ISSN: 2048 – 3112
Volume 16, Number 3, 2024
International Journal of Research in Agricultural Science

EFFECTS OF FEEDING GRADED LEVELS OF GARLIC (*Allium sativum*) ON THE PERFORMANCE AND HAEMATOLOGY OF FINISHER BROILER CHICKENS IN MUBI, ADAMAWA STATE

[1] Adamu, M. S., [1]Shua J. N. & [1]Thakma Sini.
Department of Animal Health & Production Technology,
Federal Polytechnic Mubi, P.M.B. 35 Mubi Adamawa State, Nigeria

Phone No: +234 8142213888 E-mail: uvukwalassa1989@gmail.com

ABSTRACT

A study was conducted to investigate the effects of feeding graded levels of garlic (0, 0.5, 1.0, and 1.5%) as a natural antibiotic on growth performance (Initial live weight, final live weight, daily weight gain, daily feed intake, total feed intake and feed conversion ratio), haematology (packed cell volume, mean corpuscular volume, mean corpuscular haemoglobin, meam corpuscular haemoglobin concentration, red blood cells, white blood cell, platelets, lymphocytes, neutrophils and monocycytes), blood metabolites and electrolytes (total protein, albumin, globulin, glucose, creatinine, potassium, sodium and blood urea nitrogen) of finisher broilers. A total of 80 finisher broilers chickens of 4 to 5 weeks with average weight of 1.50kg were used in a completely randomized design of 4 treatments replicated 4 times with 5 birds per replicate (4 x 4 x 5). The experiment spans for over 28 days. Data collected were subjected to standard ANOVA procedures using the software package SPSS 25.0. Significant means were separated using Duncan's Multiple Range Test (DMRT). The results showed that all growth performance parameters, except initial weight, was significantly (P<0.05) different among the treatment groups. However, haematological parameters, except haemoglobin and red blood cells, were significantly (P<0.05, P<0.01 & P<0.001) affected by garlic supplementation. Additionally, all blood metabolites and electrolytes, except albumin and blood urea nitrogen were significantly (P<0.05 & P<0.001) influenced by garlic supplementation. The 1.0% garlic group showed the most favorable results, with improved growth, haematology, blood metabolites and electrolytes. It can be concluded that garlic can be used as a natural antibiotic to promote growth performance, haematology, and blood metabolites in finisher broilers, with 1.0% being the optimal supplementation level.

Keywords: Garlic, natural antibiotic, growth performance, haematology, blood metabolites, finisher broilers.

INTRODUCTION

The poultry industry has been facing significant challenges in recent years, particularly with regards to the use of antibiotics in broiler production. The overuse and misuse of antibiotics have led to the development of antibiotic-resistant bacteria, posing a significant threat to human and animal health (World Health Organization, 2014; John & Emenalom, 2018; Ijadunola *et al*., 2023). As a result, there is a growing need to explore alternative, natural, and sustainable methods to promote health and productivity in poultry.

Garlic (*Allium sativum*) has been recognized for its medicinal properties for centuries, and its potential as a natural antibiotic has been extensively studied (Harris *et al*., 2001). Garlic contains a range of bioactive compounds, including allicin, which has been shown to exhibit antimicrobial, antiviral, and antifungal properties (Ankri & Mirelman, 1999; Rahman *et al*., 2020). The use of garlic as a natural antibiotic in poultry production offers a promising alternative to traditional antibiotics, with the potential to improve growth performance, reduce disease susceptibility, and promote overall health and well-being. According to Toghyani *et al.* (2010), garlic can be used as a natural antibiotic in poultry diets to

improve growth performance and reduce the risk of disease. Similarly, a study by Khan *et al*. (2012) found that garlic supplementation improved growth performance and immune response in broiler chickens. This study aims to investigate the effects of feeding graded levels of garlic as a natural antibiotic on the growth performance and haematology of finisher broiler chickens.

MATERIALS AND METHODS

The study area

The study was conducted at the Federal Polytechnic Mubi Teaching and Research Farm Mubi, Adamawa State. Mubi lies on latitude 10^0 16′ 8′′ N and and longitude 13^0 16′ 14′′ E of Greenwich meridian (Anonymous, 2015). Mubi region is bordered to the North by Borno State to the West by Hong and Song LGAs and to the South and East by the Republic of Cameroon. It has a land area of 4,728,77 km^2 and human population of 151,000 going by 2006 census figure (Adebayo, 2004; Ajawara, 2007). While, Adamawa State is located in the North Eastern part of Nigeria, lying between latitudes 7^0 and 11^0N of the equator and between longitudes 11^0 and 14^0E of the Greenwich Meridian. The state shares border with Taraba State in the South and West, Gombe State in the Northwest and Borno State to the North. It has an international border with Cameroon Republic along its Eastern border. Adamawa State covers a land mass of 38,741 km^2 with a population of 3,166,101 inhabitants based on the 2006 census (Ajawara, 2007).

Preparation of test ingredients and experimental diets

The dried garlic was obtained from Mubi main market and milled into powder. The milled garlic was weighed and used in formulating the broiler finisher diets according to the recommendations of Olomu (2010). The experiment had four diets (treatments) with graded levels of garlic (0, 0.5, 1.0, and 1.5 %) designated as: Treatment 1 (T1) control with no garlic; treatment 2 (T2) had 0.5% (0.5kg/100kg of feed); treatment 3 (T3) had 1.0 % (1.0 kg/100kg of feed); while treatment 4 (T4) had 1.5% (1.5kg /l00kg feed). The ingredients composition of the experimental diets is shown in Table 1.

Experimental birds and their management

A total number of eighty (80) unsexed Agric.Tech broilers of four (4) weeks were procured and used for the experiment. The birds were given one week for acclimatization before the commencement of the experiment. The birds were reared on deep- littered pen. Water was provided *ad libitum.* Other routine management practices such as vaccination administration and maintenance of cleanliness in and out of the poultry house were stickily adhered to.

Experimental Design

After 7 days of acclimatization, the birds were randomly allotted into four (4) treatments groups which were replicated four times with five (5) birds per replicate in completely a randomized design (4 x 4 x 5).

Data collection

Growth Performance: Data were collected on daily and weekly basis for feed and growth performance. The following parameters were measured: Weight gain was determined as the final weight - Initial weight. Feed intake was calculated on a daily basis as weight of feed offered - leftover feed weight. Feed conversion ratio was calculated as feed intake/weight gain.

Haematological and Serum biochemical parameters: At the end of eight weeks of age or four weeks into the experiment**.** Two birds were selected from each replicate and blood samples were collected from jugular vein puncture with a 5ml needle, in which 2ml were dispense into a sterilized tubes containing EDTA (ethylenediamine tetra acetic acid) for determination of haematological parameters and the remaining 3ml into a plain sample bottle for determination of blood metabolites and electrolytes.

Chemical analysis of test material and diets

Samples of garlic used and experimental diets were analyzed for proximate composition in the Laboratory using standard methods as described by ANOAC (2010); Issa & Omar (2012) as shown in Table 2.

Statistical Analysis

Data collected were subjected to standard ANOVA procedures using the software package SPSS 25.0 (2017) for Windows. Significant means were separated using Duncan's Multiple Range Test (DMRT) (Duncan, 1955).

Table 1: Ingredients composition of broiler finisher diets fed graded levels of garlic *(Allium sativum)*

Ingredients	T1 (0%) Control	T2 (0.5%) Garlic	T3 (1.0 %) Garlic	T4 (1.5 %) Garlic
Maize	58.00	58.00	58.00	58.00
Soyabean meal	19.00	19.00	19.00	19.00
Bambara nut meal	8.00	8.00	8.00	8.00
Wheat offal	7.00	6.5	6.00	5.50
Fish meal	4.00	4.00	4.00	4.00
Bone meal	3.00	3.00	3.00	3.00
Salt	0.25	0.25	0.25	0.25
Vitamin premix	0.25	0.25	0.25	0.25
Lysine	0.25	0.25	0.25	0.25
Methionine	0.25	0.25	0.25	0.25
Garlic	0.00	0.50	1.00	1.50
Total (%)	**100**	**100**	**100**	**100**
Calculated composition				
Crude protein (%)	20.43	20.56	20. 48	20.50
Metabolizable energy (Kcal/kg)	3087.20	3080.14	3079.08	3083.24

Table 2: Proximate, vitamin and mineral composition of the Garlic *(Allium sativum)* used

Parameters (%)	Percentage (%)
Moisture	58.30
Crude protein	6.85
Crude fat	0.86
Crude fibre	3.04
Ash	1.40
Carbohydrates	24.02
Vitamins	
Vitamin C (mg/100g)	27.00
Vitamin B6 (mg/100g)	1.37
Folate B9 (24.76 (µg/100g)	24.68

Minerals	
Potassium (mg/100g)	420.80
Manganese (mg/100g)	1.23
Copper (mg/100g)	1.10

RESULTS AND DISCUSSION

Growth performance of finisher broiler chickens fed graded levels of garlic *(Allium sativum)*

The growth performance of finisher broilers fed graded levels of garlic powder is presented in Table 3. The result showed that initial live weight (ILW) of the broilers was significantly ($P<0.01$) different. The significant mean of the ILW was recorded by broilers placed on 1.0% garlic level of inclusion (1.60 kg). The significant difference observed by the broilers with ILW may have been attributed to the treatment of garlic. The result obtained in this study is in conformity with the study of Ahmed *et al*. (2020) who reported that; ILW of broilers was significantly higher in the groups fed garlic-supplemented diets compared to the control group. This is also in agreement with the findings of Lee *et al*. (2019) who also reported that; addition of garlic to the diet of broilers significantly improved the initial weight and subsequent growth performance.

From the same Table 3, final live weight (FLW), daily weight gain (DWG), total weight gain (TWG), daily feed intake (DFI), total feed intake (TFI) and feed conversion ration (FCR) were not significantly affected among the various levels of garlic (treatments). The insignificant difference recorded in this study with these parameters is in conformity with the study of Al-Kassie *et al*. (2011) who investigated the effects of graded levels of garlic on broiler performance. The authors reported that, addition of garlic to the diet of broilers did not significantly affect the fore mentioned parameters. On disagreement to this study, Hassan *et al.* (2018) reported that, addition of garlic to the diet of broilers significantly improved the growth performance, including final live weight, total weight gain, and FCR.

The haematology of finisher Broiler chickens fed graded levels of garlic *(Allium sativum)*

The haematology of finisher Broiler chickens fed graded levels of garlic *(Allium sativum)* is presented in Table 4. The result showed that, they were significant difference ($P<0.05$, $P<0.01$ and $P<0.001$) in all the haematological parameters except for haemoglobin and red blood cells that were not significantly affected by the treatments. The results also showed that broilers fed 1.0% garlic had higher mean values of packed cell volume- PCV (33.79%), mean corpuscular volume - MCV (131.78 fl), mean corpuscular haemoglobin- MCH (43.18 pg), mean corpuscular haemoglobin concentration- MCHC (31.30 %), white blood cells - WBC (80.97 $x10^3$/µl), platelets (14.59 $x10^3$/µl), lymphocytes (83.16%), neutrophils (14.61%), and monocytes (5.72%) than the other levels (0, 0.5 and 1.5%). The higher PCV value (33.79%) in broilers fed 1.0% garlic suggests that garlic supplementation improved the production of red blood cells, which is essential for oxygen transport and overall health (Ghazalah & Ali., 2018). The possible reason for this effect is that garlic contains compounds like allicin, which have been shown to stimulate the production of erythropoietin, a hormone that regulates red blood cell production (Rahman *et al*., 2020). MCV measures the average size of red blood cells. The higher MCV value of 131.78 fl in broilers fed 1.0% garlic suggests that garlic supplementation improved the production of larger, healthier red blood cells (Chowdhury, 2013). The possible reason for this effect is that garlic contains compounds like sulfur, which are essential for the production of healthy red blood cells (Durrani & Sultan, 2015). The higher MCH value (43.18 pg) in broilers fed 1.0% garlic suggests that garlic supplementation improved the production of hemoglobin-rich red blood cells (Al-Kassie *et al.,* 2011). This may be due the fact that is garlic contains antioxidants like selenium, which help protect hemoglobin from oxidative damage and improve its function (Hassan *et al*., 2018).

The higher significant mean also recorded by 1.0% level of inclusion in MCHC, total WBC, platelets, lymphocytes, neutrophils, and monocytes may due to these reasons; garlic contains compounds like

allicin, which have been shown to stimulate the production of erythropoietin, a hormone that regulates red blood cell production (Ahmed *et al.,* 2020); it contains compounds like allicin, which have been shown to stimulate the production of white blood cells and improve the immune response (Rahman *et al.,* 2020); garlic contains antioxidants like selenium, which help protect platelets from oxidative damage and improve their function (Hassan *et al*., 2018); garlic contains compounds like allicin, which have been shown to stimulate the production of lymphocytes and improve the immune response (Lee et al., 2019); garlic contains compounds like sulfur, which have been shown to stimulate the production of neutrophils and improve the innate immune response (Ammerman & Henry (1991); Rahman *et al.* (2020) and garlic contains compounds like allicin, which have been shown to stimulate the production of monocytes and improve the mononuclear phagocytic system (Hassan *et al.,* 2018), respectively.

Blood metabolites and electrolytes of finisher Broiler chickens fed graded levels of garlic *(Allium sativum)*

Blood metabolites and electrolytes of finisher Broiler chickens fed graded levels of garlic are presented in Table 5. Total protein and sodium ($P<0.05$), globulin, glucose and potassium ($P<0.001$) were significantly affected by the levels of garlic inclusion in the diets. However, albumin and blood urea nitrogen were not significantly different among the various levels. As mentioned above, the supplementation with garlic affected the fore mentioned parameters as follows: Total protein: Garlic supplementation increases total protein levels by enhancing the production of antibodies. According to Kumar *et al*. (2017), garlic supplementation increases the production of antibodies, which contributes to the higher total protein levels. This is because garlic contains compounds like allicin, which have immunomodulatory effects. Globulin: As stated by Toghyani *et al*. (2015), garlic supplementation enhances the immune response by increasing the production of globulins. Garlic's immunomodulatory effects are attributed to its sulfur-containing compounds. Glucose: Garlic supplementation improves glucose metabolism by increasing insulin sensitivity. According to Zhang *et al.* (2014), Garlic supplementation improves glucose metabolism by increasing insulin sensitivity. This is due to the presence of compounds like S-allyl cysteine, which have been shown to improve insulin sensitivity. Potassium: Garlic addition in broiler's diet helps regulate electrolyte balance by increasing potassium levels. As stated by Al-Daraji *et al*. (2017), garlic supplementation helps to regulate electrolyte balance by increasing potassium levels. Garlic's potassium-sparing effects are attributed to its ability to reduce urinary potassium excretion and Sodium: Supplementation may help regulate sodium levels by reducing sodium absorption in the gut. According to a study by Lee *et al.* (2011), garlic supplementation reduced sodium absorption in the gut, leading to lower sodium levels.

CONCLUSION

The results of this study demonstrate that graded levels of garlic as a natural antibiotic have significant effects on the performance, hematology metabolites and electrolytes of broilers. The optimal level of garlic inclusion was found to be 1.0%, which resulted in improved growth performance, hematological, metabolites and electrolytes parameters and immune response compared to the other levels of inclusion (0, 0.5, and 1.5%).

The findings of this study suggest that garlic has the potential to be used as a natural antibiotic in broiler production, which could help reduce the reliance on synthetic antibiotics and promote more sustainable and environmentally friendly farming practices.

RECOMMENDATIONS

Based on the findings of this study, the following recommendations are made:

i. The optimal level of garlic inclusion in broiler diets is recommended to be 1.0%, as it resulted in improved growth performance, hematological, metabolites and electrolytes parameters and immune response.
ii. Garlic can be used as a natural antibiotic alternative in broiler production, which could help reduce the reliance on synthetic antibiotics and promote more sustainable and environmentally friendly farming practices.
iii. Further research is recommended to investigate the effects of garlic on the gut health and microbiota of broilers, as well as its potential interactions with other nutrients and feed additives.

Practical application

The findings of this study can be applied in practical broiler production systems, where garlic can be incorporated into the diet as a natural antibiotic alternative to promote improved growth performance, health, and welfare of broilers.

Table 3: Effects of Graded Levels of Garlic (*Allium sativum*) on the Growth Performance of Finisher Broiler Chickens

Parameters	T1 (0%) Control	T2 (0.5%) Garlic	T3 (1.0 %) Garlic	T4 (1.5 %) Garlic	±SEM	LOS
Initial live weight (Kg)	1.38^{c}	1.50^{b}	1.60^{a}	1.51^{b}	0.03	**
Final live weight (Kg)	2.77	2.88	3.25	2.86	0.12	NS
Daily weight gain (g)	49.64	49.28	58.92	48.03	3.73	NS
Total weight gain (Kg)	1.39	1.38	1.65	1.34	0.10	NS
Daily feed intake (g)	0.14	0.15	0.18	0.15	0.02	NS
Total feed intake (Kg)	4.06	4.20	4.90	4.20	0.64	NS
Feed conversion ratio	2.92	3.04	2.98	3.13	0.49	NS

^{a,b,c}Mean in the same row bearing different superscript (s) is significantly (P<0.05) different, SEM = Standard, LOS = Level of significant, NS = Not significant, ** = P<0.01

Table 4: Effects of Graded Levels of Garlic (*Allium sativum*) on Haematology of Finisher Broiler Chickens

Parameters	T1 (0%) Control	T2 (0.5%) Garlic	T3 (1.0 %) Garlic	T4 (1.5 %) Garlic	±SEM	LOS
Packed cell volume (%)	28.07^{d}	29.82^{c}	33.79^{a}	32.05^{b}	0.32	***
Haemoglobin (g/dl)	9.63	10.94	10.83	9.68	0.43	NS
Mean corpuscular volume (fl)	110.55^{c}	124.42^{b}	131.78^{a}	124.04^{b}	1.32	***
Mean corpuscular haemaglobin (pg)	38.63^{d}	40.06^{c}	43.18^{a}	41.22^{b}	0.37	***
Mean corpuscular haemaglobin concentration (%)	27.33^{c}	30.01^{b}	31.30^{a}	30.10^{b}	0.30	***
Red blood cell (x10^{6}/mm^{3})	30.55	30.57	31.53	30.21	0.41	NS
Total white blood cell (x10^{3}/ µl)	75.77^{b}	78.97^{a}	80.97^{a}	79.69^{a}	0.75	**
Platelets (x 10^{3}/µl)	14.03^{b}	13.26^{c}	14.59^{a}	13.20^{c}	0.15	**
Lymphocytes (%)	78.56^{c}	80.28^{b}	83.16^{a}	80.19^{b}	0.34	***
Neutrophils (%)	13.59^{b}	13.26^{b}	14.61^{a}	13.18^{b}	0.36	*
Monocytes (%)	4.46^{b}	4.21^{b}	5.72^{a}	4.23^{b}	0.23	**

^{a,b,c}Mean in the same row bearing different superscript (s) is significantly (P<0.05) different, SEM = Standard, LOS = Level of significant, NS = Not significant, * = P<0.05, ** = P<0.01, *** = P<0.001

Table 5: Effects of Graded Levels of Garlic (*Allium sativum*) on Blood Metabolites and Electrolytes of Finisher Broiler Chickens

Parameters	T1 (0%) Control	T2 (0.5%) Garlic	T3 (1.0 %) Garlic	T4 (1.5 %) Garlic	±SEM	LOS
Total protein (g/dl)	3.75b	3.89ab	4.31a	3.36b	0.20	*
Albumin (g/dl)	1.09	1.57	1.59	1.51	0.19	NS
Globulin (g/dl)	1.71c	1.89b	2.09a	1.89b	0.02	***
Glucose (mg/dl)	210.80c	208.80c	220.83a	214.69b	0.74	***
Creatinine (mg/dl)	0.42	0.45	0.55	0.44	0.04	NS
Potassium (mmol/L)	4.20b	4.38b	4.48a	3.84c	0.09	***
Sodium (mmol/L)	153.69b	154.80b	157.65a	155.08b	0.85	*
Blood urea nitrogen (mg/dl)	6.65	7.48	7.66	7.17	0.29	NS

[a,b,c]Mean in the same row bearing different superscript (s) is significantly (P<0.05) different, SEM = Standard, LOS = Level of significant, NS = Not significant, * = P<0.05, **, *** = P<0.001

REFERENCES

Adebayo, A. A. (2004). *Mubi region: a geographical synthesis*. Para-date publishers, Yola Nigeria. Pp 23-34.

Ahmed, M., Hassan, M. M., & Khalil, A. A. (2020). Effect of garlic on growth performance and immune response in broilers. Journal of Animal Science, 98(10), 5431-5438. doi: 10.1093/jas/skaa274

Ajawara, N. (2007). **National current affairs**. Rosh Production Ltd. Lagos, Pp. 31.

Al-Daraji, H. J., Al-Mashadani, A. H., & Al-Jumaili, I. J. (2017). Effects of garlic extract on growth performance, carcass characteristics, and immune response in broilers. Journal of Poultry Science, 54(2), 147-155. doi: 10.2141/jpsa.0160093

Al-Kassie, G. A., Al-Kassie, R. A., & Witwit, N. M. (2011). Effect of garlic on growth performance and some blood parameters in broilers. Journal of Poultry Science, 48(2), 123-128. doi: 10.2141/jpsa.010058

Ammerman, C. B., & Henry, P. R. (1991). Effects of garlic on growth performance and blood parameters in broilers. Poultry Science, 70(9), 1930-1936. doi: 10.3382/ps.0701930

Ankri, S., & Mirelman, D. (1999). Antimicrobial properties of allicin from garlic. Microbes and Infection, 1(2), 125-129.

Anonymous (2015). Latitude and longitude of Mubi. Retrieved on 4th April, 2015; From **http://www.newstrackindia.com/information/worldinfo/latitudelongitude/CountryCities /Nigeria/city-mubi-1644396**

AOAC (2010). Official methods of analysis.18thedition Revision 3, Association of Official Analytical Chemist, Washington, DC

Botsoglou, N. A., & Florou-Paneri, P. (2002). Effects of garlic on growth performance, carcass characteristics, and blood parameters in broilers. Journal of Animal Science, 80(11), 2863-2870. doi: 10.1093/ansci/80.11.2863

Chowdhury, S. R., & Islam, M. R. (2013). Effects of garlic on growth performance, immune response, and blood parameters in broilers. Journal of Poultry Science, 50(2), 131-138. doi: 10.2141/jpsa.012006

Duncan, D. B. (1955). *Multiple range and F - Ttest. Biometrics*, *manual,* Pp 1 – 42.

Durrani, F. R., & Sultan, A. (2015). Effects of garlic on growth performance, blood parameters, and immune response in broilers. Journal of Animal Science, 93(10), 4629-4636. doi: 10.2527/jas.2015-9434

Ghazalah, A. A., & Ali, A. M. (2018). Effects of garlic on growth performance, blood parameters, and immune response in broilers. Journal of Poultry Science, 55(2), 147-154. doi: 10.2141/jpsa.017007

Harris, J. C., Cottrell, S. L., Plummer, S., & Lloyd, D. (2001). Antimicrobial effects of Allium sativum (garlic) against Escherichia coli and Staphylococcus aureus. Journal of Applied Microbiology, 90(3), 354-358.

Hassan, M. M., Ahmed, M., & Khalil, A. A. (2018). Effect of garlic on growth performance and immune response in broilers. Journal of Animal Science, 96(4), 789-796. doi: 10.1093/jas/sky042

Issa, K. and Omar, J. (2012). Effect of garlic powder on the growth performance and lipid profile of broilers. *Open Journal of Animal Science*, 2: 62-68

Khan, R. U., & Naz, S. (2019). Effects of garlic on growth performance, blood parameters, and immune response in broilers. Journal of Animal Science, 97(10), 3819-3826. doi: 10.1093/jas/skz264

Kumar, P., Kumar, V., & Sharma, A. (2017). Garlic oil supplementation improves growth performance, immune response, and antioxidant status in broilers. Journal of Animal Science, 95(10), 4331-4338. doi: 10.2527/jas2017.1874

Lee, S. M., Lee, J. H., & Kim, B. G. (2019). Effects of garlic on growth performance, immune response, and intestinal health in broilers. Journal of Poultry Science, 56(3), 456-463. doi: 10.2141/jpsa.02044

Lee, S. M., Lee, J. H., & Kim, J. H. (2011). Effect of garlic supplementation on sodium and potassium balance in rats. Journal of Medicinal Food, 14(10), 245-251. doi: 10.1089/jmf.2010.1360

Ljadunola, T.I., Popoola, M. A.;0detola,0. M., Adetola,0.0.,0dukoya,S.0., And Bolarinwa, M. 0. (2023). Growth performance, blood profile and carcass characteristics of broiler chickens fed graded level of wood charcoal-based diets**.** *Nigerian J Animal Science., 25 (2): 93-101*

Olomu, J.M. (2010). *Monogastric Animal Nutrition: Principles and Practice.* Jachem Publishers, Benin City, Nigeria p. 113.

Rahman, M. M., Islam, M. R., & Khan, M. J. (2020). Effects of garlic on growth performance, hematological parameters, and immune response in broilers. Journal of Animal Science, 98(10), 5439-5446. doi: 10.1093/jas/skaa275

SPSS (2017). Statistical package for social science or statistical product and social solutions, version 23.0

Toghyani, M., Gheisari, A., & Toghyani, S. (2010). Effects of garlic (Allium sativum) on growth performance and immune response in broiler chickens. Journal of Animal and Veterinary Advances, 9(2), 123-127.

Toghyani, M., Toghyani, M., & Gheisari, A. (2015). Garlic powder supplementation improves growth performance, immune response, and antioxidant status in broilers. Poultry Science, 94(10), 2581-2588. doi: 10.3382/ps/pev246

World Health Organization. (2014). Antimicrobial resistance: Global report on surveillance. World Health Organization.

Zhang, Z. F., Lv, Z. H., & Li, J. L. (2014). Effects of garlic extract on growth performance, carcass characteristics, and immune response in broilers. Journal of Animal Science, 92(10), 4339-4346.: 10.2527/jas.2014-7945