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Beneficial Effects of Dietary *Allium sativum* (Garlic) Supplementation on Health and Production of Poultry: A Mini-Review

Deepak Chandran[1*], Talha Bin Emran[2], Firzan Nainu[3], Khan Sharun[4], Manoj Kumar[5], Saikat Mitra[6], Sandip Chakraborty[7],Ranjan K. Mohapatra[8], Hardeep Singh Tuli[9], and Kuldeep Dhama[10]

[1]Department of Veterinary Sciences and Animal Husbandry, Amrita School of Agricultural Sciences, Amrita Vishwa Vidyapeetham University, Coimbatore, Tamil Nadu, India – 642109.
[2]Department of Pharmacy, BGC Trust University Bangladesh, Chittagong, Bangladesh.
[3]Faculty of Pharmacy, Universitas Hasanuddin, Makassar 90245, Indonesia.
[4]Division of Surgery, ICAR-Indian Veterinary Research Institute, Bareilly, Uttar Pradesh, India – 243122.
[5]Chemical and Biochemical Processing Division, ICAR – Central Institute for Research on Cotton Technology, Mumbai, India - 400019.
[6]Department of Pharmacy, Faculty of Pharmacy, University of Dhaka, Dhaka 1000, Bangladesh.
[7]Department of Veterinary Microbiology, College of Veterinary Sciences and Animal Husbandry, R.K. Nagar, West Tripura, Tripura-799008, India.
[8]Department of Chemistry, Government College of Engineering, Keonjhar-758002, Odisha, India.
[9]Department of Biotechnology, Maharishi Markandeshwar (Deemed to be University), Mullana, Ambala-133207, Haryana, India.
[10]Division of Pathology, ICAR-Indian Veterinary Research Institute, Bareilly, Uttar Pradesh, India – 243122.

Abstract

Poultry is the most important source of animal protein in the world, and it is also one of the largest users of antibiotics as growth promoters. Medicinal properties of *Allium sativum* (Garlic) have been recognised since ancient times. The emergence of multi-drug resistant diseases in poultry is linked to antibiotic use in poultry feed. Therefore,garlic as a feed additive can enhance poultry production. Organosulfur compounds, polyphenols, saponins, fructans, and fructooligosaccharides are some of the bioactive chemicals found in garlic, which have shown proven physiological effects in poultry such as antioxidant, antibacterial, antiviral, immunostimulatory, intestinal homeostasis, and cholesterol-lowering activities. This article highlights the beneficial applications of garlic as a feed additive in poultry, itseffects on growth performance, illness prevention, gastrointestinal and immunological

**Corresponding author* : Email : c_deepak@cb.amrita.edu

regulation for safeguarding health of birds.

Key words: *Allium sativum,* antibiotic resistance, poultry production, physiological implications

Antibiotic resistance is on the rise as a result of increase in global consumption of animal products, posing a major threat to both animal and human health (Chandran and Arabi, 2019; Chandran *et al.,* 2019; Lejaniya *et al.,* 2021; Sharun *et al.,* 2021; Uddin *et al*., 2021; Kumar *et al.,* 2022a). While poultry accounts for more than half the world's protein intake from animal sources, antibiotics are used as growth boosters in the poultry industry (Kothari *et al.,* 2019). Various herbs and plant metabolites have been shown to have a variety of positive applications and modes of action that can help improve chicken productivity and bird health(Dhama *et al.,* 2015; Yadav *et al.,* 2016;Deepak *et al.,* 2020; Abdelli *et al.,* 2021; Hartady *et al.,* 2021; Seidavi *et al.,* 2022). Due to their abundance in pharmaceuticals, plant-based treatments like phytotherapy are very well appreciated by the public (Dhama *et al*., 2014; Dhama *et al.,* 2018; Chandran *et al.,* 2021a; Chandran *et al.,* 2021b; Alajil *et al.,* 2022; Kumar *et al.,* 2022b). It has been demonstrated in numerous studies that garlic's bioactive components are advantageous to poultry health and production potentials due to their antibacterial, hypocholesterolaemia, antioxidant, immunomodulatory and growth stimulating properties (Kothari*et al.,* 2019; Sasi *et al.,* 2021).

According to the most recent scientific estimates, sulfur-containing chemicals, enzymes, 17 amino acids, and minerals, including selenium are present in garlic. Aside from alliin, allicin, methiin, diallydisulphide, dialkyl polysulphide, S-allylcysteine (SAC), S-ally-mercapto cysteine (SAMC), N-alfa-fructosyl arginine, glutamyl 7 cysteines, and S allyl cysteine sulfoxides are the most important phytochemicals in garlic (Khan *et al.,* 2012; Ogbuewu *et al.,* 2018; Chandran *et al.,* 2019a; Kumar *et al.,* 2022c). Phytochemicals in garlic, which have a wide range of favourable effects on broiler and layer production as well as physiological biochemistry, may be a factor in its ability to boost production in poultry (Prakash *et al.,* 2021a; Prakash *et al.,* 2021b). Growth, feed conversion efficiency, egg production and quality, immune system activation, and blood cholesterol reduction have all been favourably influenced in poultry (Khan *et al.,* 2012). This paper aims to shed light on the beneficial impacts of garlic on the health and production of poultry.

Effect of garlic on broiler production

Many studies have shown that *Allium sativum* (garlic) positively influences broiler feed conversion rate (FCR) and average daily gain (ADG). Fadlalla *et al* (2010) have demonstrated that garlic can boost FCR in broiler chicks by increasing intestinal villus height, size, and cell area and promoting the absorption process. Garlic supplementation enhances pancreatic enzyme activity and generates a favourable environment for food digestion (Sasi *et al.,* 2021). The ADG and FCR of broilers fed 0.5% garlic in their diet were higher. At the same time, consuming more than 4% garlic in broiler diets has been demonstrated to have a detrimental effect on growth (Prakash *et al.,* 2021a). A study on broilers demonstrated that supplementing the diet with 0.5% garlic boosted both FCR and ADG while preserving carcass production and organ weights (heart, gizzard, liver, spleen, and pancreas). Broilers fed a diet containing 1.0 g/kg garlic had greater FCR and ADG (Mansoub, 2011). It also boosted FCR, ADG, and carcass production while retaining equal average daily feed intake (ADFI) and carcass yield with garlic extract.

Ashayerizadeh *et al* (2009) observed that feeding broilers with garlic increased carcass yield while negatively influencing ADFI, FCR, ADG, or breast weight. Garlic's potential to improve digestion and immunity has been linked to its growth-promoting properties. The findings of Onyimonyi *et al* (2012) discovered that broilers fed garlic supplemented diets had improved performance parameters (ADFI, FCR, ADG) and survival. Similarly,Kumar *et al* (2010)observed that birds administered with 250ppm garlicfor 42 days had greater ADG. Adding 0.125–1.25% garlic powder to starter broiler meals improved ADG, carcass weight, and organ weight (Javandel *et al.,* 2008). Broiler feed intake, FCR, and weight gain were unaffected by garlic at 1 g/kg

feed (Prakash *et al.*,2021a).Variations in dietary garlic, inclusion rates and feeding durations could explain some of the discrepancies between trials. According to Okoro *et al* (2016), broiler breeder cocks' semen count, viability, and morphology improved when garlic was added to their diets. Garlic daily supplements helped broiler breeder chickens have optimal concentrations of dead sperms, actual live sperms, as well as acrosome detachment and abnormalities.

Effect of garlic on egg qualityand production

Several studies have indicated that phytoadditives boost egg quality and egg-laying performance. With the addition of garlic powder to the feed, Olobatoke and Mulugeta (2011) found that egg weight was increased while cholesterol and triglyceride levels in the yolk and blood were reduced. Khan *et al* (2012) discovered that layers fed a diet containing up to 8% garlic powder for six weeks produced more eggs.Mahmood *et al* (2015) tested four diets: control, 0.25%, 0.50%, and 1.0% garlic juice in the layer diets. Compared to the controls, the treated group had higher albumen weights, yolk weights, shell weights, albumen heights and Haugh units. However, poultry fed garlic powder at a rate of 5, 10 and 15 g/kg reduced yolk weight (Mottaghitalab and Taraz, 2002). Garlic powder added to a corn-based feed enhanced desi laying hen egg output by 8%, but egg weight and quantity did not increase. (Khan *et al.,* 2008). The egg production by layerswent up by 2% when they were fed an all-herb diet with 0.05% garlic powder, 0.3% cinnamon powder, and 0.03% of each dry herb, namely oregano thyme, basil, and rosemary (Gerzilov *et al.,* 2015). It was shown that laying hens' egg production increased when garlic powder was added to their diet at a rate of 1%. One study showed that supplementation of garlic in the poultry diet at the rate of 20 gram/ kilogram (in crushed form) may result in off flavour (Khan *et al.,* 2012). But certain other studies have shown that flavour as well as color of eggs remain unchanged even when garlic powder is consumed upto 30 gram/ kilogram of feed (Olobatoke and Mulugeta, 2011).

Effect of garlic on haematology and blood chemistry

The blood chemistry benefits of garlic have been well demonstrated in the scientific literature. Adding garlic to broilershas been shown to increase total white blood cell count in broilers (Prakash *et al.,* 2021a). There is also improvement in the haemoglobin as well as red blood cells (RBCs) in broilers fed with diet rich in garlic powder (Ismail *et al.,* 2021). However,there is linear reduction in the count of RBCs and osmotic fragility of erythrocytes in broilers under standard temperature conditions when the diet contains increased level of garlic bulb (Varmaghany *et al.,* 2015). The addition of 0.3% garlic to broiler feed for four weeks resulted in a significant increase in white blood cell count but did not affecttotal serum proteins or sensory indices (Fadlalla *et al.,* 2010). A 6% increase in packed cell volume (PCV) was observed in the garlic-supplemented broiler group, as Ufele and Ogbumuo (2018) reported. The drop in hepatic cholesterol level reported in broilers fed a diet containing 2% garlic for two weeks could be due to the depressing action of garlic bioactive components on enzymes such as hydroxymethylglutaryl-CoA reductase, cholesterol 7-hydroxylase, and fatty acid synthetase. Three diets were used to test broiler performance: control (no garlic), 1.5% garlic, and 3.0% garlic. In comparison to the unsupplemented group, the 1.5% garlic diet resulted in lower belly fat content and increased breast weight. Broiler blood cholesterol and cholesterol in the breast and thigh muscles were both reduced by a meal containing 3% garlic powder (Milosevic *et al.,* 2013).

Garlic has been used as hypolipidemic and hypocholesterolemic medicine in folk medicine for hundreds of years. There is a link between elevated blood cholesterol and triacylglycerides in animal protein and cardiovascular disease in humans. Many experts believe that garlic plays a function in lowering cholesterol levels in poultry, particularly broilers, layers, and quails, by inhibiting critical enzymes such as the malic enzyme, fatty acid synthase, glucose-6-phosphate dehydrogenation, and 3-hydroxy-methylglutaryl CoA (HMG) reductase (Omer *et al.,* 2019). The finding of Prakash *et al* (2021a) also is suggestive of the fact that there is improvement in the profile of cholesterol in terms of low-density lipoprotein (LDL); triglycerides as

well as cholesterol in the serum of broiler when plant mixture containing garlic as a crucial ingredient is fed to the birds. When 0.75% garlic is added to the rations of broiler over a period of 8 weeks, the level of total cholesterol decreases in comparison to addition of 0.25% or 0.5% of garlic in the ration (Onyimonyi *et al.,* 2012). Allicin is considered to be the active ingredient present in garlic. As far as the mechanism of action is concerned, there is reduction in the synthesis of cholesterol by allicin thereby preventing thrombosis (Omer *et al.,*2019; Kumar *et al.,* 2021). Garlic's cholesterol-lowering properties may be ascribed to the presence of the steroidal saponins, which may impede cholesterol absorption in the small intestine or directly influence cholesterol metabolism (Lanzotti *et al.,* 2014).

Effect of garlic on intestinal microbiota and morphology

Microorganisms in poultry's digestive systems are dominated by Firmicutes, Bacteroids, and Proteobacteria. Additionally, the gut microbiome is recognised as playing a critical role in regulating host growth and health due to its ability to transfer nutrients from indigestible food substrates, exclude pathogens through competition, detoxify, build the gut barrier, and modulate the immune system (Stanley *et al.,* 2014). Allicin, one of the bioactive molecules in garlic, has been found to improve and renew the intestinal epithelium layer, as well as raise crypt depth and villus height, which improves the digestive system's capacity by increasing nutritional absorption and assimilation (Prakash *et al.,* 2021a). Garlic administration enhanced the diameters of the duodenum, jejunum, and ileum, such as villus height, width, crypt depth, and surface area (Ur Rahman *et al.,* 2017). Navidshad *et al* (2018) also found that villus height is increased due to supplementation of garlic powder in the diet as greater number of nutrients are absorbed and less *E. coli* is present in the intestine when the villi are larger. Adding 0.5%garlic to the broiler diet significantly raised villus height, crypt depth, and jejunum surface area (Mehmood *et al.,* 2015). Increased absorptive surface area of the intestine in broilers fed garlic supplementation (10g/kg feed) was found to correlate with a higher body weight gain (Karangiya *et al.,* 2016). Garlic extract (0.04 to 0.06 g/kg feed) reduced *E. coli*, Clostridium, and *Staphylococcus aureus* levels in the ileocecal digesta of broilers. No differences were found in coliform and streptococcus counts due to the dietary interventions with what and its inclusion level. A decrease in Clostridium levels was attributed to essential oils' antibacterial properties. No matter how few studies are there on the mechanisms by which garlic affects the health and physiology of poultry guts, it is obvious from the results listed above that they help maintain a healthy gut environment by inhibiting pathogenic microbes from multiplication. However, using next-generation sequencing to gain a better understanding of gut/microbe interactions as well as the variety of the gut microbial community, new pathways for enhancing chicken health and productivity will open up (Kothari *et al.,* 2019).

Effectof garlic on control of infectious diseases

Eimeria, Salmonella, Clostridium perfringens, and Escherichia coli have all been successfully treated using garlic-derived feed additives in recent trials in broilers (Prakash *et al.,* 2021a; Prakash *et al.,* 2021b). Elmowalid *et al* (2009) found that supplementing broilers' diets with garlic for three weeks protected them against a multi-drug-resistant strain of *E. coli* O78, with mortality rates dropping from 60% to 10%. The bioactive phenolic and non-phenolic compounds in garlic are thought to be the cause of this impact (Sasi *et al.,* 2021; Kumar *et al.,* 2022d; Kumari *et al.,* 2022). *Eimeria* pathogens die due to the phenolic chemicals in garlic acting on their cytoplasmic membranes and altering their cation permeability (Ali *et al.,* 2019).Garlic extract (40 mg/mL) was effective in treating Cobb broiler chicks infected with *Salmonella typhimurium*. After therapy with garlic extract, the mortality rate was reduced from 53.3% to 13%. Compared to infected non-treated groups, the body weight of infected hens was dramatically improved with garlic extract treatment. Salmonella multidrug-resistant strains couldbe reduced by garlic's capacity to reduce their ability to invade, resist antimicrobial agents, and build biofilms (Salem *et al.,* 2017). Prakash *et al* (2021b) found that supplementation with garlic reduced the caecal

burden of *Clostridium perfringens*, and this was due to the organosulfur components in garlic. Further, it has been found that in order to ameliorate the detrimental effect of *Clostridium perfringens* induced necrotic enteritis, garlic nano-hydrogel at the rate of 400 mg/kg is found to be effective. Chickens infected with *Ascaridi-agalli* could be treated with garlic oil at 2%, 4% and 6% concentrations (Kavindra and Shalini, 2000; Shojai *et al.,* 2016). Reticuloendotheliosis virus (REV) induced inflammation and damage (oxidative) are minimized by allicin. The possible inhibition of the extracellular-signal-regulated kinase (ERK)/mitogen-activated protein kinase (MAPK) pathway by allicin is thought to be responsible for its anti-REV action (Wang *et al.,* 2017a).

Effect of garlic on immune response

Poultry diet and nutrition have an important role in a bird's ability to fight off disease. Several studies have recommended the use of garlic in poultry to prevent disease or improve the immune system. Following vaccination with Newcastle disease virus (NDV), sheep red blood cells (SRBC), and Brucella abortus, Hanieh *et al* (2010) discovered that eating garlic increased humoral immunological activity in White Leghorn. Garlic (10 g/kg diet) enhanced antibody production after immunization against the NDV, SRBC, and BA, probably due to an increase in CD4/CD8 cells (Sasi *et al.,* 2021; Prakash *et al.,* 2021b). Garlic supplementation increased the relative weight of the spleen and thymus, which was related to an increase in lymphocyte proliferation and the quantity of white blood cells (WBCs). Garlic extracts boosted spleen and thymocyte proliferation, as well as IL-2 and IFN-γ gene expression and macrophage reactive oxygen species generation (Wang *et al.,* 2017b).Multi-drug resistant *E coli* O78 was defeated by chicks fed garlic-supplemented diets that increased phagocytosis and strengthened the ability of the chicks to kill the pathogen, as well as reduced nitric oxide production (Elmowalid *et al.,*2009). TLR 2, TLR 4, and TLR 7 gene expression were all significantly increased in commercial broilers fed a diet enriched with garlic powder and holy basil leaf powder (Sheoran *et al.,* 2017). In a study by Toghyani *et al* (2011), who hypothesized that the higher the dose, the stronger the immunological response, there was no influence on immune-related parameters such as antibody titres or the weight of lymphoid organs, albumin-to-globulin ratio or heterophil-to-lymphocyte ratio in broilers.There is a need for further research into the processes of molecular signalling and immune response activation based on the results of the previous studies on the immunological effects of garlic in poultry. Long-term studies on the immunological response of chickens to garlic supplementation will help researchers better understand how to use dietary immunomodulation to reduce the risk of illness and treat it in the field.

Conclusion and future perspectives

Fructans and other fructooligosaccharides (FOS), saponins, and other beneficial substances are found in garlic. The immune responses and intestinal environment of poultry are improved when garlic is fed as a supplement to their feed. This is especially true when poultry is stressed or faced with illness challenges. The extraction, encapsulation, fermentation, and heating operations significantly impact garlic's chemical composition and biological activity. Poultry nutritionists must be aware of the inherent differences in garlic products used in various studies in order to give the appropriate advantages in poultry feed. Because of its bioavailability, garlic as a poultry feed additive could benefit from dosing regimen modifications. This review is expected to motivate the use of garlic as a feed supplement for poultry health and disease control.

Garlic as poultry feed additives provides both opportunities and challenges, as evidenced by the results of the studies cited above. To realize the potential of garlic, both in terms of poultry health and economics, there are a number of obstacles to overcome. More research in this field is hoped to aid us in better understanding the mechanism of action, optimal dosage, and effective delivery routes of these medications. Due to the abundance of bioactive components found in garlic, supplementation with dried extracts is preferable to using a single isolated ingredient. Good management and farming

techniques, together with the synergistic effect of allium and other antibiotic alternatives like prebiotics, probiotics, and organic acids, will be critical to achieving long-term sustainability in poultry production.

Author Contribution

All authors have made a significant intellectual contribution to the work and approved it for publication.

Conflict of interest

The authors declare no conflict of interest.

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