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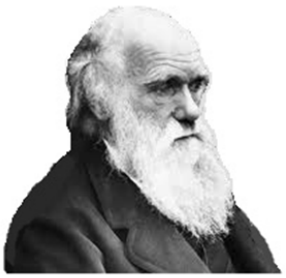

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Role of garlic (*Allium sativum*) as feed supplements in poultry industries: An overview

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ABSTRACT

Garlic (*Allium sativum*) is considered as a wonder drug of the medicinal world due to its multifunctional beneficial aspects. Garlic constitutes at least 33 sulfur containing compounds, several enzymes, amino-acids, and minerals. Over the past few years, garlic has been utilized as potential feed supplement in order to improve the growth performances and other biochemical properties of broiler chicken. The supplementation of garlic in basal diet has significantly increased the body weight gain and feed conversion ratio of broilers. Previous studies have suggested the pivotal role of garlic as an alternative to antibiotic growth promoter in poultry industries. This review overviews the studies investigated in the recent years for improving the growth performances and other important parameters of poultry.

***Keywords*:** Feed additive, Garlic, Growth performances, Poultry, *Allium sativum*

1. INTRODUCTION

Herbs and spices are being used as traditional medicines since ancient periods [1, 2]. Over the past few years, these medicinal plants are considered promising feed alternative to antibiotic growth promoters in poultry industries due to its non-toxicity and easy availability characteristics [3, 4]. They have several effects including appetite stimulator, enhance digestive secretion, immunostimulant, bactericidal, antiviral, antioxidants and are termed as phytogenics [5]. Garlic (*Allium sativum*) is one of the most important spices in medicinal system. It has been called the wonder drug of the herbal world due to its multi functional properties. Garlic

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possesses at least 33 sulphur containing compounds, several enzymes, amino acid, and minerals. Studies have shown that garlic possess broad spectrum antibacterial activities. Garlic (*Allium sativum*) had been used worldwide to fight bacterial infections as it exhibited a broad antibiotic spectrum against both Gram positive and Gram negative bacteria [6]. According to Ayurvedic and Greek system of medicine, garlic is one of the established remedies for tuberculosis. A few studies have also been proved that garlic has antimycobacterial activity against different species of *Mycobacteria* [7-10]. In addition, garlic has shown pronounced antibacterial activities against poultry associated bacterial pathogens [11, 12].

In recent years, plant extracts and spices as single or mixed compounds are being used to improve performance and health condition of the animal [13-15]. Previous studies have revealed significant effect of garlic towards the improvement of growth performances and other biochemical characteristics of poultry. This review highlights the pivotal role of garlic as feed supplements in terms of enhancing disparate characteristics of poultry.

2. GARLIC: FEED ADDITIVES IN POULTRY INDUSTRIES

Pagrut *et al*. [16] evaluated the impact of garlic additives in diets as a replacement of antibiotic on productive performance of the broilers. Thirty one day old broiler chicks were used in this study. The birds using ration supplemented with 0.5 kg/ton garlic gained the highest live weight among the treated groups and the best-feed conversion ratio although they consumed the same food. Findings concluded that the dietary inclusion of garlic in the rations may be used for economical and efficient production of broilers.

The efficacy of ginger and garlic powder as phytogenic feed additives in diet of broiler chickens was evaluated by Umatiya *et al*. [17]. A total 180 broiler chicks (Cobb 400) were randomly assigned to four treatments based on a completely randomized design. Results showed that there was no significant effect of addition of mixture of ginger and garlic on average weekly body weights and final body weights. However, body weight gain at seventh week was significantly (P<0.05) higher in treatments. Feed intake, feed conversion ratio (FCR), and carcass characteristics were similar (P>0.05) among the different treatment groups. Results concluded that dietary addition of mixture of ginger (0.1%) and garlic (0.2%) has improved body weight gain and return over feed cost in broiler chickens.

Kumar *et al*. [18] investigated the effect of dietary supplementation with different levels of garlic and holy basil leaf powder on chemical composition and cholesterol content of breast and thigh muscles of broiler chicks. A total of 280 day-old broiler chicks were procured and randomly distributed into 7 treatments, each treatment had 4 replicates with 10 chicks in each replicate. The study depicted that the percent moisture, crude protein (CP), and ether extract (EE) contents of thigh and breast muscles in broilers had no significant difference among the mean values of different treatments. Cholesterol content in thigh muscle was the lowest (P<0.05) in few treatments. Thus supplementation of garlic and holy basil powder at 0.5% and 1.0% showed the best results in terms of decreasing cholesterol content.

The effect of natural growth promoters such as garlic, black pepper, and hot red pepper in broiler chicken nutrition on production performances and chicken carcass quality was studied. At the beginning of the experiment, a total of 1200 one-day old Hubbard broilers were totally randomly distributed into eight dietary treatments with four replicates each. For nutrition of chicks three mixtures were used, starter, grower, and finisher. Dietary mixtures in the

experiments was as follows: T1 (control diet), T2 (garlic powder 0.5 g/100 g), T3 (garlic powder 1.0 g/100 g), T4 (black pepper powder 0.5 g/100 g), T5 (black pepper powder 1.0 g/100 g), T6 (hot red pepper 0.5 g/100 g), T7 (hot red pepper 1.0 g/100 g) and T8 (mixture of spices in ratio of 1:1:1 in total amount of 0.5 g/100 g). Addition of spices significantly (P<0.05) influenced the production parameters and carcass quality of broiler chickens. The highest achieved body weight of chicken was in treatment T6 (2460.6 g) which was followed by treatment T7 (2442.4 g) with statistically significant differences (P<0.05) compared to other treatments. In carcass which was ready for roasting, highest yield was recorded in dietary treatment T7 (1829.8 g) which was statistically significant (P<0.05) higher compared to treatments T1 (1626.5 g), T3 (1710.7 g), T4 (1532.2 g), and T5 (1587.5 g), respectively. The primal cuts of the most economically important value such as drumsticks with thighs had the highest weights in treatments T7 (530.7 g), T6 (525.2 g), T2 (520.2 g), and T8 (497.1 g), with statistically significant differences (P<0.05) compared to treatments T4, T5, and T1 (438.5 g, 448.7 g, and 461.1 g). Findings concluded that the addition of garlic, black pepper, and hot red pepper in broiler chicken nutrition had positive effect on production performances and in improvement of chicken carcass quality [19].

A feeding trial was conducted to investigate the effect of garlic on performance and carcass characteristics in broiler chickens [20]. Two hundred and forty 1-day-old Ross broiler chicks were randomly allocated into the 10 dietary treatments (A, B, C, D, E, F, G, H, I, and J) for 6 weeks. Treatment A or control group, received basal diet without supplementation of garlic powder while B, C, and D dietary treatments were basal diet supplemented with 0.5, 1, and 3% garlic powder, respectively, for the whole time of experiment. Birds in group E, F, and G were fed control diet supplemented with 0.5, 1, and 3% garlic powder, respectively, just in their starter diet (0-21d). Birds in three other treatments (H, I, and J) received control diet for the first 21 days and 0.5, 1, and 3% of garlic powder was added to their finisher diets, respectively. 1 and 3% supplemented groups in finisher period showed a better performance as compared with other groups.

Bharambe *et al*. [21] assessed the impact of dietary supplementation of garlic bulb and black pepper powder as herbal feed additives on feed intake and growth performance in broilers. A total of 320 day old broilers chicks of Vencobb-400 strain were divided into four treatment groups with four replicates of 20 chicks in each treatment using completely randomized design. The control group (C) was fed on basal diet without any supplementation and other three treatment groups were supplementation with 0.5% garlic bulb powder 0.5% black pepper powder and 0.5% of each supplement (garlic bulb powder and black pepper powder) in G, B, and GB groups, respectively. Statistical analysis of data revealed no effect of garlic and black pepper alone or no in combination of feed intake of experimental birds. Growth performance and efficiency of feed utilization for growth was significantly (P<0.05) higher in the garlic supplemented group (G and GB) as compared to C and B groups. Findings revealed that the supplementation of garlic bulb alone or in combination with black pepper seed powder improved growth performance and feed utilization efficiency.

The effect of feeding broiler chicks on diets containing different levels of garlic powder as natural feed additive on productive performance, carcass characteristics, and economical efficiency were studied [22]. A total of 141 one-day old, unsexed (Habbard) broiler chicks were randomly divided into four experimental groups. Each group was further subdivided into five replicates eight chicks per pen in complete randomized design. Results showed that, the diet with 3% garlic powder had significantly (P<0.05) heaviest body weight gain, the highest feed

intake, best feed conversion ratio with highest dressing, and breast percentages. The birds fed on control group produced significantly (P<0.05) highest abdominal fat percentage. The mortality rate was not affected significantly by the addition of garlic powder in broiler diet. The highest profitability ratio (1.30) was recorded by the diet with 3% garlic powder as compared to other experimental diets.

Makwana *et al*. [23] investigated the effects of adding graded levels (0, 0.1, and 0.5%) of garlic powder to the basal experimental diet on the growth performance and carcass characteristics of broiler chicks. One hundred and eighty day old unsexed white commercial broiler chicks (Cobb-400) were randomly distributed into three dietary treatments of 60 birds per treatment and each treatment contained 4 replicates (15 birds per replicate). The dietary treatments were controlled basal diet (T1), and a diet supplemented with garlic powder at 0.1% (T2) and 0.5% (T3). Daily feed intake, weekly body weight, and residue leftover were recorded to calculate the FCR. At the end of the experiment, six birds from each group were sacrificed to determine the carcass characteristics. Results revealed that dietary supplementation of 0.1% garlic powder (T2) significantly (P<0.01) improved body weight, body weight gain, feed intake, and FCR as compared to birds supplemented with 0.5% garlic powder (T3) and control diet (T1). Dietary supplementation of 0.1% garlic (T2) resulted in significant (P<0.05) improvement in dressed yield as compared to T3 and T1. On the other hand, comparable (P>0.05) effect was observed on shrinkage loss, blood loss, feather loss, eviscerated yield, and relative weight of giblet. Thus, dietary supplementation of 0.1% garlic powder had beneficial effects on growth performance and dressed yield of broiler chicks.

Zeryehun *et al*. [24] evaluated the effect of feeding different levels of garlic powder inclusion on selected blood profile and immunity of white leghorn chicken. A total of 180 chickens were randomly distributed in to 12 pens and assigned to 4 treatments. The value of hemoglobin (Hb) increased insignificantly due to supplementation of different levels of garlic powder. Total white blood cell count (TWBC), basophile, lymphocytes, heterophils, and monocytes were not affected (P>0.05) by treatments. But a slight rise in lymphocyte and heterophil counts were observed in garlic supplemented groups which may be due to immuno-stimulatory effects of garlic. Packed cell volume (PCV) and eosinophils were affected (P<0.05) by treatments. Mean values of total protein (g/dl) was not affected (P>0.05) by treatment. In general, the inclusion of 2% garlic powder improved total immunoglobulin but significantly lowered eosinophils compared to control group. The study revealed that mixing layer diets with 1-3% garlic powder could be used in practical layer diets to improve some haematological and immunoglobulin values which might consequently improve blood circulation and immunity.

A study was conducted on 120 guinea fowls to see the effect of garlic powder and chromium picolinate supplementation on growth performance, carcass characteristics, and immunological parameters of guinea fowls [25]. Birds were randomly divided into four treatment groups, having three replications consisting of ten birds each. Results indicated that both garlic and chromium picolinate supplementation improved body weight gain and feed conversion ratio (P<0.05) of guinea fowls. Feed intake of birds was also found reduced (P<0.05) in all treatment groups in comparison to control. At the end of 12 week of age, the carcass traits-eviscerated weight with and without giblet and organ weights did not differ significantly between treatment groups. The abdominal fat expressed as percentage of live weight was significantly lower (P<0.05) in all treatment groups as compared to control group. Immune response as revealed by delayed type of hypersensitivity and serum immunoglobulin

were improved in all the three supplemented groups. Thus findings concluded that garlic supplementation can improve growth performance and immunity.

El-Gogary *et al*. [26] investigated the effects of dietary supplementation with garlic extract 1 g/kg and synthesized calcium nanoparticles with garlic extract (0.5 and 1 g/kg) on growth performance, blood profiles, and histology in broilers. A total of 112 one day-old unsexed broiler chicks were randomly allotted to 4 treatments with 4 replications per treatment and 28 chicks per pen floor. Findings showed that the supplementation of Nano garlic at 0.5 g/kg of diet had beneficial effects on lipid profile, immunity, antioxidant status, and histological observations of broiler chicken.

A feeding trail was conducted to determine the effect of garlic supplementation (0, 1.5, 3.0, and 4.5%) in the diet of 240 day old cockerel chicks on growth performance, economy of production, nutrients digestibility, haematological, and serum indices. Four treatments with 3 replicates each of 20 birds each were adopted in a complete randomized design. Four diets used were almost isocaloric and isonitrogenous, while data collected were subjected to ANOVA. The diets had comparable levels of nutrients, initial body weight (90.0 g), daily weight gain per bird (6.02 ± 0.39 g), and fuel conversion ratio (5.43 ± 0.5 g), while the daily fuel intake per board was significantly (P<0.05) varied and least at 4.5% inclusion level, with corresponding highest profitability and best (P<0.05) digestibility of crude protein, NFE, and ether extract. Highest (P<0.05) PCV, Hb, RBC, WBC, and lymphocyte was obtained at 4.5% level of inclusion, with corresponding high level of platelets and significantly (P<0.05) depressed urea (3.13 g/dL) [27].

A trial was aimed to find the degree of acceptance of the feed supplemented with garlic and ginger in the poultry. In the trail, the overall weekly consumption of feed was found significantly (P<0.05) highest (1.302 ± 0.03 kg) in the poultry treatment given with basal diet supplemented with 0.5% garlic and 0.5% ginger. Statistics showed similarities in result in the treatment fed with basal diet with 1% garlic and 1% ginger. Also, the analyzed result significantly (P<0.05) showed minimum weakly feed consumption (1.208 ± 0.01 kg) in the control treatment which was standard basal feed without supplementation of garlic and ginger. Acceptance of the feed supplemented with ginger and garlic was significantly higher, suggesting positive response for the use of garlic and ginger as growth promoter in the poultry feed [28].

Issa and Omar [29] investigated the effect of feeding garlic powder on the performance, digestibility, digestive organs, carcass cuts, and lipid profile of broilers. A total of 270 day-old Cobb-500 chicks were used in the experiment. Birds were partitioned into three experimental groups of 90 birds in each. Each treatment was composed of 6 replicates with 15 birds in each. The control group was fed with a commercial starter and finisher diet. The second and third groups were supplemented with garlic powder at the rate of 0.2% and 0.4%, respectively. In the last week of experiment, 18 birds from each experimental group (3 birds per replicate) were used in a metabolic trial. Total cholesterol (COL), triglycerides (TG), high density lipopro-tein (HDL), low density lipoprotein (LDL) levels were determined. Results of this study showed that garlic powder had no significant effects on broilers weight gain, feed intake, FCR, carcass cuts, and visceral organs. However, garlic powder decreased (P<0.05) COL, TG, LDL, and increased HDL levels compared to control birds. The dry matter, CP, and EE digestibility were improved by feeding garlic powder. The outcomes concluded that garlic powder could provide positive advantages in broilers performance.

Khaidem *et al*. [30] evaluated the feeding of garlic powder on the performance and blood profile of broiler chicken. A total of 120 day old Cobb-400 strains of broiler were distributed into four treatments groups with 30 birds in each treatment having five replicates of 6 birds each. The birds were reared in cages and were fed with diet supplemented with 0%, 0.25%, 0.50%, and 0.75% of garlic powder. Results revealed that there was no significant (P>0.05) difference in the body weight, gain in weight, feed intake and feed conversion efficiency, performance index, dressing percentage, carcass, and organ weights due to different levels of garlic, though the values were observed to be numerically better in garlic treated groups. Dietary supplementation of garlic had significant (P<0.05) effect on WBC and RBC and the values were observed to be maximum at the highest level of garlic (0.75%) and the least in control group (0%). Haemoglobin and differential WBC count were unaffected by garlic treatment.

Lukanov *et al*. [31] evaluated the effect of feed supplementation with garlic powder on growth performance, carcass yield, and meat quality in broiler chickens. The experiment was conducted with 120 male broiler chickens divided into 4 groups. Results demonstrated a steady tendency towards increase in live body weight throughout the fattening period proportionally to the level of dietary garlic powder supplementation. After feed supplementation with increasing doses of garlic powder, FCR (kg/kg) maintained a stable positive tendency up to the 7^{th} week of age. Garlic powder supplementation did not influence the proportion of edible offal and meat cuts, except for abdominal fat percentage. Added to poultry feed at levels up to 0.8%, garlic powder had no adverse effect on chicken meat quality.

The beneficial effects of garlic powder as a phytogenic supplement on broilers chickens' performance were demonstrated by Al Massad et al. [32]. The assumption that garlic could improve some economic and performance characteristics of broiler chickens (i.e. body weight, feed intake, water intake, FCR, feeding cost, carcass yield, and mortality rate) were tested. A total of 400 one-day-old chicks of mixed sex were weighed and randomly assigned to four treatment groups, each with 4 replicate pens of 25 chicks. Results of the study revealed that incorporation of garlic powder in broiler diets as feed additive significantly enhanced growth, economic, and productive performance of these chickens. Physiological measurements showed better performance of garlic treated chickens compared with control group under same rearing system. Results similarly showed lower susceptibility to diseases and medicament treatment consequently; lower mortality rate compared to control groups. Furthermore, blood and meat analysis showed lower cholesterol, triglyceride, LDL, and HDL levels compared with control group. Findings concluded that garlic can be effectively used in broilers feeding to replace antibiotic as growth promoter.

The effects of incorporating garlic powder as a growth promoter in broiler feed on growth performance and carcass characteristics profile were assessed [33]. One hundred and eighty 1-day-old white commercial broiler chicks (Cobb-400) were randomly divided into 60 birds per dietary treatment and each treatment contained 4 replicates (15 birds per replicate). Results revealed that dietary supplementation of 0.1% garlic powder significantly (P<0.01) improved body weight, body weight gain, feed intake, and FCR as compared to birds supplemented with 0.5 % garlic powder and control. Dietary supplementation of 0.1% garlic resulted in significant (P<0.05) improvement in dressed yield as compared to treatments. On the other hand, comparable (P>0.05) effect was observed on shrinkage loss, blood loss, feather loss, eviscerated yield, and relative weight of giblet. Total feed cost, total cost/kg live weight, and total cost/kg meat was reduced (P<0.05) in 0.1% garlic as compared to 0.5% garlic

supplemented birds or control. Thus, dietary supplementation of 0.1% garlic showed beneficial effect on growth performance, dressed yield, and cost of production.

One hundred and eighty white commercial broiler chicks (Cobb 400) were randomly divided into three groups to study the effects of garlic supplementation on growth performance. Results revealed that dietary supplementation of 0.1% garlic powder significantly (P<0.01) improved body weight, body weight gain, feed intake, and FCR as compared to birds supplemented with 0.5% garlic powder and control. Dietary supplementation of 0.1% garlic resulted in significant (P<0.05) improvement in dressed yield as compared to treatments. On the other hand, comparable (P>0.05) effect was observed on shrinkage loss, blood loss, feather loss, eviscerated yield, and relative weight of giblet. Total feed cost, total cost/kg live weight, and total cost/kg meat was reduced (P<0.05) in 0.1% garlic as compared to 0.5% garlic supplemented birds or control [34].

A total of one hundred and sixty one-day old, unsexed (Ross-308) broiler chicks were randomly divided into four experimental groups. Each group was further subdivided into five replicates at the rate of eight chicks per pen in complete randomized design. The birds were fed on two basal diets (starter and finisher diets). The garlic and ginger powder were added in different mixture levels to the basal diets resulting in four experimental groups. Results showed that, the diet with 1.75% mixture powder (1.5% garlic + 0.25% ginger) had significantly (P<0.05) heaviest body weight gain, best FCR, and highest dressing percentage with the highest commercial cuts percentages (breast, drumstick, and thigh). Birds fed with the control diet recorded significantly (P<0.05) highest abdominal fat, liver, and gizzard percentages. The morality rate was not significantly affected by the inclusion of mixture of garlic and ginger powder in broiler diet. The highest profitability ratio was obtained by the diet with 1.75% mixture powder [35].

Taufik and Maruddin [36] investigated the effect of garlic supplementation in drinking water on the performance of broiler chickens, carcass weight, and quantity of abdominal fat weight. Completely randomized design was arranged. One-day old broiler chickens Lohmann MB 202 with initial weight of ±40 g (unsexed, 100 birds), were randomly introduced to the following treatments: (P0) water + 0% carcass; (P1) water + 3% carcass; (P2) water + 6% carcass and (P3) water + 9% carcass. Each treatment was carried out at 5 replications, using at least 5 chickens for each replication. Garlic was supplemented in water for chickens, from one-day old to the end of experimental period (35 days). Results concluded that the addition of garlic solution does not have an effect on the overall performance of the broiler, carcass weight, and abdominal fat, but based on the average value of performance, carcass weight, and abdominal fat.

Karangiya *et al*. [37] evaluated the effect of supplementation of garlic, ginger, and their combination in the diets of broiler chickens and assessment in terms of feed intake, growth performance, and economics of feeding. A total of 240 1-day-old Cobb-400 broiler chicks were randomly assigned to four dietary treatments each with three replicates of 20 chicks per replicate (n=60). Four experimental diets were formulated in such a way that control diet (T1) contained neither ginger nor garlic, while birds in group T2 and T3 were fed with diets containing 1% garlic and ginger, respectively. Diet 4 (T4 group) contained a combination of 1% of garlic and ginger.

The feeding experiment was carried out for 42 days, and different parameters evaluated includes feed intake, weight gain, FCR, gut morphometry, and economics of feeding in terms of return over feed cost (ROFC) and European Performance Efficiency Index.

Feed intake of experimental birds in ginger and mixture of garlic and ginger supplemented groups, i.e., T3 and T4 groups have significantly (P<0.05) higher feed intake as compared to control. While, feeding of garlic have non-significant effect on feed intake as compared to other groups. A body weight gain (g/bird) was found to be significantly (P<0.05) higher in garlic (T2 group) and ginger (T3 group) supplemented group as compare to control and garlic and ginger mixture supplemented group (T4 group).

Feed conversion ratio was significantly (P<0.05) lower in ginger (T3 group) supplemented group as compare to other groups. Mean villi length, villi width, and cryptal depth were significantly (P<0.05) higher in T3 group than rest of all three groups, indicating increased absorptive surface area. ROFC was significantly (P<0.05) lower in T3 and T4 groups as compare to control. However, it was not significantly different between control and T2 group. Results concluded that the supplementation of garlic improved the performance of broilers when added at the rate of 1% of broiler ration and can be a viable alternative to antibiotic growth promoter in the feeding of broiler chicken.

3. CONCLUSIONS

The supplementation of garlic in the basal diet significantly affected the performances and other parameters of broiler chicken. In view of the prior reports, garlic can certainly be used as an effective alternative to antibiotic growth promoters in poultry industries.

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