

## Review on Production Potential Areas, Nutrient Composition and Utilization of Garlic (*Allium sativum* L.) as Poultry Feed Additive and Their Effect on Broiler Performances in Ethiopia

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**Abstract:** *Allium sativum* L. (garlic) is the most important species of the onion genus, *Allium* belonging to the family Alliaceae. It is readily available and widely used around the world as it can be grown year round. Various studies have revealed that the species is an asexually propagated plant cultivated since time immemorial. Garlic is best known as a spice and herbal medicine for treatment and prevention of an array of diseases i.e., having health benefits. Several reports are available advocating the roles of these herbs/feed additives in improving growth performance, meat quality, anti-cholesteremic effects and as well as immuno-modulating effects on broiler chickens. This review paper deals with the garlic production in Ethiopia, summarize the nutrient and medicinal values, utilization of garlic as poultry feed additive and their effects on broiler performance, carcass traits and biochemical constituents. This review paper indicates as garlic is a perennial bulb-forming plant that belongs to the genus *Allium* in the family Liliaceae, which has been used for centuries as a flavouring agent, traditional medicine and a functional food to enhance physical and mental health. Garlic is an important cash crop for smallholder farmers in Ethiopia such as Ambo, Debre-Work, Adet, Sinana and many other areas of the Ethiopian highlands produce the bulk of garlic under the small-scale farmer sector. Using of such herbal feed additives is gaining importance in animal production due to ban on the use of certain antibiotics and cost effectiveness. Medical herbs to improve digestibility, antimicrobial, anti-inflammatory, antioxidant and immune-stimulant activity which must be exploited in the feeding of animals as well as a safe food product for human beings. Relative to the previous works done in this review paper tried to include different research papers previous works done regarding with garlic importance with respect to the nutrient quality and utilization of garlic (*Allium sativum*) as poultry feed additive and their effect on broiler.

**Key words:** Ethiopia · Garlic · Nutrient Composition · Broiler Performance · Medicinal Values · Spice

### INTRODUCTION

*Allium sativum* L. (garlic) is a member of the Alliaceae family and it is one of the major vegetable crops known worldwide with respect to its production and economic value. Next to onion, garlic is the second most widely cultivated species in Ethiopia. Growth and yield of garlic are influenced by different nutrient management and other factors during their production in the field. The crop grown both under rain fed and under irrigation. It is best

known as a spice and herbal medicine for treatment and prevention of an array of diseases [1]. Its volatile oil has many sulfur containing compounds that are responsible for the strong odor, its distinctive flavor and pungency as well as for its healthful benefits [2]. Several reports are available advocating the roles of these herbs/feed additives in improving growth performance, meat quality, anti-cholesteremic effects and as well as immuno-modulating effects on broiler chickens [3, 4]. Therefore, this review is aimed to achieve the following objectives:

- To review *Allium sativum* (garlic) production areas in Ethiopia.
- To summarize nutrient composition and medicinal value of garlic.
- To review the utilization of garlic as poultry feed additive and their effects on broiler performance, carcass traits and biochemical constituents.

## MATERIALS AND METHODS

**Data Collection:** Methods of data collection for the present review article was done by searching literature for data on garlic biology, production in Ethiopia, nutrient composition, Abstracts of various research and review articles, Science direct, Web of Science, Animal nutrition Database and Google Scholar.

### GARLIC (*Allium sativum*)

**Garlic Production in Ethiopia:** It was reported that *A. sativum* (2n=16) is the most important species of the onion genus, *Allium* belonging to the family Alliaceae [5]. It is readily available and widely used around the world as it can be grown year round [6]. The center of origin for garlic is central Asia, from which the plant spread worldwide and is now cultivated from mountainous tropical to temperate regions [7].

*A. sativum* is an important cash crop for smallholder farmers in Ethiopia [8]. Ambo, Debre-Work, Adet, Sinana and many other areas of the Ethiopian highlands produce the bulk of garlic under the small-scale farmer sector [9]. It is known as a spice and herbal medicine for treatment as well as prevention against various diseases [10, 11]. According to MoARD [12], in Ethiopia, small growers in the highlands grow garlic traditionally but due to faulty cultural practices, yields are generally low. The yield in large-scale production with irrigation is expected to be about 10 tons per hectare. It is adapted to cool climates and should not generally be planted an altitude below 2,000 m.a.s.l. Amount of rainfall during the growing period (4.5 to 6 months) should be 600 mm to 700 mm. The optimum temperature for growing garlic lies between 12°C and 24°C. Garlic withstands moderate frost. On well-drained soils, rain fed crops may be planted on flat beds; but on heavy soils, which are poorly drained during the rains; it is advisable to plant on ridges as for irrigated crops. It is essential to select land with high fertility or to apply considerable quantities of manure or fertilizers to obtain good yields. The total area under cultivation in the world is 1,199,929 ha with total production of 17,674,893 tones [13]. In Ethiopia, the demand of garlic increasing

and thus its production is increasing from year to year. The area under garlic cultivation is also increasing. The current annual production is estimated to be 222,548 tones on 21,258 ha of land with the productivity of 10.5 t/ha [14].

**Numerous Problems Accounted for the Low Mean Yield of Garlic in Ethiopia:** Among which lack of proper planting materials, inappropriate agronomic practices, absence of proper pest and disease management practices and marketing facilities are the prominent ones. Even though, a number of experiments had been conducted on garlic in Ethiopia, there is a large gap between the work done and the demand of the country for the crop. Past efforts have been engaged in identifying production constraints, improving garlic cultivars and its production practices [15].

**Nutrient Composition of Garlic:** Garlic (*Allium sativum*) is a perennial herb with a bulb divided into segments/cloves [16]. The composition of a garlic bulb varies greatly depending on cultivar, agronomic practices, climate, soil fertility and postharvest storage conditions that determine the quality and intensity of flavor as well as nutritional and nutraceutical values of the crop [8]. This review gives highlights of some important facts regarding therapeutic use of nutraceuticals as the traditional remedies.

In proximate analysis of garlic, chemical/nutrient composition of garlic was analyzed and presented in Table 1. Results showed that garlic contained moisture contents 64.58±2.06, crude protein 7.87±0.32, crude fat 0.52±0.01, crude fiber 2.3±0.08, ash 2.46±0.09 and NFE 22.27±0.95%, whereas dry matter in garlic sample was calculated to be 35.42±1.09 % [17]. As stated by the same authors the results are comparable with the earlier findings of Otunola *et al.* [18]. They showed that moisture, crude protein, crude fat, total carbohydrates, fiber and ash contents in garlic sample were 4.55±0.1, 15.33±0.0, 0.72±0.0, 73.22±0.0, 2.10±0.0, 4.08±0.10%, respectively, on dry basis. Previous findings by Nwinuka *et al.* [19] revealed that garlic contains moisture, crude protein, crude fat, total carbohydrates and ash contents, i.e. 4.88±0.13, 17.35±0.00, 0.68±0.0, 73.03±0.06 and 4.06±0.10% correspondingly on dry weight basis. They mentioned that 100 g of garlic sample provides about 367.64 Kcal.

The results of proximate analysis of garlic powder are also comparable to the research conducted at another group of researchers Odeunmi *et al.* [20] evaluated the chemical composition of garlic and concluded that it

Table 1: Proximate composition of garlic (*Allium sativum*)

Parameter	Quantity (%)
Moisture	64.58± 2.06
Crude protein	7.87±0.32
Crude fat	0.52±0.01
Crude fiber	2.3±0.08
Ash	2.46±0.09
NFE	22.27±0.95

Source: Sajid *et al.* [17]

contains moisture 66.57±1.58%, protein 7.87±0.76%, fat 0.52±0.09%, crude fiber 1.33±0.04%, dry matter 33.43±1.58% and ash contents 0.73±0.19%. Garlic contains at least 33 sulfur compounds, several enzymes, 17 amino acids and minerals such as selenium [21]. Chemistry of garlic is a complex mechanism, which has probably evolved as an individual protective mechanism against microorganisms and other impairment. Garlic is made of portions known as cloves, which may be separated for cooking and eating. Within these cloves, there are quite a few sulfur-containing chemicals, such as allicin, alliin and ajoene [22]. Allicin produces the odor that is characteristic of the garlic bulb. It is produced when the plant tissue is broken, allowing enzymes like alliinase to react with alliin to form allicin. Allicin then acts to protect the plant from further damage [22].

Researches have shown that active components found in garlic are based on organic sulphurous compounds aliin, allicin, ajoene and allylpropyl disulphide [23, 24]. Furthermore, the garlic contains enzymes:  $\alpha$ -allinase, peroxidase and myrosinase, amino acids and their glycosides (arginine and others), vitamins (C, E, A, D and B group vitamins), minerals (iodine, potassium, sodium, calcium, magnesium, selenium, silicon, phosphorus) [25].

**Medicinal Value of Garlic:** *A. sativum* is a perennial bulb-forming plant that belongs to the genus *Allium* in the family Liliaceae, which has been used for centuries as a flavoring agent, traditional medicine and a functional food to enhance physical and mental health. It is an important medicinal herb extensively cultivated in many countries and has played an important dietary function as well as a medicinal role for centuries [26].

The use of antibiotics in animal feed as growth promoters in many countries is prohibited Rahmatnejad *et al.* [27] and there is a growing interest in the use of biologically active compounds from natural sources [28]. Garlic is an important medicinal plant because of its wide range of useful properties not only for human consumption, but also used as an additive in animal

nutrition. It has immune-stimulating properties, many of which are contributed by the oregano sulfur compounds [29]. Recently, two proteins have been identified as the major immune modulator proteins of both raw garlic and aged garlic extract and have been shown to be identical to the well characterized garlic lectins or agglutinins, *Allium sativum* agglutinin (ASA I) and ASA II [30].

Probiotics, prebiotics and medicinal herbs as natural additives are used a lot in poultry nutrition to improve their performance and their health condition [27, 28]. Garlic has an important role because of its broad spectrum of action and availability to poultry breeders [31]. According to the same authors the beneficial effect of garlic on chickens antimicrobial, antioxidant effect, reduced mortality, increased secretion in the stomach, stimulates growth, improves feed efficiency. Antimicrobial compounds produced by microorganisms have been used in animal rations as growth promoters for many years [32]. Antibiotics have been used widely to prevent infections and poultry diseases for the improvement of meat and egg production. However, use of antibiotics is restricted due to drug resistance in bacteria, drug residue in carcass and also the alteration of natural gut microflora [33]. Moreover, use of antibiotics growth promoters is limited in many countries around the world [34]. Removing, these kinds of growth promoters from broilers' diet result in lower growth performance and less resistance against diseases. Therefore, using other alternatives is being concerned. Recently, plant and spices as single compounds or as mixed preparations can play a role in supporting both performance and health status of the animals [35]. Garlic (*Allium sativum*) is a medicinal herb for the prevention and treatment of many diseases [1]. In Ethiopia, many more plants including garlic are used as a spice (condiment) or as herbal medicine for the treatment of various ailments. It has an antibiotic productive performance when added as a food supplement in broiler diets, stimulate the immune system, causes quantitative changes of blood leukocytes, enhances digestion, used as growth promoters, increasing body gain, feed intake and feed efficiency [36].

Many beneficial health properties of garlic are attributed to organosulphur compounds, particularly to thiosulfates [37]. Allicin (diallylthiosulfinate) is the most abundant compound representing about 70% of all thiosulfates present, or formed in crushed garlic [38]. According to Nahor and Zakaria [39], therapeutic use of *A. sativum* has been recognized as a potential medicinal value for thousands of years to different micro-organisms.

For example, antifungal, antiviral, antibacterial, antihelminthic, antiseptic and anti-inflammatory properties of *A. sativum* are well documented. Moreover, *A. sativum* extracts exhibited activity against both gram negative (*E. coli*, *Salmonella* spp. and *Citrobacter* sp., *Enterobacter* sp., *Pseudomonas* sp. and *Kilabsella* sp.) and gram positive (*S. aureus*, *S. pneumonia*, Group A *Streptococcus* and *Bacillus anthrax*) all of which are causes of morbidity worldwide.

**Utilization of Garlic as a Poultry Feed Additive:** Feed contributes about 60-65% of the cost of poultry production. There is an immense demand to reduce feed cost and to utilize efficiently nutrients for higher economic return. Different natural feed additives have gained considerable attention during the last few decades to enhance feed utilization and growth performance of poultry [40].

Plant-derived additives used in animal nutrition to improve performance have been called “phytogenic feed additives” [41]. This form of feed additives has recently become of particular interest for use in poultry production and there have been an increasing number of scientific publications since the ban on feeding antibiotics growth promoters in 2006. In commercial broiler production mainly powder forms or essential oils of garlic (*Allium sativum*), oregano (*Origanum vulgare*), rosemary (*Rosmarinus officinalis*), sage (*Salvia officinalis*), thyme (*Thymus vulgaris*), black pepper (*Piper nigrum*) and chilli (*Capsicum annum*) are used singly or in combination as feed additives [42, 43]. Garlic is one of the most traditionally used plants as a spice and herb. It has been used for a variety of reasons, most of which have been approved scientifically: anti-atherosclerotic, antimicrobial, hypolipidemic, antithrombosis, anti-hypertension and anti-diabetes etc [23]. In addition, this additive has a relatively low market price and it is added in small amounts of 0.2 to 2%, thus not increasing the production costs, which is of particular importance to manufacturers [44].

Moreover, the industrialization of poultry husbandry and the improvement of feed nutritional efficiency have accelerated the introduction of feed additives which became widely used in animal feed for many decades. The objective outlined by scientists, is to increase production (eggs, meat) while maintaining animals in good health. The use of antibiotics in poultry feed as a growth promoter is beneficial in the improvement of production parameters and disease prevention. However, this large

utilization has led to the increasing resistance of pathogens to antibiotics and the accumulation of antibiotic residues in animal products and in the environment. This situation requires the world to restrict using antibiotic growth promoters (AGPs) in animal feed [45]. Therefore, medicinal herbs as potential sources of herbal feed additives for chickens are extended every day [24]. These medicinal plants/herbs as natural feed additives are recently used in poultry and fish diets to enhance the performance and the immune response of birds and fish. In this connection, the garlic plant contains many important components and nutrients beneficial to human and animal nutrition [46]. Therefore, the utilization of garlic (*Allium sativum*) as a food condiment and dietary supplement with great health benefits has been widely reported [23, 25].

**Effect on Broiler Performance:** Feed additives are non-nutritive substances used in poultry feed including antibiotics, enzymes, antioxidants, pellet-binders, antifungal, colored pigments and flavoring agents. Feed additives are generally used to improve feed intake and to increase the growth rate in broilers [47, 48]. For many years feed additives have been widely used to increase animals' performance and recently it has been used in poultry industry to improve growth, feed efficiency and layers performance [49]. Similarly, garlic (*A. sativum*), as feed supplements have recently been reported to exert a wide range of beneficial effects on the production performance (weight gain, feed conversion, egg production and quality) of broilers and laying hens [4, 11].

Phytogenic feed additives or phytobiotics are plant derived natural bioactive products used to improve the performance of animals and in poultry affecting their growth and health, positively. This class of feed additives has recently gained increasing interest, especially for their use in poultry nutrition. Phytobiotics have the ability to positively modulate microflora, improve broiler performance and control pathogen, especially those with zoonotic implications [50].

One category of phytobiotics is essential oils (EO) and their blend, which can exert a variety of production enhancements including the potential for selective antimicrobial effects [51] and enhance digestion [52]. Moreover, Kumar and Berwal [53] showed that the use of garlic oil (*A. sativum*) has anti-tumoral and anti-oxidative properties. Similarly, a British study showed a positive effect of garlic on growth and feed intake in chickens [54].

Coccidiosis is a parasitic disease that influences farm animals and poultry leading to real economic losses. In poultry, this occurs by affecting different parts of intestine therefore impairs feed utilization, decrease broilers growth and egg production of laying hens, causing death of birds and expending a lot of money for vaccination and the inclusion of anticoccidial drugs into the diet for long period [55]. Anticoccidial drugs have been reasonably effective on preventing serious outbreaks of coccidiosis among birds reared for broiler market. However, the life of most of these drugs is limited due to the emergence of resistant strains of *Eimeria* [56]. Therefore; a pressing need for an alternative method of control is required due to necessity for cheap and safe uses. Essential oils from garlic (*A. sativum*) supplements were evaluated as a natural alternative bioactive compound in broiler diet, which possess antimicrobial activity [57] that could be responsible for the growth promoting effect of garlic. It is recommended that supplementation with 15% of garlic per kilogram of feed will lead to an optimal reduction in cholesterol deposition and support the performance of broilers through its antibacterial and antioxidant effects [58].

Effect on carcass traits: Apart from the inadequate supply and consumption of animal protein, there has been a resurgence of interest in improving the physicochemical and sensory properties of meat, as well as its storage life. In pursuit of improved chicken healthiness and in order to fulfill consumer expectations in relation to food quality, poultry producers more and more commonly apply natural feeding supplements, mainly herbs [59].

Garlic powder as a natural growth promoter can be a potential alternative to common artificial growth promoters like antibiotics and in this respect, it can improve performance and carcass characteristics/traits in broiler chickens [54, 60]. The effect of garlic supplementation on carcass traits of chicken as conducted by Pourali *et al.* [61] is given in Table 2. Carcass traits of broilers were not significantly affected by dietary garlic supplementation. However, abdominal fat was numerically lower when higher levels of garlic were used. These results are in agreement with those of Javandel *et al.* [62] who showed no significant difference in carcass traits among birds fed garlic powder in the range of 0-2%.

**Effect on Serum Biochemical Constituents:** According to the clinical routine procedures outlined by Olorede *et al.* [63], the serum biochemical constituents were determined:

Table 2: Effect of garlic supplementation on carcass traits of chicken in 42 days

Garlic%	Carcass yield% <sup>1</sup>	Breast <sup>2</sup>	Thigh <sup>2</sup>	Pancreas <sup>2</sup>	Abdominal at <sup>1</sup>
Control	66.3	33.9	37.1	0.26	1.90
0.2	67.5	32.9	36.9	0.29	1.86
0.4	67.8	33.1	36.6	0.29	1.89
0.6	68.1	34.3	38.2	0.30	2.05
0.8	67.37	33.4	37.1	0.27	1.81
1.0	67.1	41.1	38.5	0.31	1.84
±SEM	1.444	1.243	1.536	0.113	0.207

<sup>a,b,c</sup>values in each row with no common superscript differ significantly (P<0.05); <sup>1</sup>as a percent of live weight; <sup>2</sup>as a percent of carcass weight. Source: Pourali *et al.* [61]

Mansoub [23] and Stanacev *et al.* [25] observed that serum total cholesterol and triglycerides concentration were significantly reduced by dietary inclusion of garlic compared to the control group in broilers. Garlic manifested hypocholesterolemic effects on chickens through inhibition of the most important enzymes that participate in the synthesis of cholesterol and lipids [25, 64]. Similarly, Konjufca *et al.* [65] stated that garlic reduced plasma cholesterol by decreasing the activity of 3-hydroxy-3-methylglutaryl reductase. However, Oleforuh-Okache *et al.* [64] revealed that the other serum biochemical constituents like total protein, albumin and globulin except urea when broilers were supplemented with 1 g/kg garlic which showed a positive effect.

According to Kumar *et al.* [66], on serum biochemical parameters indicate that there was significant reduction in glucose, cholesterol, Serum glutamate oxaloacetate transaminase (SGOT) and Serum glutamate pyruvate transaminase (SGPT) concentration due to *A. sativum* supplementation in broiler chickens' diets. Moreover, Jimoh *et al.* [67] reported that linear decrease was observed in the serum level of total cholesterol, low-density lipoprotein (HDL) and triacylglycerol but progressive increase in high-density lipoprotein (HDL) was obtained from the birds fed with garlic-supplemented diets when their sera were analyzed. This indicated that the garlic powder has a modulatory effect on cholesterol and lipid metabolism and can elicit hypocholesterolemic effects. As the supplementation levels of garlic increases, there was a progressive decrease in the serum total cholesterol and Low Density Lipoprotein (LDL) but High Density Lipoprotein (HDL) increases.

## CONCLUSION

From this review, garlic is a perennial bulb-forming plant that belongs to the genus *Allium* in the family

Liliaceae, which has been used for centuries as a flavouring agent, traditional medicine and a functional food to enhance physical and mental health. Numerous problems accounted for the low mean yield of *Allium sativum* in Ethiopia: among which lack of proper planting materials, inappropriate agronomic practices, absence of proper pest and disease management practices and marketing facilities are the prominent ones. Use of such herbal feed additives is gaining importance in animal production due to ban on the use of certain antibiotics and cost effectiveness. Medicinal herbs to improve digestibility, antimicrobial, anti-inflammatory, antioxidant and immune-stimulant activity which must be exploited in the feeding of animals as well as a safe food product for human beings. Herbal infusion of *A. sativum* can be effectively used in broiler production to stimulate immunity and improve their performance. Carcass traits of broilers were not significantly affected by dietary garlic supplementation. On serum biochemical parameters indicate that there was significant reduction in glucose, cholesterol, Serum glutamate oxaloacetate transaminase (SGOT) and Serum glutamate pyruvate transaminase (SGPT) concentration due to *A. sativum* supplementation as feed additives in broiler chickens' diets. Similarly, as the supplementation levels of garlic increases, there was a progressive decrease in the serum total cholesterol and Low Density Lipoprotein (LDL) but High Density Lipoprotein (HDL) increases. It is therefore important to research on standardization of correct dosages of garlic/herbal feed additive for particular function need to be studied. Herbal medicine among the Ethiopian people therefore calls for serious investigation.

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