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Effect of dietary supplementation of ginger and garlic mixture on haematology and nutrient digestibility of broiler chickens

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Abstract

The effect of dietary supplementation of ginger and garlic mixture on haematology and nutrient digestibility of broiler chickens over a period of eight weeks were assessed in this study. One hundred and fifty one-day old ArborAcre broilers were randomly assigned on weight equalisation basis to five dietary treatment groups of thirty birds. Each group consists of three replicates comprising of ten birds per replicate. Five diets were formulated for both starter and finisher phases. Dietary treatments consist of a control diet without ginger and garlic (1:1) mixture (GGM) (T1), while diets T2, T3, T4 and T5 were control diet supplemented with GGM at 0.5, 1.0, 1.5 and 2.0%, respectively. Haematological parameters and nutrient digestibility were assessed on days 28 and 56. Data were subjected to analysis of variance while trend analysis was carried out using polynomial contrast. Haematology was not significantly affected (p>0.05) by dietary treatments at days 28 and 56 however, packed cell volume (PCV)varied linearly (P=0.04)(0, 28.67%), (0.5, 31.33%), (1.0, 31.67%), (1.5, 32.33%) at day 28. Ether extract (EE, 92.33%) and ash digestibility (93.46%) increased significantly (p<0.05) with 1.5% dietary supplementation of GGM at day 28. 2.0% GGM supplementation increased (p<0.05) crude protein (CP, 88.77%) digestibility at day 56. In conclusion, the inclusion of GGM resulted in a linear increase in PCV and improved CP digestibility.

Keywords: Broiler chickens, ginger and garlic, haematology and digestibility

Effet de la complémentation alimentaire du gingembre et du mélange d'ail sur l'hématologie et la digestibilité des nutriments des poulets à gril

Résumé

L'effet de la complémentation alimentaire du gingembre et du mélange d'ail sur l'hématologie et la digestibilité des nutriments des poulets de poulets à griller sur une période de huit semaines ont été évalués dans cette étude. Cent cinquante poulets d'arboracre d'une journée d'une journée ont été attribués au hasard sur la base de la péréquation de poids à cinq groupes de traitement diététique de trente oiseaux. Chaque groupe est composé de trois réplicats comprenant dix oiseaux par réplication. Cinq régimes ont été formulés pour les phases de démarreur et de finition. Les traitements diététiques consistent en un régime de contrôle sans mélange de gingembre et ail (MGA) (1: 1) (T1), tandis que les régimes T2, T3, T4, T3, T4 et T5 étaient un régime de contrôle complété par MGA à 0,5, 1,0, 1,5 et 2,0%, respectivement. Les paramètres hématologiques et la *digestibilité des nutriments ont été évalués les jours 28 et 56. Des données ont été soumises à une analyse de la variance, tandis que l'analyse des tendances a été réalisée à l'aide de contraste polynomial. L'hématologie n'a pas été significativement touchée (p> 0,05) par des traitements diététiques aux jours 28 et 56, cependant, le volume de cellules emballé (VCE) variait linéairement (p = 0,04) (0, 28,67%), (0,5, 31,33%), (1.0, 31,67%), (1.5, 32,33%) au Jour 28. L'extrait d'éther (EE, 92,33%) et la digestibilité des cendres (93,46%) ont considérablement augmenté (p <0,05) avec une complémentation alimentaire de 1,5% de MGA au Jour 28. 2,0% MGA La supplémentation a augmenté (p <0,05) la protéine brute (PB, 88,77%) digestibilité au jour 56. En conclusion, l'inclusion de MGA a entraîné une augmentation linéaire du VCE et une digestibilité de PB améliorée.*

Mots-clés: poulets à gril, gingembre et ail, hématologie et digestibilité

Introduction

The need for poultry meat is on the increase both locally and internationally, and to meet the increasing demand, most commercial poultry enterprise operates using an intensive system of production (Oso *et al*., 2021). The intensive system which ensures and sustains high feed efficiency of poultry, however, is highly challenged with various infections which may be devastating, and huge losses may be incurred (Carrasco *et al*., 2019). Conventionally used condiments usually called antibiotic growth promoters (AGPs) are used for combating various infections experienced in poultry production (Murugesan *et al*., 2015). Doses of these growth promoters also improved feed utilization efficiency with resultant improved growth and increased economic returns (Suresh *et al*., 2018). However, consequent harmful residual effects on consumers involving transmission of antibiotic resistant bacteria and transfer of zoonotic infections are issues of concern discouraging its use in poultry production (Durairajan *et al*., 2021; Rahmatnejad *et al*., 2009). To confront these threats, alternatives to antibiotics collectively called phytogenics are being explored which include medicinal plants and their products, plant extracts and essential oils of plants/parts of plants and plant extracts (Alloui *et al*., 2014) which are capable of positively influencing performance and immune status of birds without adverse effect on animal and final consumers (Karangiya *et al*., 2016; Borgohain *et al*., 2019). There is an increase in the use of phytogenics in recent times as feed supplements in poultry production and this has attracted much attention due to the inherent beneficial properties of the plants (Abou-Elkhair *et al*., 2014; Paraskeuas *et al*., 2017; Basit *et al*., 2020). Ginger and garlic belong to this class of phytogenic plants which are natural growth promoters that are suitable alternatives to feed antibiotics. In addition, these herbal plants are locally accessible and available in adequate quantity (Gbenga *et al*., 2009). Ginger supplementation in the diets of poultry birds has been reported to positively influence gastric secretion, small intestinal morphology and increase digestive enzyme activities (Ali *et al*. 2008; Incharoen and Yamauchi, 2009). Gingerols, gingerdiol and gingerdione as a constituent of ginger has the ability to exhibit digestive enzyme stimulation and antimicrobial activity (Dieumou *et al*., 2009). Garlic (*Allium sativum*) used all over the world as herbal remedy for the treatment of various diseases is potent because of its' constituent bioactive compounds such as diallylpolysulphide which makes it an effective antimicrobial agent (Amagese *et al*., 2001). Al-Shuwaili *et al*. (2015) also reported strong stimulating effect of garlic supplementation on immune and digestive system of birds. Garlic has been reported to affect haematological indices which influence the physiological and pathological status of poultry birds (Oleforuh-okoleh *et al*., 2015). Several studies have identified the separate use of these plants but, dearth of information exists on the synergistic effect of combining ginger and garlic. Furthermore, inconsistent results have been generated by dietary inclusion of their mixtures. Therefore, this present study was designed to evaluate the haematological indices and nutrient digestibility of broilers fed diet supplemented with varying level of ginger and garlic mixtures.

Materials and methods

Experimental site

The experiment was carried out at the Teaching and Research Farm, School of Agriculture, Lagos State University, Epe campus, Lagos State, Nigeria. The farm is located on Latitude 6°35'09.4"N and Longitude 3°59'54.7"E. It lies in the low land rain forest within the savannah agro-ecological zones with annual rainfall of 1694 mm and temperature of 27.1°C (Google Earth, 2019).

Source and preparation of test ingredients

Fresh ginger and garlic were purchased from the local market in Epe. The ginger and garlic were peeled, cut into chips and air dried. The dried ginger and garlic chips were ground into smooth powder using blender manufactured by Kenwood in 2010 and stored separately in an air-tight container. A blend of ginger and garlic was made by mixing equal quantity (w/w) of garlic and ginger to obtain phytogenic blend of ginger and garlic mixture (GGM) and stored prior to commencement of experimental trial

Experimental animals and dietary treatment

The necessary biosecurity measures were observed prior to the arrival of 150 broiler chicks purchased from Chi Farm, Ibadan. After arrival, the birds were weighed and allotted to five dietary treatments (T_1, T_2, T_3, T_4 and T_5) on weight equalization basis. A completely randomized design was used with the birds allotted to 15 pens. Each treatment has three replicates with 10 birds per replicate. Dietary treatments consist of a control diet without ginger and garlic mixture (GGM) (T1), while diets T2, T3, T4 and T5 were control diets supplemented with GGM at 0.5, 1.0, 1.5 and 2.0%, respectively. The experimental diets (Table 1) were formulated for starter (0-28days) and finisher phase (29-56 days) of the study based on nutrient requirement guide (Arbor Acre broiler management, 2014). The experiment lasted for eight weeks and all birds were raised intensively using a deep litter system with spacing of 1m^2 per bird while feed and water were supplied *ad-libitum* during the experimental period.

Data collection

Hematological indices

On days 28 and 56 of the experiment, 2.5mL blood samples was collected from the wing vein of 3 birds per replicate into vials containing ethylene diaminetetra-acetic acid (EDTA) as anticoagulant and used to determine the following: packed cell volume (PCV), red blood cell count (RBC), haemoglobin concentration (Hb), total white blood cell count (WBC) and WBC differential: heterophil, lymphocyte and Eosinophil using standard techniques (Schalm *et al*., 1975; Coles, 1986). The mean corpuscular hemoglobin (MCH)and mean corpuscular volume (MCV) were calculated according to Bush (1991).

Digestibility trial

On day 28 and 56 of the experiment, one broiler from each pen (three birds per treatment) were selected and arranged in clean, separate and disinfected metabolic cages. Three days of acclimatization was allowed before the commencement of the

Table 1: Gross composition (%) of the basal experiemental diets

Ingredients (%)	Starter (0-28 days)	Finisher (29-56 days)
Maize	50	63
Soyabean meal	19	19
Groundnut cake	15	8
Fish meal	2	1
Wheat offal	10	5
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**
Calculated nutrients		
Metabolizable energy (kcal/kg)	2970	3097
Crude protein (%)	22.88	19.13
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. A 10,000,000 (iu), Vit D3, 2,000,000 (iv), Vit. 23,000(mg), Vit.k3 2000 (mg), Vit. B1, 1800 (mg), Vit. B2 5,500 (mg), Niacin 27, 500mg, Pantothenicacid 750mg Vit B6 3,000mg, Vit B12 15mg, folicacid 750mg, Biotin H2 60mg, chlorinechloride 300,000 mg, Cobalt 200mg, Copper300mg, Iodine 1000mg, Iron 20,000mg, Manganese 40,000 (mg), Selenium 200mg, Zinc 30,000mg, Anti oxidant 1,250mg.

Finisherpremix Vit. A. 5,500,000 (iu), Vit D3. 1500,000 (iu), Vit E. 10,000 (mg), Vit.k3 1,500 (mg), Vit. B1, 1,600 (mg), Vit. B2 24,000 (mg),niacin 20,000mg, pantothenicacid 5,000mg vit B6 1,500mg, Vit. B12 10mg, folicacid 500mg, Biotin H2 750mg, chlorinechloride 175,500 mg, cobalt 200mg, copper 300mg, iodine 1,000mg, iron 20,000mg, manganese 40,000 (mg), selenium 200mg, zinc 30,000mg, anti oxidant 1,250mg.

digestibility trial. A known weight of feed that represents the average weight of daily intake was offered to birds and leftover feed was recorded and deducted from the feed supplied to determine the feed intake of the experimental animals. The excreta were collected daily for five days. The daily excreta voided for each bird was sundried and stored in polythene bags. Total collections per bird were pooled at the expiration of 5 days metabolic trial. The dried faeces was ground and sampled for proximate analysis.Proximate compositions of feed samples and dried excreta samples were determined (AOAC, 2005) for nutrient digestibility calculations.

Statistical analysis

Data from this study were analyzed using a one-way analysis of variance (ANOVA) of SAS Statistical software (SAS, 2000). Differences between mean values were separated using Tukey's Test in SAS Software and significance were based on a probability of $p<0.05$. Orthogonal polynomial contrast analysis was also done to determine the linear, quadratic and cubic response trend to different levels of GGM.

Results

Effect of phytogenic inclusion on haematological indices of broiler chickens

Table 2 shows the effect of phytogenic

Table 2:Effect of phytogenic inclusion on haematological indices of broiler chickens

	Inclusion levels of ginger and garlic composite					Pooled	P-value	Contrast		
Parameters	0	0.5	1.0	1.5	2.0	SEM		*Linear*	*Quadratic*	*Cubic*
Day 28										
Packed cell volume (%)	28.67	31.33	31.67	32.33	31.33	0.84	0.087	0.04	0.05	0.81
Red blood cell ($\times 10^{12}$/ L)	2.18	2.36	2.38	2.45	2.27	0.10	0.378	0.69	0.12	0.43
White blood cell ($\times 10^{9}$/ L)	7.37	5.57	8.83	6.33	8.47	1.61	0.589	0.57	0.79	0.85
Haemoglobin (g/dL)	9.67	10.50	10.73	10.93	10.43	0.36	0.201	0.24	0.17	1.00
Heterophil (%)	28.00	27.33	26.33	33.67	36.00	4.51	0.497	0.15	0.42	0.75
Lymphocyte (%)	68.00	68.33	69.33	62.00	59.67	4.77	0.538	0.16	0.46	0.78
Eosinophil (%)	1.00	1.00	0.67	2.00	2.33	0.42	0.076	0.02	0.02	0.02
MCV (fl)	13.12	13.40	13.34	13.21	13.78	0.25	0.445	0.19	0.56	0.50
MCH (pg)	44.40	44.87	45.28	45.11	46.37	0.71	0.426	0.09	0.80	0.38
Day 56										
Packed cell volume (%)	35.67	38.67	32.67	32.00	36.00	2.58	0.408	0.48	0.47	0.13
Red blood cell ($\times 10^{12}$/ L)	2.45	2.69	2.37	2.36	2.64	0.17	0.517	0.63	0.68	0.17
White blood cell ($\times 10^{9}$/ L)	10.17	11.60	11.33	9.40	10.83	1.57	0.855	0.85	0.87	0.31
Haemoglobin (g/dL)	12.07	13.03	10.90	10.77	12.13	0.83	0.333	0.55	0.28	0.10
Heterophil (%)	28.00	33.67	29.67	33.33	32.00	3.90	0.811	0.55	0.67	0.71
Lymphocyte (%)	68.00	62.00	66.00	62.33	64.67	4.05	0.813	0.63	0.57	0.76
Eosinophil (%)	1.33	0.33	0.67	1.67	1.33	0.33	0.092	0.24	0.14	0.03
MCV (fl)	14.55	14.41	13.74	13.55	13.63	0.46	0.439	0.23	0.73	0.68
MCH (pg)	49.23	48.63	45.83	45.63	46.03	1.67	0.426	0.12	0.40	0.66

MCV= Mean corpuscular volume
MCH= Mean corpuscular haemoglobin
SEM= standard error of mean

supplementation on the haematology of broilers at days 28 and 56. The haematological parameters were not significantly (p>0.05) affected by dietary treatment. The linear trend shows that at day 28, PCV (Linear, P=0.04) increased initially with increasing inclusion of GGM from 0.5 to 1.5% but decreased with 2.0% GGM. Eosinophil count (Linear, P=0.02; Quadratic, P= 0.02; Cubic= 0.02) was similar for broilers fed control diet and those fed diet containing 0.5% GGM but reduced with 1.0% GGM supplementation, however, increases with dietary inclusion of GGM from 1.0% to 2.0%. At day 56, eosinophil count (Cubic, P=0.03) reduced with 0.5% GGM inclusion but increased with the inclusion of 1.0 and 1.5% GGM with resultant decrease with 2.0% inclusion of GGM in broiler diet.

Effect of phytogenic supplementation of GGM on nutrient digestibility of broiler chickens

The nutrient digestibility of broiler chickens fed diet containing garlic and ginger mixture at day 28 and 56 is presented in Table 3. At day 28, Ether extract varies linearly and quadratically (Linear, p<0.01; Quadratic, p=0.04) across treatments with broilers fed diet containing 1.5% GGM having higher ether extract digestibility compared to those fed control diet and those on diet containing 0.5% GGM. Crude ash digestibility varies cubically (cubic, p<0.01). Broilers fed the control diet and those fed diet containing 1.5 and 2.0% GGM recorded increased ash digestibility while those fed diet containing 0.5% GGM had reduced crude ash digestibility. On day 56, dry matter digestibility was not significantly (p>0.05) affected while other parameters were significantly (p<0.05) affected by dietary treatments. Crude protein digestibility varies quadratically and cubically (Quadratic, p=0.01; cubic, p=0.02). Broilers fed diet containing 0.5% and those fed diet containing 2.0% GGM had increased crude protein digestibility higher than those fed diet containing 1.0% GGM. Quadratic variation (Quadratic, P<0.01) occurred for ether extract digestibility. Inclusion of 0.5% and 1.5% GGM resulted in reduced ether extract digestibility. Inclusion of 1.0% GGM in the diet of broilers increased (p<0.05) crude ash digestibility while those fed diet containing 2.0% GGM had reduced (p<0.05) crude ash digestibility. Nitrogen free extract (NFE) varies cubically (Cubic, p<0.01) across treatments. Inclusion of 0.5% GGM in broiler diet resulted in higher (p<0.05) nitrogen free extract digestibility compared to those fed diet containing 1.0% and 1.5% GGM.

Discussion

Haematology

The haematology of broiler chickens at days 28 and 56 was not significantly affected by the dietary treatment which is consistent with earlier report (Jimoh *et al*. 2012) which stated that haematological parameters were not significantly affected by garlic supplementation in broiler diets. However, there was a linear increase in PCV with GGM supplementationfrom 0.5 to 1.5% which was observed to be higher than the control. This agreed with the findings of Elagib *et al*. (2013) who reported a numerical increase in PCV counts of broilers fed garlic treated diet. The increase in PCV implies improved protein intake and tissue synthesis because a decline in PCV has been associated with protein synthesis inhibition and suppressed immune (Denli *et al*., 2009). There was linear, quadratic and cubic variation in eosinophil count with increasing eosinophil count higher than that of control from 1.0 to 2.0% GGM supplementation in broilers diet at day 28. This agrees with the report of Borgohain *et al*. (2019) who reported increase in eosinophil count with 1.0 and 1.5% inclusion of garlic powder in

Table 3:Effect of phytogenic inclusion on nutrient digestibility of broiler chickens

	Inclusion levels of ginger and garlic composite					Pooled	P-	Contrast		
Parameters (%)	0	0.5	1.0	1.5	2.0	SEM	value	*Linear*	*Quadratic*	*Cubic*
Day 28										
Dry matter	82.55	81.92	80.76	83.89	84.14	1.57	0.551	0.32	0.33	0.65
Crude protein	91.77	92.47	91.64	91.34	93.49	0.65	0.216	0.29	0.19	0.08
Ether extract	85.31^{b}	85.21^{b}	89.10^{ab}	92.33^{a}	89.81^{ab}	1.28	0.011	0.00	0.28	0.04
Crude ash	92.87^{a}	87.58^{b}	92.07^{ab}	93.46^{a}	92.62^{a}	1.00	0.013	0.12	0.15	0.00
NFE	83.23	81.56	77.93	82.90	82.61	1.70	0.243	0.98	0.10	0.55
Day 56										
Dry matter	73.40	74.31	66.60	66.78	71.65	2.09	0.069	0.13	0.07	0.07
Crude protein	87.93^{ab}	89.47^{a}	83.03^{b}	85.24^{ab}	88.77^{a}	1.06	0.008	0.46	0.01	0.02
Ether extract	87.29^{a}	75.67^{b}	78.90^{ab}	77.57^{b}	83.09^{ab}	1.85	0.008	0.29	0.00	0.20
Crude ash	89.69^{ab}	83.64^{ab}	92.43^{a}	84.37^{ab}	82.87^{b}	2.05	0.029	0.07	0.34	0.23
NFE	62.63^{ab}	72.13^{a}	58.18^{b}	54.82^{b}	61.65^{ab}	2.74	0.012	0.05	0.62	0.00

^{ab}Means on the same row with differing superscripts are significantly different (P<0.05)
NFE= Nitrogen free extract
SEM= Standard error of mean

broiler diet. At day 56, a quadratic increase in eosinophil count was also observed with 1.5% inclusion of GGM which suggests improved immune system and enhanced disease resistance. The active ingredient in ginger and garlic such as gingerol and allicin, respectively may be responsible for the proliferation of the white blood cell differential. Ginger and garlic have been reported to exhibit antimicrobial and pharmacological properties through the effects of the active ingredients (Tapsell *et al*., 2006; Ali *et al*., 2008 and Adibmoradi *et al*., 2006).

Nutrient digestibility

On day 28, Ether extract (EE) digestibility increased linearly and quadratically in broiler chickens fed 1.5 and 2.0% GGM supplemented diet. The increase in EE digestibility was associated with a phenolic compound constituent in GGM which influences digestion through endogenous enzyme stimulation in the gastrointestinal tract (Wafaa *et al*., 2012). An increase (cubical) in ash digestibility of broilers was observed for broilers fed 1.5% GGM supplemented diet. This corroborates the report of karangiya *et al*. (2016) and Sa'aci *et al*. (2018) who reported an increase in ash digestibility of broilers fed garlic powder incorporated diet and broilers administered aqueous ginger extract respectively. Crude protein (CP) digestibility increased quadratically and cubically with broilers fed diet containing 0.5 and 2.0% GGM at day 56. Ash and carbohydrate (NFE) digestibility also increased with 1% GGM and 0.5% GGM inclusion, respectively in broiler chickens' diet. This agrees with Hossian *et al*. (2015) who reported increased CP and crude fibre (CF) digestibility of rabbits fed diet containing garlic powder. The increased nutrient digestibility could be attributed to improved absorptive capacity through increased pancreatic enzyme stimulation by bioactive compounds present in GGM. Duwa *et al*. (2020) also reported an increase in CP, Ash and NFE digestibility of broilers fed diet containing ginger as a feed additive. Ginger has been reported to improve the digestive process through enhanced pancreatic enzyme activity (Windisch *et al*., 2008).

Conclusion

The haematological parameters were not significantly affected by GGM supplementation in the diets of broiler chickens. However, supplementation of GGM at 0.5 to 1.5% increased PCV and RBC count linearly at day 28. Supplementation of GGM at 1.5% increased EE digestibility at day 28 while GGM supplementation at 0.5% increased CP and NFE digestibility at day 56. Therefore, it is recommended that supplementation of ginger and garlic mixtures at 0.5% could improve the health status of broiler chickens and also enhance the nutrients digestibility.

References

Abou-Elkhair, R., Ahmed, H.A. and Selim, S. 2014. Effects of black pepper (*Piper nigrum*), turmeric powder (*Curcuma longa*) and coriander seeds (*Coriandrumsativum*) and their combinations as feed additives on growth performance, carcass traits, some blood parameters and humoral immune response of broiler chickens.*Asian Australasian Journal of Animal Sciences*. 27: 847-854.

Adibmoradi, M., Navidshad, B., Seifdavati, J. and Royan, M. 2006. .Effect of dietary garlic meal on histological structure of small intestine in broiler chickens. *Journal of Poultry Sciences*. 43: 378-383. http://dx.doi.org/10.2141/jpsa.43.378

Ali, B.H., Blunden, G., Tanira, M.O., and Nemmar, A. 2008. Some phytochemical, pharmacological and toxicological properties if ginger (*Zingiberofficinale*Roscoe): A review of recent research. *Food Chemistry and Toxicology*. 46: 409-420. http://dx.doi.org/10.1016/j.fct.2007.09.085

Alloui, M.N., Agabou, A. and Alloui, N. 2014. Application of herbs and phytogenic feed additives in poultry production- A Review.*Global Journal of Animal Scientific Research*. 2: 234-243.

Al-Shuwaili, M.A., Ibrahim, E.I. and Naqi Al-Bayati, M.T. 2015. Effect of dietary herbal plants supplement in turkey diet on performance and some blood biochemical parameters. *Global Journal of Bioscience and Biotechnology*. 4(2): 153-157.

Amagese, H., Petesch, B., Matsuura, H., Kasuga, S. and Itakura, Y. 2001. Recent advances on the nutritional effects associated with the use of garlic as a supplement: Intake of garlic and its bioactive components. *The Journal of Nutrition*. 131: 955S-962S.

AOAC. 2005. Association of Official Analytical Chemists, Official Methods of Analysis. 15th ed., Vol. 1, Arlington, Virginia.

Arbor Acre Broiler Management Handbook, 2014. Source:http://images.proultry.com/files/company/1759/AA_Broiler_Handbook2014i_EN.pdf

Basit, M., Arifah, A.K., Loh, T.C., Saleha, A.A., Sallen, A., Kaka, U. and Idris, S.B. 2020. Effects of graded dose dietary supplementation of *Piper betle* leaf meal and *Persicariaodorata* leaf meal on growth performance, apparent ileal digestibility and gut morphology in broilers. *Saudi Journal of Biological Sciences*. 27(6): 1503-1513.

Borgohain, B., Mahanta, J.D., Sapcota, D., Handique, B. and Islam, R. 2019. Effect of feeding garlic (*Allium sativum*) on haematological, serum biochemical profile and carcass characteristics in broiler chicken. *International Journal Current Microbiology and Applied Sciences*. 8(10): 492-500. https://doi.org/10.20546/ijcmas.2019.810.054

Bush, B.M. 1991. Interpretation of Laboratory Results for Small Animal Clinicians. Blackwell Scientific Publications. London, UK, pp: 32–67.

Carrasco, J.M.D., Casanova, N.A. and Fern, M.E. 2019. Microbiota, gut health and chicken productivity/: What is the Connectionfi *Microorganisms*. 7(374): 1-15.

Coles, E.H. 1986. Veterinary Clinical Pathology (4th Edition). W.B. Sunders Company, Harcourt Brace Jovanovidi, Inc.

Denli, M., Blandox, J.C., Guynot, M.E., Salado, S. and Perez, J.F. 2009. Effects of dietary Afladetox on performance, serum biochemistry, histopathological changes, and aflatoxin residues in broilers exposed to aflatoxin B1. *Poultry Science*. 88: 1444-1451.

Dieumou, F.E., Teguia, J.R., Kuiate, J.R., Tamokou, J.D., Fonge, N.B. and Dongmo, M.C. 2009. Effects of ginger (Zingiberofficinale) and garlic (Allium sativum) essential oils on growth performance and gut microbial population of broiler chickens. *Livestock Research for Rural Development*. 21:25-34

Durairajan, R., Murugan, M., Karthik, K. and Porteen, K. 2021. Farmer's stance on antibiotic resistance to E. coli and extended spectrum -β-lactamase producing (esbl) E. coli isolated from poultry droppings. *Asian Journal of Dairy and Food Research*. 40: 88-93.

Duwa, H., Amaza, I. B., Dikko, M.I., Raymond, J. B. and Paullyne, U. O. 2020.Effect of ginger (Zingiberofficinale) on the growth performance and nutrient digestibility of finisher broiler chickens in semi-arid zone of Nigeria. *Nigerian Journal of Animal Science*. 22 (3): 279-286.

Elagib, H.A.A., El-Amin, W.I.A., Elamin, K.M. and Malik, H.E.E. 2013.Effect of dietary garlic (*Allium sativum*) supplementation as feed additive on broiler performance and blood profile. *Journal of Animal Science*. 3: 58-64.

Gbenga, O. E., Adebisi, O. E., Fajemisin, A. N. and Adetunji, A. V. 2009. Response of broiler chickens in terms of performance and meat quality to garlic (*Allium sativum*) supplementation. African Journal of *Agricultural Research*. 4: 511-517.

Google Earth, 2019.

Hossian, M.J., Kamruzzaman, M., Akbar, M.A. and Haque, M.A. 2015.Feeding garlic powder on growth performance, nutrient digestibility and carcass characteristics of rabbit. *International Journal of Natural and Social Sciences*. 2(5): 74-81.

Incharoen, T. and Yamauchi, K. 2009. Production performance, egg quality and intestinal histology in laying hens fed dietary dried fermented ginger. *Poultry Science*. 8(11): 1078-1085.

Jimoh, A. A., Olorede, B. R., Abubakar,

A., Fabiyi, J. P., Ibitoye, E. B., Suleiman, N. and Garba, S. 2012. Lipids profile and haematological indices of broiler chickens fed garlic (Allium sativum) supplemented diets. *Journal of Veterinary Advance*. 2: 474-480.

Karangiya, V.K., Savsani, H.H., Shrikant, S.P., Garg, D.D., Murthy, K.S., Ribadiya, N.K. and Vekariya, S.J. 2016. Effect of dietary supplementation of garlic, ginger and their combination on feed intake, growth performance and economics in commercial broilers. *Veterinary World*. 9: 245–250.

Murugesan, G.R., Syed, B., Haldar, S. and Pender, C. 2015. Phytogenic feed additives as an alternative to antibiotic growth promoters in broiler chickens. *Frontiers in Veterinary Science*. 2(21): 1-6

Oleforuh-Okoleh, V.U., Ndofor-Foleng, H.M., Olorunleke, S. O., and Uguru. J. O. 2015. Evaluation of growth performance, haematological and serum biochemical response of broiler chickens to aqueous extract of ginger and garlic. *Journal of Agricultural Science*. 7(4): 167-173

Oso, A.O., Suganthi, R.U., Malik, P.K., Thirumalaisamy, G. and Awachat, V.B. 2021.Effect ofdietarysupplementation of a phyto-supplement on carcass characteristics of broiler chickens.*Asian Journal of Dairy and Food Research*. DOI: 10.18805/ajdfr.DR-1661.

Paraskeuas, V., Fegeros, K., Palamidi, I., Hunger, C. and Mountzouris, K.C. 2017. Growth performance, nutrient digestibility, antioxidant capacity, blood biochemical biomarkers and cytokines expression in broiler chickens fed different phytogenic levels. *Animal Nutrition*. 3: 114-120.

Rahmatnejad, E., Roshanfekr, H., Ashayerizadeh, O., Mamooee, M. and Ashayerizadeh, A. 2009.Evaluation of the effect of several non-antibiotic additives on growth performance of broiler chickens. *Journal of Animal and Veterinary Advances*. 8: 1670-1673.

Sa'aci, Z.A., Alabi, O.J., Brown, D. and Ng'ambi, J.W. 2018.Effect of aqueous ginger (*Zingiberofficinale*) extract on growth performance, nutrient digestibility and economy of feed conversion of broiler chickens. *Animal Nutrition and Feed Technology*. 18: 225-231. doi:10.5958/0974-181X.2018.00021.5

SAS Institute, 2000. SAS/STAT(R) Inc. User's Guide, Version 9, SAS Institute, Inc. Cary, NC.

Schalm, O.W., Jain, N.C. and Qureshi, M.Q. 1975. Veterinary Hematology, third ed. Lea and Fibinger, Philadelphia.

Suresh, G., Das, R.K., Brar, S.K., Rouissi, T., Ramirez, A.A., Chorfi, Y. and Godbout, S. 2018. Alternatives to antibiotics in poultry feed: molecular perspectives. *Critical Reviews in Microbiology*. 44(3): 318-335

Tapsell, L. C., Hemphill, I., Cobiac, L., Patch, C. S., Sullivan, D. R., Fenech, M., Inge, K.E. 2006. Health benefits of herbs and spices: The past, the present, the future. *Medical Journal of Australia*. 185: 4-

24.http://dx.doi.org/10.3923/crpsaj.2011.12.23

Wafaa, B.Z., Khadiga, A.A., Bakheit, M.D. and Ahmed, G.M. 2012. The effect of ginger root powder (Zingiberofficinale) supplementation on broiler chicks' performance, blood and serum constituents. *Journal of Animal Feed Research*. 1: 457-460.

Windisch, W., Schedle, K., Plitzner, C., and Kroismayr, A. 2008. Use of phytogenic products as feed additives for swine and poultry. *Journal of Animal Science*. 86: 140–148.

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