**Impact of Dietary Garlic Inclusion on Weight Gain, Feed Intake and Growth Efficiency in Broiler**

**Abstract**

This study aimed to evaluate the effects of incorporating garlic into the diet on broiler growth performance. A total of 120 one-day-old Cobb-500 broiler chicks were randomly assigned to four dietary treatments, each with 30 chicks and three replicates per treatment. Four experimental diets were formulated: a control diet and three treatment diets with garlic powder at concentrations of 0.2% (T1), 0.4% (T2), and 0.6% (T3) in the feed mixture. The feeding experiment was conducted over a period of 42 days, during which various parameters were assessed, including feed intake, weight gain, feed conversion ratio (FCR), live body weight, carcass yield, carcass cuts, and Bursa cloacalis (Bursa of Fabricius) measurements.

The findings indicated no significant differences (p≤0.05) between the groups in terms of growth performance. However, the inclusion of garlic powder in the diets improved live body weight, increased the feed conversion ratio (FCR), and decreased cumulative feed intake. Additionally, the Bursa cloacalis was slightly higher in the control group compared to the experimental groups.

**Keywords:** garlic, growth performance, body weight, Bursa cloacalis

1. **Introduction**

The significance of poultry production today lies primarily in its short proliferation term, comparatively fast turnover on investment, and provision of high-quality protein (Adeyemo et al., 2010). Poultry meat production is crucial for meeting the protein needs of the rapidly growing human population and presents an attractive investment opportunity (Gueye, 2009). The proportion of poultry feed mixtures is important in terms of meeting the nutritional and energy demands necessary to increase poultry body weight without compromising carcass meat quality (Haščík et al., 2010; Saleh et al., 2004; Donaldson et al., 1957; Combs and Nicholson, 1964). The growth performance and use of alternative feed additives in poultry diets have been studied for many years (USDA, 2008).

Garlic, a natural plant with the active ingredient allicin, rapidly decomposes into various volatile organosulfur compounds with bioactive properties (Chang and Cheong, 2008). Garlic has been used as both food and folk medicine for centuries, with numerous biological properties including antimicrobial, anti-cancer, and antioxidant effects. Additionally, it possesses antiviral, antifungal, expectorant, antiseptic, antihistamine, and immunostimulatory properties (Hannan et al., 2011). Garlic has a long history as a remedy for colds, coughs, and asthma, and is known to strengthen the immune system. Its medicinal effects include lowering blood cholesterol levels, anti-platelet aggregation, anti-inflammatory activity, and inhibition of cholesterol synthesis (Shobana, 2009).

Various garlic extracts have demonstrated activity against Gram-negative and Gram-positive bacteria, including species of Escherichia, Salmonella, Staphylococcus, Streptococcus, Klebsiella, Proteus, Bacillus, Clostridium, Helicobacter pylori, and even acid-fast bacilli such as Mycobacterium tuberculosis. Allicin, a thiosulfinate compound found in garlic, has been reported for its antibacterial activity by inhibiting RNA synthesis (Hannan et al., 2011). Components of garlic include amino acids (e.g., glutamic acid, arginine, aspartic acid, leucine, lysine, valine), minerals (e.g., manganese, potassium, calcium, phosphorus, magnesium, selenium, sodium, iron, zinc, copper), vitamins (e.g., vitamin B6, vitamin C, folic acid, pantothenic acid, niacin), essential oils with sulfur-containing components (e.g., allyl disulfide, allyl trisulfide), alliin (converted to allicin by the enzyme alliinase), ajoene (produced by allicin condensation), quercetin, and sugars (e.g., fructose, glucose) (Bangyuan et al., 2021).

The Bursa cloacalis (Bursa of Fabricius) (BC) is a unique immune organ located in the cloacae of avian species. It acts as both a primary and secondary lymphoid organ and is responsible for the development and differentiation of BC lymphocytes (Abbate et al., 2007).

**2.Materials and Methods**

**2.1 Location and Experimental Birds Management**

The study was conducted at the poultry farm of Merowe University of Technology, Sudan. A total of 120 unsexed one-day-old Cobb-500 which were divided into (4) groups each had (30) chicks which were divided three replicates’ according to a completely randomized design (CRD) for 42 days. Broiler chicks were obtained from a local commercial hatchery (Sudanese Nile Poultry Company, Northern Sudan). The chicks were housed in pens (1 square meter each) within an open-sided deep litter house.

The birds were maintained under strict hygienic conditions and confined throughout the experimental period. The temperature was controlled during the fattening period, starting at 33°C on the first day and decreasing by approximately 2°C each week. Continuous lighting was provided during the feeding period. Each pen was equipped with a feed dispenser, and water was provided ad libitum through a self-feed pump.

The chicks were randomly selected and weighed to obtain their initial body weight, ensuring no significant differences among the groups. They were then allotted to four treatment groups (C, T1, T2, and T3) with 30 chicks per group, divided into three replicates, following a completely randomized design (CRD) for 42 days. Each group was fed the same starter complete feed mixture (CFM) from the first to the 21st day of age and a grower complete feed mixture (CFM) from the 22nd to the 42nd day. The treatment groups were fed garlic at varying concentrations: T1 (0.2%), T2 (0.4%), and T3 (0.6%) in the broiler feed mixture, respectively.

**2.2 Garlic Preparation**

Garlic bulbs (Allium sativum) were purchased from the local market. The garlic bulbs were sun-dried separately and subsequently ground into a fine powder. This garlic powder was then incorporated into the broiler basal feed mixture at different levels.

**2.3 Performance Parameters Measured**

Beginning after the first week of the experimental period, body weight, body gain, feed intake, and feed conversion ratio (FCR) were recorded weekly for each group. The health of the experimental stock and mortalities were closely monitored and recorded daily.

**2.4 Carcass Processing and Data Recording**

At the end of the 6th week, birds were weighed individually after an overnight fast (except for water). The birds were then slaughtered, scalded in hot water at a temperature of 53°C for 2 minutes, and de-feathered by hand. The head and shanks were removed close to the skull and at the hock joints, respectively. Evisceration was performed by a posterior ventral cut, allowing for the complete removal and weighing of the viscera. Abdominal fat, including the fat surrounding the gizzard, was also weighed.

The hot carcass weight (without the neck) was recorded individually, and all carcasses were chilled in a refrigerator at 4°C for 24 hours. The following morning, the carcasses were removed from the refrigerator, allowed to thaw at room temperature for 4 hours, and then weighed individually to determine the cold carcass weight. Each carcass was dissected into various cuts, including breast, drumstick, thigh, wing, and back. The sum of the drumstick and thigh comprised the leg. Carcass cuts were recorded as percentages of the cold carcass weight, while hot carcass weight, shank weight, and visceral organ weights were expressed as proportions of live body weight.

**2.4 Statistical Analysis**

Data from this experiment were analyzed using the General Linear Model in SPSS Statistics 17.0 (Statistical Package for the Social Sciences, released 23 August 2008). Significant differences were determined by One-Way ANOVA, followed by Duncan’s Multiple Range Test (DMRT (P ≤ 0.05) as the limit of significance.

Table 1: Calculated analysis of the experimental diet

|  |  |  |
| --- | --- | --- |
| Item | Starter (from 1st to 21st day) | Grower(22nd to 42nd day ) |
| Metabolizable energy (Kcal/kg) | 2991 | 3089 |
| Crude fat, % | 4.43 | 5.17 |
| Crude protein,% | 2143. | 18.7 |
| Lysine, % | 1.15 | 1.14 |
| Methionine,% | 0.53 | 0,54 |
| Cystine, % | 0.29 | 0.26 |
| Methionine + cystine,% | 0.82 | 0.80 |
| Calcium,% | .0.98 | 0.87 |
| Available phosphorus,% | 0.77 | 0.68 |
| Caloric-protein ratio | 140 | 165 |

1. **Results and Discussion**

The findings presented in Tables 2, 3, 4, 5, 6, 7, and 8 show the effects of adding garlic powder as a dietary supplement on the growth performance of Cobb-500 broiler chickens. The parameters measured include weekly feed intake, body gain, feed conversion ratio (FCR), and live body weight. The results indicated no significant (P≤0.05) differences between the treatment groups.

Our results align with those of Amouzmehr et al. (2012), who observed no significant effects of adding garlic extract at levels of 0.3% and 0.6% on broiler growth performance. Similarly, Konjufca et al. (1997) found that dietary garlic did not affect body weight gain and FCR. Qureshi et al. (1983) reported that garlic supplementation did not impact body weight and feed intake in broiler chickens. Sarica et al. (2005) also found no significant differences in weight gain between chickens fed a garlic extract-containing diet and the control group. Cross et al. (2002) reported no significant (P≤0.05) differences in weight gain of chickens fed with garlic and thyme extracts compared to the control group. Moreover, Botsoglou (2002, 2004) and Onibi et al. (2009) found no significant (P≤0.05) effects of garlic powder supplementation on the weight gain of broiler chickens.

Conversely, some researchers reported different outcomes. Lewis et al. (2003) and Demir et al. (2003) found that garlic improved FCR and body weight gain. Senthilkumar et al. (2015) reported that garlic powder supplementation at a 0.3% level increased body weight, feed intake, and FCR during the pre-starter, starter, and finisher phases. Eltazi et al. (2014) also found that the inclusion of garlic powder in the diet of broilers significantly (P≤0.05) enhanced body weight and weight gain compared to the control group.

The variations in the results of different studies could be attributed to differences in the source and composition of garlic used, preparation processes, feed inclusion levels, overall diet composition, breed strain of broilers used in the studies, environmental stress factors, and methods of administration of the feed additives (Khalid Khalifa et al. 2021).

Our findings are supported by Zaib et al. (2015), who studied the effect of garlic on the health and performance of broilers and found that garlic improved weight gain. Similarly, Shams Hayat et al. (2022) reported that garlic significantly improved weight gain for treatment groups (G. 0.9%) and FCR for group (G. 0.6%) compared to the control group. Eid and Iraqi (2014) found similar results, observing that broilers fed diets supplemented with 200 g of garlic powder per tonne had better growth performance and immune response against Newcastle and avian influenza viruses.

Moreover, Lee KW et al. (2014) supported our findings, demonstrating that dietary fermented garlic marginally improved growth performance, intestinal morphology, and altered blood characteristics of broiler chickens, particularly during the early rearing days. Karangiya et al. (2016) concluded that garlic supplementation at 1% of the broiler ration improved performance and could be a viable alternative to antibiotic growth promoters.

Our findings also showed that the Bursa cloacalis (Bursa of Fabricius) was higher in the control group compared to the treatment groups. This suggests that garlic improves poultry immunity, aligning with Bangyuan et al. (2021), who studied the histomorphological structure of the Bursa cloacalis in young Leiothrix lutea using light microscopy and transmission electron microscopy.

**Table (2) Feed intake of broiler chickens**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Parameter weight /gm | C | T1 (0. 2% garlic) | T2 (0. 4% garlic) | T3 (0. 6% garlic) |
| Second week | **426.7±17.6** | **408±13.9** | **391±11.5** | **421±14.7** |
| Third week | **558±24.1** | **570.3±17.4** | **553.3±35.9** | **551.7±17.6** |
| Fourth week | **845.3±31.1** | **863±26.1** | **855.7±16.9** | **848.3±27** |
| Fifth week | **931.7±27.5** | **934±12.8** | **905.3±13.3** | **943.3±20.8** |
| Sixth week | **973.3±46.2** | **962.3±13.3** | **1000.3±25.5** | **997.3±71.1** |
| Total feed intake | **3735±118.7** | **3721±26.9** | **3705.7±14** | **3762±95.1** |
| Second week | **188±7** | **188.3±22** | **185±7** | **173±10.7** |

C: Control (without garlic powder) , T1:0. 2% garlic powder, T2: 0.4% garlic powder, T3: 0.6% garlic powder,. Means on the same raw with the same superscripts significantly different (P≤0.05).

**Table (3) Body gain of broiler chickens**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Parameter weight /gm | C | T1 (0. 2% garlic) | T2 (0. 4% garlic) | T3 (0. 6% garlic) |
| Second week | **188±7** | **188.3±22** | **185±7** | **173±10.7** |
| Third week | **345.7±12.5** | **335±56** | **341.7±12.7** | **330.3±27.6** |
| Fourth week | **522.3±21.4** | **508.3±59.1** | **506.7±24.8** | **517±55.4** |
| Fifth week | **626±17.3** | **675.7±50.1** | **660.3±76.7** | **687.3±20.1** |
| Sixth week | **585.3±42.8** | **614.7±16.8** | **570.3±104.5** | **523.7±58.8** |
| Total gain | **2267.3±60.5** | **2322±170** | **2264±118** | **2231.7±84.7** |

C: Control (without garlic powder) , T1:0. 2% garlic powder, T2: 0.4% garlic powder, T3: 0.6% garlic powder,. Means on the same raw with the same superscripts are significantly different (P≤0.05).

**Table (4) Feed conversion ratio (kg/kg) of broiler chickens**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Parameter weight /gm | C | T1 (0. 2% garlic) | T2 (0. 4% garlic) | T3 (0. 6% garlic) |
| Second week | **2.3±.2** | **2.2±0.3** | **2.1±0.12** | **2.4±0.2** |
| Third week | **1.6±.1** | **1.7±0.4** | **1.7±0.1** | **1.7±0.2** |
| Fourth week | **1.6** | **1.7±0.2** | **1.7±0.1** | **1.7±0.2** |
| Fifth week | **1.5** | **1.4±0.1** | **1.4±0.2** | **1.4±0.1** |
| Sixth week | **1.7±.1** | **1.6±0.1** | **1.8±0.2** | **1.9±0.3** |
| Average F.C.R | **1.7±.02** | **1.6±0.1** | **1.6±0.8** | **1.7±0.1** |

C: Control (without garlic powder) , T1:0. 2% garlic powder, T2: 0.4% garlic powder, T3: 0.6% garlic powder,. Means on the same raw with the same superscripts significantly different (P≤0.05).

**Table (5) live body weight (g) of broiler chickens**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Parameter weight /gm | C | T1 (0. 2% garlic) | T2 (0. 4% garlic) | T3 (0. 6% garlic) |
| Initial weight | **125** | **125** | **125** | **125** |
| Second week | **313±7** | **313±22** | **310.±7** | **298±10** |
| Third week | **658.7±19.5** | **648±75** | **651±19** | **628.7±38** |
| Fourth week | **1181±4.6** | **1156.7±131.7** | **1158.3±42.2** | **1145.7±38.5** |
| Fifth week | **1807±21.8** | **1832.3±167.3** | **1818.7±53.5** | **1833±58.6** |
| Sixth week | **2392.3±60.5** | **2447±170** | **2389±117.9** | **2356.7±84.7** |

C: Control (without garlic powder) , T1:0. 2% garlic powder, T2: 0.4% garlic powder, T3: 0.6% garlic powder,. Means on the same raw with the same superscripts significantly different (P≤0.05).

**Table (6) carcass yield of broiler chickens**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Parameter weight /gm | C | T1 (0. 2% garlic) | T2 (0. 4% garlic) | T3 (0. 6% garlic) |
| Slaughter weight | 2392.3±60.5 | 2447±170 | 2389±117.9 | 2356.7±84.7 |
| Hot carcass weight | 1791.3±72.1 | 1856.7±14.7 | 1710.7±43 | 1721.7±63.7 |
| Dressing percentage weight | 75±0.02 | 76±0.01 | 73±0.02 | 73±0.01 |
| Cold carcass weight | **1781.7±146.3** | **1805±113** | **1781.7±178** | **1891.7±283** |

C: Control (without garlic powder) , T1:0. 2% garlic powder, T2: 0.4% garlic powder, T3: 0.6% garlic powder,. Means on the same raw with the same superscripts significantly different (P≤0.05).

**Table (7) Carcass cuts of broiler chickens**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Parameter weight /gm | C | T1 (0. 2% garlic) | T2 (0. 4% garlic) | T3 (0. 6% garlic) |
| Breast weight | 666.7±47.2 | 603.3±48.6 | 663.7±77.5 | 695±191 |
| Breast muscle | 531.7±27.5 | 476.7±31.8 | 513.3±45.4 | 540±162.6 |
| Drum stick weight | 503.3±40.4 | 590±45.8 | 500±127 | 603.3±87.4 |
| Thigh weight | 350±20 | 383.3±20.8 | 390±26.5 | 416.7±73.7 |
| Back weight | 368.3±49.3 | 395±40 | 360±43.6 | 376.7±27.5 |
| Wing weight | 183.3±15.3 | 200±26.5 | 193.3±32.1 | 193.3±15.3 |
| Breast weight% | 37.4±0.54 | 33.5±2.5 | 37.3±3.5 | 36.3±5.3 |
| Drum stick weight % | 28.3±1.8 | 32.7±0.5 | 28±6.5 | 32±2.7 |
| Back weight % | 20.6±1 | 21.9±1.3 | 20.2±1.1 | 20.1±1.7 |
| Wingweight% | 10.3±0.4 | 11±0.8 | 10.8±0.7 | 10.3±1.2 |

C: Control (without garlic powder) , T1:0. 2% garlic powder, T2: 0.4% garlic powder, T3: 0.6% garlic powder, . Means on the same raw with the same superscripts significantly different (P≤0.05).

**Table (8) internal organ weight of broiler chicken on day-42**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Parameter weight/gm | C | T1 (0. 2% garlic) | T2 (0. 4% garlic) | T3 (0. 6% garlic) |
| Hot carcass | 1791.3±72.1 | 1856.7±14.7 | 1710.7±43 | 1721.7±63.7 |
| Hart  | 14±1 | 13±1.7 | 13.3±1.5 | 13.3±1.5 |
| Hart% | 0.78±0.1 | 0.70±0.1 | 0.78±0.1 | 0.77±0.1 |
| Liver  | 43±6 | 44.7±4.5 | 42±4.4 | 43±1 |
| Liver % | 2.4±.24 | 2.4±0.06 | 2.5±0.2 | 2.5±0.1 |
| Spleen  | 1.7±0.7 | 1.8±0.2 | 1.8±0.2 | 1.9±0.2 |
| Spleen % | 0.1±0.04 | 0.1±0.02 | 0.1±0.01 | 0.1±0.02 |
| Gizzard  | 50.3±6.1 | 50.7±3.8 | 46±2 | 46.7±2.5 |
| Gizzard % | 2.8±0.5 | 2.7±0.23 | 2.7±0.1 | 2.7±0.12 |
| Abdominal fat  | 26.3±5.5 | 20.7±4.7 | 25.3±5 | 25±5.2 |
| Abdominal fat% | 1.5±0.3 | 1.1±0.2 | 1.5±0.3 | 1.5±0.3 |
| Bursa of Fabricius | 5±1 | 4.3±0.6 | 5.7±2 | 3.7±0.6 |
| Bursa of Fabricius% | 0.3±0.04 | 0.2±0.02 | 0.3±0.12 | 0.2±.03 |

C: Control (without garlic powder) , T1:0. 2% garlic powder, T2: 0.4% garlic powder, T3: 0.6% garlic powder Means on the same raw with the same superscripts significantly different (P≤0.05).

**Conclusion**: The present study concludes that garlic supplementation marginally improved broiler growth performance. Additionally, the Bursa of Fabricius (BC) was slightly larger in the control group compared to the experimental groups

**DISCLAIMER (ARTIFICIAL INTELLIGENCE)**

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

**References**

Adeyemo, G.O., Ologhobo, A.D., & Adebiyi, O.A. (2010). The effect of graded levels of dietary methionine on the haematology and serum biochemistry of broilers. Int. J. Poult. Sci., 9:158-161.

Gueye, E.F. (2009). The role of networks in information dissemination to family poultry farmers. World’s Poult. Sci. J., 65:115-123.

Haščík, P., Kačániová, M., Mihok, M., Pochop, J., &Benczová, E. (2010). Performance of various broiler chicken hybrids fed with commercially produced feed mixtures. Int. J. Poult. Sci., 9:1076-1082.

Saleh, E.A., Watkins, S.E., Waldroup, A.L., & Waldroup, P.W. (2004). Effects of dietary nutrient density on performance and carcass quality of male broilers grown for further processing. Int. J. Poult. Sci., 3:1-10.

Donaldson, W.E., Combs, G.F., Romoser, G.L., & Supplee, W.C. (1957). Studies on energy levels in poultry rations. 2. Tolerance of growing chicks to dietary fat. Poult. Sci., 36:807-815.

Combs, G.F., & Nicholson, J.L. (1964). Testing energy, amino acid and protein level specifications for linear programming of broiler rations. Feed Stuffs, 36:17-19.

Chang, K.J., & Cheong, S.H. (2008). Volatile organosulfur and nutrient compounds from garlic by cultivating areas and processing methods. Fed. Am. Soc. Exp. Bio. J., 22: 1108.2.

Hannan, A., Ikramullah, M., Usman, M., Hussain, S., Muhammad, A.M., & Javed, K. (2011). Antimicrobial Activity of Garlic (Allium sativum) Against Multi-Drug Resistance Mycobacterium tuberculosis. Pakistan Journal of Pharmaceutical Sciences, 24(1), 81-85.

Shobana, S., Vidhya, V.G., & Ramya, M. (2009). Antibacterial Activity of Garlic Varieties (Ophioscordon and Sativum) on Enteric Pathogens. Current Research Journal of Biological Sciences, 1(3), 123-126.

Amouzmehr, A., Dastar, B., Nejad, J.Gh., Sung, K., Lohakare, J., & Forghani, F. (2012). Effects of Garlic and Thyme Extracts on Growth Performance and Carcass Characteristics of Broiler Chicks. Journal of Animal Science and Technology, 54(3), 185-190. http://dx.doi.org/10.5187/JAST.2012.54.3.185.

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

Qureshi, A.A., Abuirmeileh, N., Din, Z.Z., Elson, C.E., & Burger, W.C. (1983). Inhibition of cholesterol and fatty acid biosynthesis in liver enzymes and chicken hepatocytes by polar fractions of garlic. Lipids, 18: 343-348.

Sarica, S., Ciftci, A., Demir, E., Kilinc, K., & Yildirim, Y. (2005). Use of antibiotic growth promoter and two herbal natural feed additives with and without exogenous enzymes in wheat-based broiler diets. S. Afr. Anim. Sci., 35:61-72.

Cross, H.R., Durland, P.R., & Seideman, S.C. (1986). Sensory qualities of meat. In: Bechtel, P.J. (Ed.), Muscle as food. New York: Academic Press. pp. 297–320.

Botsoglou, N.A., Christaki, E., Florou-Paner, P., Giannenas, I., Papageorgiou, G., &Spais, A.B. (2004). The effect of a mixture of herbal essential oils or ă-tocopheryl acetate on performance parameters and oxidation of body lipid in broiler. S. Afr. J. Anim. Sci., 34:52-61.

Botsoglou, N.A., Florou-Paneri, E., Christaki, E., Fletouris, D.J., &Spais, B.A. (2002). Effect of dietary oregano essential oil on performance of chickens and on iron-induced lipid oxidation of breast, thigh and abdominal fat tissues. British Poultry Science, 43: 223-230.

Onibi, E.G., Adebisi, E.O., Fajemisin, N.A., &Adetunji, V.A. (2009). Response of broiler chickens in terms of performance and meat quality to garlic (Allium sativum) supplementation. Afr. J. Agric. Res., 4(5): 511-517.

Lewis, M.R., Rose, S.P., Mackenzie, A.M., & Tucker, L.A. (2003). Effects of dietary inclusion of plant extracts on the growth performance of male broiler chickens. Brit. Poult. Sci., 44 (Suppl. 1), S43–S44.

Eltazi, S.M.A., Mohamed, K.A., & Mukhtar, M.A. (2014). Effect of using garlic powder as natural feed additive on performance and carcass quality of broiler chicken. Assiut Vet. Med. J., 60(141), April 2014.

Demir, E., Sarica, S., Ozcan, M.A., &Suicmez, M. (2003). The use of natural feed additives as alternatives for an antibiotic growth promoter in broiler diet. Br. Poult. Sci., 44: S44-S45.

Senthilkumar, S., Madesh, N., Doraisamy, K.A., Purushothaman, M.R., Chandrasekaran, D., Vasanthakumar, P., Thirumalaisamy, G., Siva, M.S., Sasikumar, P., &Pangayarselvi, B. (2015). Effect of garlic supplementation on growth performance in broilers. Conference Paper, Proceedings of the National Conference on Nutritional, Functional and Safety Challenges of Food. Organized by SRM University, March 2015.

Khalifa, K.M. (2021). The effects of garlic and ginger as a supplement diet on broiler chicken growth performance, meat quality and intestinal microbes. Ph.D. Thesis, Merowe University of Technology (Abdulatif Alhamad), Sudan.

Bangyuan, W., Yu, Z., Deng, J., Yuan, S., & Peng, X. (2021). Histomorphological Structure of the Bursa cloacalis (Bursa of Fabricius) in Young Leiothrix lutea: A Comparative Study Using Light Microscopy and Transmission Electron Microscopy. Int. J. Morphol., 39(6), 1646-1654.

Abbate, F., Pfarrer, C., Jones, C.J.P., Ciriaco, E., &Germanà, G. (2007). Age-dependent changes in the pigeon bursa of Fabricius vasculature: a comparative study using light microscopy and scanning electron microscopy of vessel casts. J. Anat., 211(3), 387-398.

Karangiya, V.K., Savsani, H.H., Patil, S.S., Garg, D.D., Murthy, K.S., Ribadiya, N.K., &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, EISSN: 2231-0916.

Lee, K.W., Kim, G.H., Kim, J.H., Yeon, J.S., Cho, S.B., Chang, B.S., & Kim, S.K. (2016). Effects of Dietary Fermented Garlic on the Growth Performance, Relative Organ Weights, Intestinal Morphology, Cecal Microflora and Serum Characteristics of Broiler Chickens. Brazilian Journal of Poultry Science RevistaBrasileira de CiênciaAvícola, 18(3), 511-518.

Zaibur Rehman, M.T., & Munir, M.T. (2015). Effect of garlic on the health and performance of broilers. Veterinaria, 3(1), 32-39.

Shams-ul-Hayat, R.A., Hayat, K.A., Din, I.-u., Khan, S., Ullah, F., Hussain, W., Shahzad, F., & Khan, R.A. (2022). Effect of Garlic (Allium Sativum)Supplementation on Growth Performance and Serum Biochemistry of Broiler Chicks. American Academic Scientific Research Journal for Engineering, Technology, and Sciences (ASRJETS), 85(1), 287-300.

Eid, K.M., & Iraqi, M.M. (2014). Effect of garlic powder on growth performance and immune response for Newcastle and avian