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Dietary effect of garlic (*Allium sativum*) supplementation on growth performance, blood profile, carcass characteristics and cost benefit of broiler chicken

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Abstract

Poultry scientists have been charged to opt for natural feed supplements to develop ideal, safe and cost effective feeds as against the synthetic ones. Thus, a 56 day feeding trial was conducted to determine the effect of garlic bulb meal (GBM) as a natural feed additive on growth performance, blood profile, carcass characteristics and cost benefit of broiler chicken. A total of 150, one day old broiler chicks, were randomly allotted into four dietary treatments with three replicate of 12 birds each in a completely randomized design. Four diets were compounded to contain 0, 1, 5, 10 g/kg GBM respectively. Parameters assessed were feed intake, weight gain, feed conversion ratio, haematological, serum biochemical indices, carcass and cost benefits. Results showed that, GBM based diet significantly (P<0.05) influenced the feed conversion ratio across the dietary treatments as birds in D_2 recorded the lowest FCR (1.64) values. The GBM supplementation groups had improved haematological parameters across the dietary treatments most especially in PCV (23.33 - 36.00%), Hb (7.66 – 12.06 g/dL) and RBC (2.15 – 3.69 × 10^3 iu/L) values. Serum biochemical indices of broiler chicken observed in this study increased across the dietary treatments as GBM inclusion levels increased. Birds fed 5g/kg (13.66 and 4.10 g/L) and 10g/kg (14.13 and 4.23 g/L) GBM based diet recorded the highest total protein and globulin values. GBM supplemental diet had no (P>0.05) effect on carcass characteristics of broiler chicken except the spleen. The spleen (0.09 – 0.23%) of the experimental birds increased across the dietary treatments as GBM inclusion levels increased. It was therefore concluded that the garlic powder supplemented at 1g/kg in the diet of broiler chicken supported optimal performance of the birds.

Keywords: Herbs, Additives, Garlic, Metabolites, Feed Cost

Effet alimentaire de la supplémentation en ail (*Allium sativum*) sur les performances de croissance, le profil sanguin, les caractéristiques de carcasse et les avantages coûteux du poulet de chair

Résumé

Les scientifiques avicoles ont été chargés d'opter pour des compléments alimentaires naturels pour développer des aliments idéaux, sûrs et rentables par rapport aux aliments synthétiques. Ainsi, un essai d'alimentation de 56 jours a été mené pour déterminer l'effet de la farine de bulbes d'ail (FBA) en tant qu'additif alimentaire naturel sur les performances de croissance, le profil sanguin, les caractéristiques de la carcasse et le rapport coût-avantage du poulet à griller. Un total de 150 poussins de chair âgés d'un jour ont été répartis au hasard dans quatre traitements diététiques avec trois répétitions de 12 oiseaux chacune dans une conception entièrement randomisée. Quatre régimes ont été composés pour contenir respectivement 0, 1, 5, 10 g/kg de FBA. Les paramètres évalués étaient l'apport alimentaire, le gain de poids, l'indice de conversion alimentaire, les indices hématologiques et biochimiques sériques, la carcasse et les avantages en termes de coûts. Les résultats ont montré que le régime alimentaire à base de FBA influençait de manière significative (P

<0,05) le taux de conversion alimentaire à travers les traitements diététiques, car les oiseaux de D2 enregistraient les valeurs FCR les plus basses (1,64). Les groupes de supplémentation en FBA présentaient des paramètres hématologiques améliorés dans tous les traitements diététiques, en particulier dans les valeurs PCV (23,33 - 36,00%), Hb (7,66 - 12,06 g/dL) et RBC (2,15 - 3,69 × 103 ui/L). Les indices biochimiques sériques du poulet à griller observés dans cette étude ont augmenté à travers les traitements diététiques à mesure que les niveaux d'inclusion de FBA augmentaient. Les oiseaux nourris avec un régime à base de FBA de 5 g/kg (13,66 et 4,10 g/L) et 10 g/kg (14,13 et 4,23 g/L) ont enregistré les valeurs de protéines totales et de globuline les plus élevées. Le régime alimentaire complémentaire FBA n'a eu aucun effet (P> 0,05) sur les caractéristiques de la carcasse du poulet à griller, à l'exception de la rate. La rate (0,09 à 0,23 %) des oiseaux expérimentaux a augmenté au cours des traitements diététiques à mesure que les niveaux d'inclusion de FBA augmentaient. Il a donc été conclu que la poudre d'ail supplémentée à 1 g/kg dans l'alimentation des poulets à griller favorisait les performances optimales des oiseaux.

Mots-clés : Herbes, Additifs, Ail, Métabolites, Coût de l'alimentation

Introduction

Poultry meat production is one of the most important and fast growing industry in the country helping to meet up with the masses protein requirement. Unfortunately, some unlettered or dishonest poultry growers are not following the withdrawal period for antibiotics in their broiler feed, which have adverse effects in poultry health and its residues in meat can cause danger for human health feeding on such chicken. Since 1950's farmers have been using antibiotics in animals feed regularly to attain increased growth rate (Ogle, 2013). The usage of antibiotics has therefore been restricted in so many ways, such as drug resistance to bacterial and the residual influence it causes on meat (Kamal and Abo- Omar, 2012). The consumers of today's world are much aware of their health and the quality of their food items. Safe food is not luxury for the rich, rather a right for every individual. Based on this, poultry farmers are more interested in fulfilling consumer's expectations such that there will be continuous production of good quality and healthy chicken (Iji *et al.,* 2001). In pursuit of improved chicken, the harmful effects of synthetic antibiotics on livestock can be averted by the use of natural feed additives such as garlic (Javandel *et al.,* 2008). Feed additives play a significant role in improving the nutritive values of feed ingredients which will invariably enhance the performance of poultry birds. Garlic has been a subject of considerable interest as a medicinal and therapeutic agent worldwide since ancient times (Shetty *et al.,* 2013). Main pharmacological effects of garlic are attributed to its organosulfur compounds (Tapiero *et al.,* 2004). Allicin being the main bioactive component of garlic may however account for some effects of garlic (Amagase *et al.,* 2001). Garlic has also been described as an alternative antibiotic growth promoter (Demir *et al.,* 2003) in broiler production enhancing feed conversion ratio, decreasing the mortality rate (Horton *et a1.,* 1991) and improving the carcass characteristics of broiler chicken (Bampidis *et al*., 2005). It is a highly studied medicinal plant used as growth promoter in broiler chickens (Lewis *et al.,* 2003). This plant is endowed with antibiotic, anticancer, antioxidant, immunomodulatory, anti-inflammatory, hypoglycemic, hypo-cholestrolemic and cardiovascular protecting effects (Reuter *et al.,* 1996). Although diet comprising of garlic powder has been described as having beneficial effects on body metabolites

(Mottaghitalab and Taraz, 2002) and also imposes positive effects on haematological parameters (Kung-chi, 2006) in poultry birds. Thus this study is designed to determine the effect of dietary garlic supplementation on growth performance, blood profile, carcass characteristics and cost benefit of broiler chicken

Materials and methods

Experimental site

This study was conducted at the Teaching and Research Farm of Federal College of Animal Health and Production Technology, Moor plantation, Apata, Ibadan, Oyo State.

Source of test ingredient and preparation

The garlic bulbs used for this study were purchased from a local market in Ibadan, Oyo State. The Garlic bulbs were de-segmented, de-skinned, cut into pieces, sun dried and ground to powder. The Garlic bulb Meal (GBM) was incorporated at varying levels of 0, 1, 5, 10g/kg GBM to formulate four (4) dietary treatments in the starter and finisher phase as indicated in Table 1.

Table 1: Gross Composition of Experimental Diets at Starter and Finisher Phase

Ingredients	Starter Phase (g/kg)				Finisher Phase (g/kg)			
	0	1	5	10	0	1	5	10
Maize	50.50	50.50	50.50	50.50	50.00	50.00	50.00	50.00
Soya bean meal	30.00	30.00	30.00	30.00	20.00	20.00	20.00	20.00
Groundnut cake	5.00	5.00	5.00	5.00	10.00	10.00	10.00	10.00
Fishmeal (72%)	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Wheat offal	7.30	7.30	7.30	7.30	15.00	15.00	15.00	15.00
Bone meal	2.50	2.50	2.50	2.50	2.30	2.30	2.30	2.30
Limestone	2.00	2.00	2.00	2.00	0.10	0.10	0.10	0.10
Methionine	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Lysine	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Premix(starter)	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Salt	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
*GBM	-	++	+++	++++	-	++	+++	++++
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Calculated analysis								
Metabolizable Energy (Kcal/Kg)	2830.4	2830.4	2830.4	2830.4	2832	2832	2832	2832
Crude Protein (%)	22.50	22.50	22.50	22.50	21.64	21.64	21.64	21.64

Vitamin A: 40000000IU. Vit D3: 2500000IU Vit E: 40000mg. Vit. K3: 800mg. Vit B3:3000mg, Vit B2: 6000mg. Vit.B6: 5000mg.Vit B12: 25mg. Niacin 6000mg. Panthothenic; 2000MG. Folic acid: 800mg. Biotin: 8mg. Manganese: 300000mg. Iron: 800mg. Zinc: 200 00mg. Cobalt 80mg. Iodine: 400mg. Selenium: 40mg. Chlorine: 800000mg. *Garlic Bulb Meal -:0g/kg; ++:1g/kg; +++:5g/kg; ++++:10g/kg

Experimental animals and their management

A total number of 150, one day old broiler chicks were acquired from a reputable hatchery. Initial weight of the experimental birds was taken and they were randomly allotted into four dietary treatments containing 36 birds per treatment, after which each group was further subdivided into three replicates consisting of 12 birds each. Birds were housed in deep litter system such that each replicate was kept in a separate compartment; feed and water were supplied *ad libitum*. Temperature, ventilation and humidity were maintained at the recommended level adequate heat was provided for the chicks at the brooding phase. Weekly weight gain, feed intake and feed to gain ratio were recorded. Mortality was also taken as they occur.

Data collection

Growth performance

Data were collected for growth performance on weekly basis. Feed intake, initial weight, final weight, body weight gain were computed at the expiration of the experiment.

Feed intake

Feed intake is the quantity of feed consumed by the animals. Feed left over was removed from the feed given i.e. *Feed intake = feed given – feed left over.*

Feed conversion ratio (FCR)

This is the quantity of feed required by the birds to attain 1kg of weight gain. This is computed by calculating the total feed consumed (kg) divided by the total weight gain (kg).

$$FCR = \frac{\text{Total feed consumed}}{\text{Total weight gained}}$$

Body Weight Gain (BWG)

The body weight gain was obtained by subtracting the initial weight from the final weight of the animals.

BWG = final weight – Initial weight

Carcass evaluation

At the end of the feeding trial, three birds were selected from each replicate, making nine birds per treatment, fasted for 10 hours, weighed, slaughtered and dressed. Slaughtered weight, De-feathered weight, eviscerated weight, dressed weight, relative cut-up parts and organ weights were also recorded. The carcass, prime cuts and organs were expressed as a percentage of live weight.

***Data analysis*:** All data collected were subjected to analysis of variance using SAS package version 9 (SAS, 2005). Significant differences among treatment means were separated using Duncan Multiple Range Test of the same statistical package.

Results

Presented in Table 2 is the growth performance of broiler chickens fed diets containing varied levels of GBM. The result showed no significant (P>0.05) difference in all parameters measured except for feed conversion ratio where birds on 1g/kg GBM based diets had better feed conversion when compared with birds in the other groups.

Table 2: Growth performance of broiler birds fed diet containing varying levels of garlic bulb meal

Parameters	Inclusion levels of GBM (g/kg)				
	0	**1**	**5**	**10**	SEM
Initial weight(g)	38.36	41.08	40.67	37.74	0.74
Final weight (g)	1995.00	2200.00	2065.00	1937.00	39.00
Total weight gain (g)	1956.64	2158.92	2024.33	1899.26	38.66
Average daily weight gain (g/b/d)	34.94	38.55	36.15	33.92	0.69
Feed intake (g)	3695.42	3537.57	3532.68	3787.50	74.88
Average daily feed intake (g/b/d)	65.99	63.17	63.08	67.3	1.34
Feed conversion ratio	1.88^{b}	1.64^{c}	1.75^{bc}	1.99^{a}	0.10

^{ab}Means along the same row with different superscripts are significantly different (P<0.05) SEM: Standard error of mean.

Presented in Table 3 are the carcass characteristics of broiler chickens fed diets containing varied levels of GBM. The result showed no significant variations in all parameters measured except the spleen, where birds on 0g/kg (0.09%) and 1 g/kg (0.11%) dietary supplementation of GBM had significantly (p<0.05) lowered relative splenic weights. Birds on 10g/kg (0.23%) dietary supplementation of GBM had higher relative splenic weight.

Table 3: Carcass characteristics of broiler chickens fed diets containing varied levels of garlic bulb meal

Parameters	Inclusion levels of GBM (g/kg)				
	0	**1**	**5**	**10**	**SEM**
Live weight (g)	2200.00	2300.00	2066.70	1900.00	71.60
Slaughtered weight (g)	1966.70	2166.70	1916.70	1733.30	72.68
De-feathered weight (g)	1800.00	2033.30	1833.30	1633.30	76.00
Eviscerated weight (g)	1600.00	1733.30	1583.30	1466.70	60.09
Dressed weight (g)	1433.30	1566.70	1400.00	1266.70	48.98
Cut parts expressed as % of Live weight					
Head	2.39	2.52	2.05	2.44	0.07
Neck	3.68	4.17	4.00	3.98	0.13
Breast muscle	19.68	20.64	15.29	20.12	1.07
Wings	3.77	3.89	3.89	3.73	0.09
Back muscle	14.14	17.55	16.98	14.82	0.63
Thigh	4.89	5.04	5.08	5.89	0.20
Drumstick	4.99	4.62	4.62	4.47	0.18
Shank	1.77	1.75	1.93	2.44	0.07
Organ expressed as % of Live weight					
Liver	2.19	0.71	2.05	1.76	0.40
Kidney	0.13	0.14	0.15	0.18	1.24
Spleen	0.09^{b}	0.11^{b}	0.17^{ab}	0.23^{a}	0.02
Gizzard	1.93	1.80	1.88	1.92	0.08
Lungs	0.56	0.60	0.57	0.42	0.03
Heart	0.45	0.55	0.57	0.51	3.62

^{ab}Means along the same row with different superscripts are significantly different (P<0.05) SEM: Standard error of mean

Presented in Table 4 are the haematological parameters of broiler chickens fed diets containing varying levels of GBM. The haematological parameters were significantly influenced by the dietary garlic supplementation except the white blood cell. The packed cell volume (23.33-36.00%), haemoglobin concentration (7.66-12.06 g/dL) and red blood cell (2.15-3.69× 10^{3}) values observed in this study increased as dietary supplementation of GBM increased.

Presented in Table 5 are the serum biochemical indices of broiler chicken fed diet containing varying levels of GBM. Garlic bulb meal (GBM) based diet significantly influenced the serum biochemical indices observed in this study except the glucose and cholesterol. The total protein, globulin, albumin and blood urea nitrogen values of the experimental birds increased across the dietary treatments as the GBM inclusion levels increased.

Table 6 shows the cost benefit of chickens fed diet containing varying levels of garlic bulb meal. The GBM supplementation significantly influenced the cost benefit parameters investigated in this study. The feed intake in kg, feed cost per kg, total feed cost and feed cost per weight gain were all significantly reduced at 1g/kg inclusion of GBM but increased at 10g/kg GBM inclusion level.

Table 4: Haematological parameters of broiler chickens fed diets containing varying levels of garlic bulb meal

Parameters	Inclusion levels of GBM (g/kg)					
	0	**1**	**5**	**10**	SEM	*Range of Values
PCV (%)	23.33[b]	33.00[a]	32.66[a]	36.00[a]	1.81	28.28 ± 0.70
Hb (g/dL)	7.66[b]	11.20[a]	11.06[a]	12.06[a]	0.62	12.19 ± 0.20
RBC (× 10^3IU/L)	2.15[b]	3.33[a]	3.22[a]	3.69[a]	0.20	2.14 ± 0.06
WBC (× 10^4IU/L)	12.13	15.90	14.07	15.00	6.73	20.09 ± 0.05
MCV (fL)	102.00[b]	101.00[b]	105.00[ab]	108.00[a]	1.58	132.3 ± 3.3
MCH (Pg)	35.00[a]	33.66[ab]	34.00[ab]	32.33[b]	0.41	57.11 ± 1.56
MCHC (g/dL)	30.66	34.00	34.00	33.66	0.65	43.22 ±1.09

[ab]Means along the same row with different superscripts are significantly different (P<0.05) SEM: Standard error of mean, FCR: Feed conversion ratio, PCV: Packed cell volume,Hb: haemoglobulin, RBC: red blood cell, WBC: white blood cell, MCV: mean cell volume, MCH: mean cell haemoglobulin, MCHC: Mean cell haemoglobulin concentration, *Talebi *et al*. (2005).

Table 5: Serum biochemical indices of broiler chickens fed diets containing varying levels of garlic bulb meal

Parameters	Inclusion levels of GBM (g/kg)				
	0	**1**	**5**	**10**	**SEM**
Feed Intake (Kg)	3.70[ab]	3.53[b]	3.53[b]	3.79[a]	0.04
Feed Cost per kg(₦/Kg)	251.50[d]	251.60[c]	251.90[b]	252.40[a]	0.10
Total feed Cost (₦)	930.55[b]	888.15[c]	889.47[c]	956.60[a]	9.18
Feed Cost per weight gain (₦/Kg)	474.77[b]	411.18[c]	440.20[b]	503.47[a]	244.86

[ab]Means along the same row with different superscripts are significantly different (P<0.05). SEM: Standard error of mean, BUN: Blood urea nitrogen, *Talebi *et al.*(2005).

Table 6: Cost benefit of broiler birds fed diet containing varying levels of garlic bulb meal

Parameters	Inclusion levels of GBM (g/kg)					
	0	1	5	10	SEM	*Range of Values
Total Protein (g/L)	8.33[b]	11.33[ab]	13.66[a]	14.13[a]	0.79	24.50-45.20
Globulin (g/L)	2.50[b]	3.40[ab]	4.10[a]	4.23[a]	0.24	7.40-13.10
Albumin (g/L)	5.83[b]	7.93[a]	9.56[a]	9.90[a]	0.55	1.45-4.10
Glucose (mmol/L)	61.67	88.00	59.67	75.33	6.08	9.20-31
Cholesterol (mg/dL)	30.00	33.00	30.66	37.53	2.22	100-129
BUN (mol/dL)	2.10[b]	2.46[ab]	3.73[ab]	4.03[a]	0.33	25.40-40.70

[ab]Means along the same row with different superscripts are significantly different (P<0.05). SEM: Standard error of mean,

Discussion

Garlic bulb meal (GBM) based diet did not affect growth parameters observed in this study except the feed conversion ratio (FCR). However, feed conversion ratio varied significantly across the dietary treatments in which chickens fed 1g/kg GBM based diet recorded the best FCR values (1.64). This actually pointed to the fact that birds fed 1g/kg GBM was at their optimal level in which they better utilized feed consumed into weight gain and this improved the feed conversion ratio (FCR) value. The improvement in FCR upon the supplementation was probably due to the increased activity of sulfur compounds mainly alliin, allicin, ajoene of garlic. This was in accordance with the observation of Tollba and Hassan (2003) that garlic supplementation improved broiler's growth and FCR. Feed additives have been widely used to increase animals' performance and

recently it is used in poultry industry to improve growth and feed efficiency (Khan *et al.,* 2007). Jahan *et al*. (2008) also reported that phytogenic feed additives have shown promising results as regards weight gain, feed efficiency, low mortality and increased livability in poultry birds. However, insignificant feed intake values obtained across the dietary treatments contradicted the observation of Abouelfetouh and Moussa (2012) who reported that feed additives are generally used to improve feed intake purposely to increase the growth rate in broiler chickens. The live, eviscerated and carcass weights were unaffected by dietary GBM supplementation as well as relative weights of cut parts and visceral organs except the spleen. This agrees with the findings of Samanthi *et al*. (2015) who observed that basal diet with or without supplementation of garlic powder had no effects on carcass yield in terms of dressing percentage, relative primal cuts and visceral weights. Although alteration in the quality of intact muscle is possible by nutrition this was not the case of this experiment

Supplementation of GBM in the diets of the birds significantly ($p<0.05$) influenced packed cell volume (23.33 - 36.00%), haemoglobin concentration (7.66 - 12.06 g/dL) and red blood cell (2.15 - 3.69 x 10^3 IU/L). This is in agreement with findings of Oluwole (2001), where garlic extract was observed to have significant effect on haematological parameters. Birds on dietary supplementation of GBM had significantly higher red blood cell count than birds on 0g/kg, this significant difference concerns the fact that the production of erythrocytes has significant relationship with the supplementation of GBM.

Dietary garlic supplementation exhibited a significantly positive effect on total protein, globulin, albumin and blood urea nitrogen which was in agreement with the observation of Konjufca *et al.* (1997) but contradicted the result obtained by Toghyani *et al.* (2011) that garlic supplementation did not induce any significant effect on the serum concentration of protein and albumin. Serum cholesterol values obtained in this study were not influenced by dietary garlic supplementation diet but contradicted the result observed by Yalçin *et al*. (2006) that serum cholesterol levels were significantly ($P<0.05$) reduced across the dietary treatments in growing rabbit fed dietary garlic supplementation. The same was also noticed in the reports of Bondana *et al.* (2019) who reported significant difference in the serum cholesterol among different treatments of broiler chickens fed garlic powder.

The cost benefit of broiler chicken fed dietary GBM on feed intake, feed cost/kg, total cost of feed and feed cost per weight gain showed significance ($p<0.05$). The highest total feed intake per kg was noticed in the treatment fed 10% inclusion of GBM and the same trend was also noticed in the feed cost/kg, total cost of feed and feed cost per weight gained. The total feed cost was highest (956.60) in birds fed 10% GBM and this was followed by the control treatment (930.55) without inclusion of GBM. Birds fed 1% and 5% of GBM were not significantly different from one another (888.15) and (889.47). These results obtained in this study were similar with the previous observation of Fayed *et al*. (2011) and Zekić *et al*. (2014) who reported that dietary inclusion of garlic in the diet may be used for economical and efficient production of broilers.

Conclusion

It can be concluded that the garlic powder supplemented at 1g/kg in the diet of broiler chicken gave optimal performance and improved serum biochemical, haematological indices of broiler chicken.

More so, considering the cost benefit, dietary garlic supplementation **at 1g/kg** showed cheapest feed cost per weight gain values that the broiler chicken could be produced when compared to other dietary treatments

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References

Abouelfetouh, A. Y. and Moussa, N. K. 2012. Enhancement of Antimicrobial Activity of Four Classes of Antibiotics Combined with Garlic. *Asian Journal of Plant Sciences.* 11: 148-152.

Amagase, H., Petesch, B. L., Matsuura, K. S. and Itakura, Y. 2001. Intake of garlic and its bioactive components. *J. Nut.*, 131: 955–962

Bampidis, V. A., Christodoulou, V., Christaki, E., Florou-Paneri, P. and Spais, A. B. 2005. Effect of dietary garlic bulb and garlic husk supplementation on performance and carcass characteristics of growing lambs. *Animal Feed Science Technology.* 121: 273- 283

Bondona Borgohain, Joga Dev Mahanta, Deben Sapcota, Bornalee Handique and Rafiqul Islam. 2019. Effect of Feeding Garlic (*Allium sativum*) on Haematological, Serum Biochemical Profile and Carcass Characteristics in Broiler Chicken. *International Journal of Current Microbiology and Applied Sciences* 8(10)*: 2319-7706*

Demir, E., Sarica, S., Ozcan, M. A. and Suicmez, M. 2003. The use of natural feed additives as alternatives for an antibiotic growth promoter in broiler diets. *British Poultry Science.* 44(S): 44-45

Fayed, R., Razek, H. and Jehan, M. O. 2011. Effect of dietary garlic supplementation on performance, carcass traits, and meat quality in broiler chickens. *Proceedings of the 15th International Congress of theInternational Society for Animal Hygiene*, Vienna, Austria.

Horton, G. M. J., Fennell, M. J. and Prasad, B. M. 1991. Effects of dietary garlic (*Allium sativum*) on performance, carcass composition and blood chemistry changes in broiler chickens. *Canadian Journal of Animal Science* 71: 939-942.

Iji, P. A., Saki, A. and Tivey, D. R. 2001. Body and intestinal growth of broiler chicks on a
commercial starter diet. Intestinal weight and mucosal development. *British Poultry Science*.42: 505 - 513.

Jahan, Z. A., Ahsan, U. H., Muhammad, Y., Tanveer, A. and Sarzamin, K. 2008. Evaluation of different medicinal plants as growth promoters for broiler chicks. *Sarhad J Agric*; 24: 323-329.

Javandel, F., Navidshad, B., Seifdavati, J., Pourrahimi, G.H. and Baniyaghoub, S. 2008. The favorite dosage of garlic meal as a feed additive in broiler chickens ration. *Pakistan Journal of Biological Sciences* 11: 1746-1749.

Kamal, J. I. and Abo-Omar, J. M. 2012. Effect of garlic powder on performance and lipid profile of broilers. *Open Journal of Animal Sciences*. 2: 62 - 68.

Khan, H. S., Sardar, R, and Anjum, M. A. 2007. Effects of Dietary Garlic on

Performance and Serum and Egg Yolk Cholesterol Concentration in Laying Hens. *Asian Journal of Poultry Science*. 1: 22-27. http://scialert.net/abstract/?doi=ajpsaj.2007.22.27

Konjufca, V. H., Pesti, G. M. and Bakalli, R. I. 1997. Modulation of cholesterol levels in broiler meat by dietary garlic and copper. *Poultry Science*. 76: 1264–1271.

Kung-chi, C., Mei-chin, Y. and Wan-Ju, C. 2006. Effect of diallyltrisulfide-rich garlic oil on blood coagulation and plasma activity of anticoagulation factors in rats. *Food Chem. Toxicol*., 45: 502-507

Lewis, M. R., Rose, S. P., Mackenzie, A. M. and Tucker, L. A. 2003. Effects of dietary inclusion of plant extracts on the growth performance of male broiler chickens. *Br, Poult, Sci,* 44: S43-S44.

Mottaghitalab, M. and Taraz, Z. 2002. Effects of garlic (Allium sativum) on egg yolk and blood serum cholesterol in Aryan breed laying hens. *British Poultry of Science*. 43: 42-43.

Ogle, M. 2013. Riots, Rage, Resistance: A Brief History of How Antibiotics Arrived on the Farm. Scientific American. Available at ps://blogs.scientificamerica n.com Retrieved June 14, 2019

Oluwole, F. S. 2001. Effect of garlic on some haematological and biochemical parameters. *African Journal of Biomedical Resources.* Pg: 34

Reuter, H. D., Koch, H. P. and Lawson, L. D. 1996. Therapeutic effects and applications of garlic and its preparations. In: Garlic: The science and therapeutic application of Allium sativum L. and Related Species, Koch, H.P. and L.D. Lawson (Eds.). Williams and Wilkins, Baltimore, MD, 135 - 213.

Samanthi, K. A. M., Nayananjalie, W. A. D., Adikari, A. M. J. B. and Liyanage, R. 2015. Dietary garlic (*Allium sativum* L.) supplementation on performance, meat quality and lipid profile in broilers. *Rajarata University Journal*. 3: 17-24

Shetty, S., Thomas, B., Shetty, V., Bhandary, R., Shetty, R. M. 2013. An *in-vitro* evaluation of the efficacy of garlic extract as an antimicrobial agent on periodontal pathogens: A microbiological study. AYU, 34: 445–451

SAS. 2005. User's Guide: Statistics, version 9.1. SAS institute Inc. Cary, NC, USA.Seattle, Washington. Pp: 156-339.

Tapiero, H., Townsend, D. M. and Tew, K. D. 2004. Organosulfur compounds from alliaceae in the prevention of human pathologies. *Biomed Pharmacother*., 58: 183–193.

Toghyani, M., Toghyani, M., Gheisari, A., Ghalamkari, G. and Eghbalsaied, S. 2011. Evaluation of Cinnanmon and garlic as antibiotic growth promoter substitutions on performance, immune responses, serum biochemical and heamatological parameters in broiler chicks. *Livestock Science*, 138: 167-173.

Tollba, A. A. H. and Hassan, M. S. H. 2003. Using some natural additives to improve physiological and productive performance of broiler chicks under high temperature conditions. Black cumin (*Niglla sativa*) or Garlic (*Allium sativum*). *Poultry Science*. **23**: 327-340.

Yalcın, S., Onbaşılar, E. E., Reisli, Z. and

Yalcın, S. 2006. Effect of garlic powder on the performance, egg traits and blood parameters of laying hens. *Journal of the Science of Food and Agriculture*. 86: 1336–1339. doi: 10.1002/jsfa.2515.

Zekić, V., Puvača, D., Milić, M., Beuković, D., Glamočić, N., Vukelić, D., Lukač and Zekić, S. 2014. Effect of garlic powder in broiler chicken nutrition: emphasis on production economic efficiency costs and chicken meat quality. *Cost and Agribusiness.* 10: 86-98.

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