95^{b}	132.00^{b}	2.87^{b}
T3	1200.00	1310.00^{b}	3700.64^{b}	46.78^{b}	132.14^{b}	2.82^{b}
T4	1211.00	1399.00^{a}	3800.04^{a}	49.96^{a}	135.71^{a}	2.71^{c}
SEM	11.00	32.00	45.00	1.22	1.20	0.02
P-values	0.96	0.03	0.01	0.05	0.04	0.02

^{a,b} Means on the same row with variable superscripts are significantly different (p<0.05), T1=0 g aluminum sulfate /5kg litter (control), T2= 300 g aluminum sulfate /5kg litter, T3=400g aluminum sulfate /5kg litter T4= 600g aluminum sulfate /5 kg litter, SEM = Standard error of the mean, ADWG= Average daily weight gain, ADFI=Average daily feed intake, FCR=Feed conversion ratio.

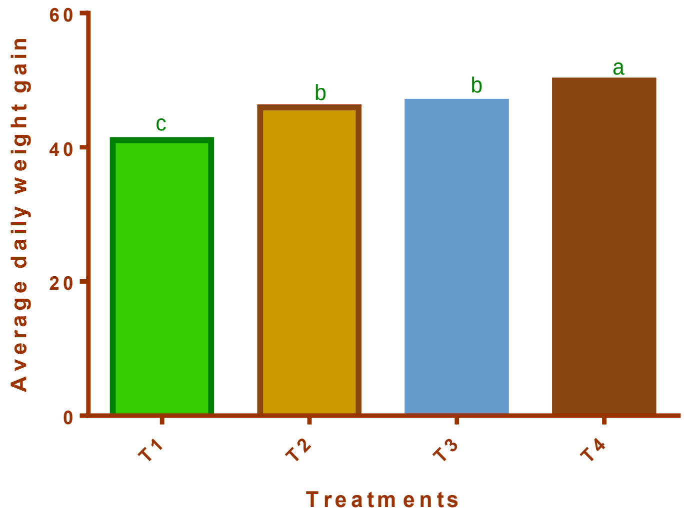

Figure 1. Average daily weight gains of broiler finisher birds reared on varying levels of alum treated litter

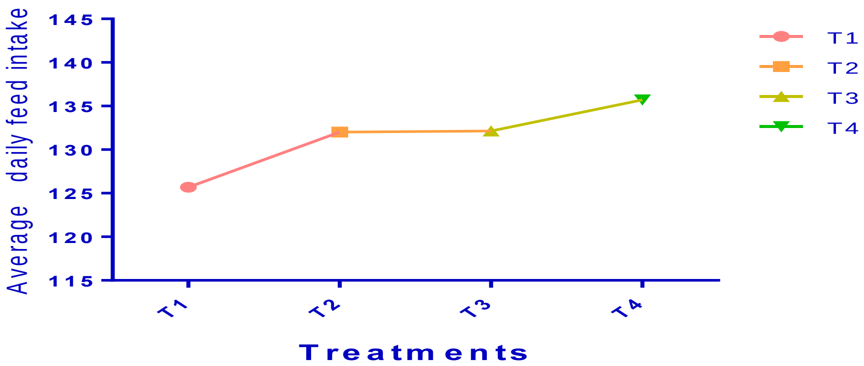

Figure 2. Average daily feed intake of broiler finisher birds reared on varying levels of alum treated litter

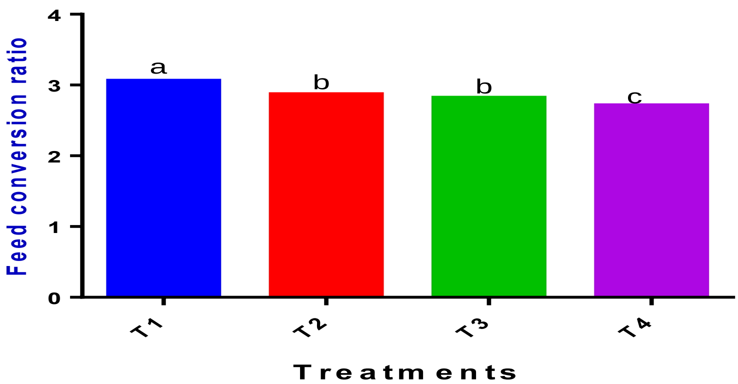

Figure 3. Feed conversion ratio of broiler finisher birds reared on varying levels of alum treated litter

Carcass Characteristics

Carcass characteristics of broiler finisher birds reared on varying levels of alum treated litter for 28 days are shown in Table 3. Values of carcass characteristics among the treatments were significant (p<0.05). Head weight values of birds on T2 and T3 were similar (p>0.05), but significantly lower than the value observed for those on T4 and lower than the values recorded in T1. Neck weights values among the treatments followed the same trend observed in head weights. Shank weight value of T1 did not differ significantly (p>0.05) from those on T2 and T3, but significantly lower than the value recorded in T4. Wing and drumstick weights followed the same trend observed in shank weights among the treatments. Thigh weight values of birds on T1 and T2 were similar (p>0.05), but significantly lower than the values obtained for those on T3 and T4.

Table 3. Results of carcass characteristics of broiler finishers birds reared on varying levels of alum treated litter for 28 day

Parameters	Head weight (g/)	Neck weight (g/)	Shank weight (g)	Wing weight (g)	Thigh weight (g)	Drumstick weight (g)
T1	51.20^{c}	39.78^{c}	78.63^{b}	148.73^{b}	224.15^{c}	137.85^{b}
T2	55.30^{b}	40.70^{b}	79.95^{b}	150.15^{b}	223.2^{c}	140.73^{b}
T3	57.50^{b}	43.68^{b}	82.95^{b}	154.35^{b}	245.75^{b}	143.10^{b}
T4	62.70^{a}	53.78^{a}	89.63^{a}	199.23^{a}	261.25^{a}	155.63^{a}
SEM	1.91	2.93	2.21	4.93	6.96	3.24
P-values	0.01	0.03	0.01	0.05	0.02	0.05

^{a,b,c} Means on the same row with different superscript are significantly different (p<0.05), T1=0g aluminum sulfate /5kg litter (control), T2= 200g aluminum sulfate /5kg litter, T3=300g aluminum sulfate /5kg litter T4= 600g aluminum sulfate /5 kg litter, SEM = Standard Error of Mean.

Organ Weights

Organ weights of broiler finisher birds reared on varying level of alum treated litter for 28 days are shown in Table 4. Values of the entire organ weights determined were significant (p<0.05). Values of kidney and crop weights of T2 and T3 were similar (p>0.05). but significantly lower than the values observed for birds on T4 and higher than the values recorded in T1. Heart weight value of T4 was the highest among the treatments followed T3, T2 and T1. Gizzard weights values of T1, T2 and T3 were the same (p>0.05), but significantly lower than the value of 55.23 recorded in T4. Liver weight values of T3 did not differ from those on T4, but significantly higher than the values observed for those on T2 and T1 respectively.

Table 4. Results of organ weights of broiler finishers birds reared on varying levels of alum treated litter for 28 days

Parameters	Kidney weight (g/)	Heart weight (g/)	Liver weight (g)	Crop weight (g)	Gizzard weight (g)
T1	1.66^{c}	10.07^{d}	32.93^{b}	6.03^{c}	50.58^{b}
T2	2.10^{b}	12.43^{c}	35.38^{b}	9.10^{b}	50.59^{b}
T3	2.20^{b}	13.87^{b}	40.26^{a}	9.05^{b}	51.58^{b}
T4	2.95^{a}	15.25^{a}	44.58^{a}	11.43^{a}	55.23^{a}
SEM	0.13	0.35	2.03	0.42	1.19
P-values	0.02	0.01	0.05	0.03	0.02

abc Means on the same row with different superscript are significantly different (p<0.05), T1=0g aluminum sulfate /5kg litter (control), T2= 200g aluminum sulfate /5kg litter, T3=300g aluminum sulfate /5kg litter T4= 600g aluminum sulfate /5 kg litter, SEM = Standard Error of Mean

Hematology

The effect of alum treated litter on hematological parameters of broiler finisher birds are shown in Table 5. Only the white blood cell values were significant among the treatments (p<0.05) with the values being higher in birds on control treatments when compared to the treatment groups.

Table 5. Results of hematology of broiler finishers birds reared on varying levels of alum treated litter for 28 days

Parameters	PCV (%/)	WBC (× 10^{6} μl)	RBC (× 10^{6} μl)	MCV (fL)	MCH (%)	MCHC (%)	Hb (g/dl)
T1	27.34	7.98^{a}	3.10	76.30	2.55	8.69	8.55
T2	27.10	6.15^{b}	3.60	76.9O	2.50	8.80	9.13
T3	28.20	5.96^{b}	3.70	83.75	2.72	8.87	9.21
T4	28.45	5.78^{b}	3.85	81.40	3.05	9.10	9.54
SEM	0.87	0.52	0.40	4.16	0.54	0.28	0.51
P-values	0.45	0.03	0.21	0.32	0.61	0.11	0.26

ab Means on the same row with different superscript are significantly different (P<0.05), PCV=Packed cell volume, WBC=White blood cell, RBC=Red blood cell, MCV=Mean corpuscular volume, MCH=Mean corpuscular hemoglobin, MCHC=Mean corpuscular hemoglobin concentration T1=0g aluminum sulfate /5kg litter (control), T2= 200g aluminum sulfate /5kg litter, T3=300g aluminum sulfate /5kg litter T4= 600g aluminum sulfate /kg litter, SEM = Standard Error of Mean

Histology of Liver

The results of the histology of the liver of broiler finisher birds reared on varying levels of alum treated litter are presented on Table 6. The values of histology liver indices were not significant (p>0.05).

Table 6. Histology of liver of broiler finishers birds reared on varying levels of alum treated litter for 28 days

Parameters	T1	T2	T3	T4	SEM	P-values
The mean diameter of the hepatocytes (μm)	46.20	44.52	45.36	47.40	0.85	0.55
The mean diameter of central vein of the liver (μm)	73.13	75.20	73.28	70.14	2.09	0.89
The mean thickness of tunica mucosa of the gall bladder (μm)	56.50	53.80	50.13	54.54	2.65	0.21
The mean thickness of tunica muscularis of the gall bladder (μm)	48.35	43.22	45.48	40.90	4.87	0.53

T1=0 g aluminum sulfate /5kg litter (control), T2= 200 g aluminum sulfate /5kg litter, T3=300 g aluminum sulfate /5kg litter T4= 600 g aluminum sulfate /5 kg litter, SEM = Standard Error of Mean

DISCUSSION

Table 3 and Figure 1-3 show the results of the growth performance of broilers reared on varying levels of alum treated litter. Weight gain, feed intake, final body weight, feed conversion ratio, carcass and organ characteristics and hematological indices all considerably improved ($p<0.05$) in favor of the treatment's groups. As the amount of alum in the litter increased, these weight gain and feed intake increased ($p<0.05$). In the current study, the improvements in FCR and body weight of broilers reared on alum treated litter were also found by other researchers (Sahoo et al., 2015; Rashid et al., 2017). Moore et al. (2000) observed that adding alum to chicken litter resulted in enhanced weight gain and feed conversion ratio compared to control group. Also, previous investigations on the effect of litter treatment with alum on birds showed that it improved weight gain and feed conversion (Guo and Song, 2009). The better ability to utilize feed due to the provision of better conditions in terms of reduced ammonia concentration as a result of litter treatment with aluminum sulfate may be responsible for the improved weight gain and FCR in favor of the treatment groups. When used as a top dressing for fresh litter (wood shaving), alum significantly reduced indoor ammonia concentrations when compared to non-treated groups, according to research by Madrid et al. (2012) and Do et al. (2005) for a multi-flock litter.

Though % ammonia litter production was not determined in the present study, however, it could have been the reason responsible for the improved weight gain, final body weight, feed intake and feed conversion ratio recorded in favor of the treatment groups. Reduced litter ammonia production promotes improved performance in poultry, while high levels of ammonia in poultry houses can negatively impact growth rate, feed efficiency, and egg output (Tasistro et al. 2007). Moore et al. (2000), who observed 4% higher body weight and 3% greater feed conversion in the alum-treated litter compared to the control litter due to decreased ammonia levels in the early growth stage, provide evidence to support this claim. Research indicates that increased ammonia generation is harmful to body weight gain in birds and feed consumption (Wheeler et al. 2004; Wang et al., 2014; Ezenwosu et al., 2022). Ammonia can restrict the movement of birds, thus, reducing feed intake and weight gain. According to Ezenwosu et al. (2022) and Sarica et al. (1996) a substantial increase in the live weight growth of the birds raised on the treated litter was observed. Ammonia's ability to act as a good oxidative stressor may be the cause of the birds raised in control treatment's having lower weight gain and high feed conversion ratio when compared to the treatment groups. Farm animals' feed intake and weight gain are impacted by stress. Feed intake typically decreases when an animal is under stress. This claim is supported by Aziz and Barnes' (2009) research on an increase in malonaldehyde (a biomarker used to assess stress in farm animals) levels in the blood of broilers raised in environments with high ammonia gas production. It's possible that control birds experienced more stress than other birds raised on litter that had been treated with alum. The inflammatory effect of ammonia in birds' gastrointestinal tracts may also be responsible for how ammonia negatively affects weight gain in birds as seen in control birds. The feed conversion ratio suffers as a result of decreased nutrient digestibility and absorption caused by inflammation of the small intestine. The low body weight gains and poor feed conversion ratio noted in control birds were consistent with Miles et al. (2004) findings regarding broilers raised in environments with high ammonia production. Li et al. (2014) also observed that broilers raised in environments with high ammonia production experienced a decrease in average daily weight gain and average daily feed intake.

The carcass characteristics of broiler finisher birds reared on varying levels of alum treated litter for 28 days are shown in Table 3. The treatment groups had better carcass indices compared to the control group. Better carcass traits observed in birds on litter treated with alum may be linked to their improved growth performnace compared to control group.In other word, the higher the growth performnace, the better the carcass traits. The results agrees with the earlier research observations that birds raised in acidified litter had significantly improved carcass traits. Birds on control group may have faced immune challenges (Chinrasri and Aengwanich, 2007) and can be used to explain why the had lower carcass traits compared to treated group.

The organ weight of broiler finisher birds reared on varying levels of alum treated litter for 28 days is shown in Table 4. However, the result of the study showed that the visceral organs weights significantly ($p<0.05$) improved in favor of the treatment groups. However, the weight of an animal is positively correlated with the weight of its body organs and treatment groups made the highest weight gains. The capacity of birds to consume and digest feed improves with normal growth of the body organs, which may account for why birds the treated groups (T2-T4) produced the highest organ weights. An effective heart will work to deliver the amount oxygen required for nutrient digestion and other bodily functions. Improved gut motility potentially increases cholecystokinin release, which in turn stimulates the release of pancreatic enzymes, which are caused by a large and well-developed gizzard (Rui et al., 2020). Increased feed storage for digestion is encouraged by well-developed crops. The reduction in the microbial population in the upper parts of the gut could help to explain in part the decreased gizzard weight observed in control and T2-T3 birds (Dehghani-Tafti and Jahanian, 2016).

Table 5 shows the results of the effect of alum litter on the hematology of broiler birds. There is a paucity of information on the effect of alum treated litter on the hematology of broiler birds, However, in hematological results, it was only the white blood cell counts were significant ($p<0.05$) with the highest value recorded in birds on control treatment. Farm animals with high white blood cells value indicate increase in pathogenic infestation. This means that birds on control treatment may have had an increased pathogenic confrontations that led to significant increase in their white blood cell production in a bid to defend themselves. White blood cells defend the body against invasion by foreign organisms. Reduced white blood cell count in the treatment group could be traceable to the litter treatment with alum which reduced pathogenic infestation from the litter during the production cycle. Application of litter amendments inside poultry houses can reduce litter microbial load (De Toledo et al., 2020).

The results of the histology of the liver of broiler finisher birds reared on varying levels of alum-mended litter are presented in Table 6. The values of histology liver indices were not significant ($p>0.05$).

CONCLUSION

Litter treaytment with alum improved growth performance, carcass characteristics, organ weights and hematological indices of broiler birds. Therefore, litter treatment with alum at 600g/5kg litter is recommended for use by broiler producers.

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Conflict of Interest

The authors declare no competing interest.

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Authors Contribution

The authors contributed equally to the article.

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