EFFECT OF GARLICPOWDER SUPPLEMENTATION ON PRODUCTIONPERFORMANCE, MEAT QUALITY, BLOOD PARAMETERS AND LIPID PROFILE OF COOB 500 BROILERSCHICKEN.

MSc. THESIS

BY

MELAKU MULUGETA DAGNE

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Thesis

Submitted to the Department of Animal sciences, college of Agriculture and Veterinary Medicine, Jimma University, in Partial fulfilment of the Requirements for the Degree of Master of Science in Agriculture (Animal production)

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MSc THESIS APPROVAL SHEET

We, the undersigned, member of the Board of Examiners of the final open defense by **Melaku Mulugeta** have read and evaluated his/her thesis entitled **"Effect of Garlic Powder Supplementation on Production Performance, Meat Quality Blood Parameters and Lipid Profile of Coob 500 Broilers"** and examined the candidate. This is therefore to certify that the thesis has been accepted in partial fulfillment of the requirements for the degree Master of Science in **Animal Production .**

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DEDICATION

This thesis manuscript is dedicated to my beloved Mother and grandmother who passed away without seeing my Success. They were believed that I would thrived nevertheless they haven't been with me.To my close relatives and honoured friends for all the sacrifices, wishes and admirable to my success in all my activities.

STATEMENT OF THE AUTHOR

I, the undersigned, declare that this Thesis is my work and is not submitted to any institution elsewhere for the grant of any academic degree, diploma or certificate and all sources of materials used for this Thesis have been properly acknowledged.

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BIOGRAPHICAL SKETCH

MelakuMulugeta was born on December 1991 from his mother Aster Zelelew and his Father Mulugeta Dagne in Bure district, IluAba Bor zone, Oromia region; Ethiopia.He completed his Elementary and Junior Education in July 2005 at Chore Elementary School and attended his Secondary education in Bure Nicolas Bohm Secondary high School from September 2006 to June 2007. He successfully completed his secondary education and enrolled Bako Agricultural, Technical and Vocational training College starting from September 2008 to July 2010 and graduated with Diploma in animal science. He was employed in government office from September 2011 to August 2014 at Ilu Aba Bor zone, Bure woreda livestock resource and fishery development office. He joined Jimma University College of Agriculture and Veterinary Medicine to pursue his B.sc degree in animal science starting from September 2015 to June 2016. After graduation again he joined Jimma University, School of Graduate studies for the Degree Master of Science in Animal production from October 2017 to 2018.

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ABBREVIATIONS

ACC	Acetyl COA carboxylase
AGP	Anti-Growth Promoters
AOAC	Association of Official Analytical Chemists
APC	Anti-gene presenting cell
CRD	Complete randomized design
DADS	Diallydisulphide
DAS	Dially sulphide
FAO	Food and Agricultural Organisation
FCR	Feed Conversion Ratio
FI	Feed Intake
GALT	Gut associated lymphoid tissue
GLM	General Linear model
HC	Haemoglobin concentration
HDL	High Density lipoprotein
JUCAVM	Jimma university college of agriculture and veterinary medicine
LDL	Low Density lipid
MCHC	Mean corpuscular haemoglobin concentration
MCV	Mean corpuscular volume
NADH	Nicotine amide dinucleotide
NADPH	Nicotine amide adenine dinucleotide phosphate
NBF	Neutral buffered formalin
PCV	Platelets count volume
PLC	platelets cell
RBC	Red Blood cells
SAC	S-allyl cysteine
WBC	White Blood cells
WHO	World Health Organisation
USDA	United States Department of Agriculture

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ABSTRACT

Feed is the major bottleneck of poultry production in Ethiopia. Therefore, the aim of this experiment was to evaluate the effects of different level of garlic powdersupplementation on production performance, meat quality, blood parameters and lipid profile of coob 500 broilers chicken. A total of 180 unsexed day old (Coob500) broiler chicks were randomly allocated to four dietary treatments within three replicates in completely randomised design (CRD). The chickens were fed on three phase basal diets; starter, grower, and finisher diets. The dietary treatments consisted of T1=control (basal diet +0% of garlic powder), T2 (basal diet +1% of garlic powder, T3 (basal diet +3% of garlic powder), T4 (basal diet+5% of garlic powder). Growth performance, carcass yield and meat quality, haematology, serum biochemical and economic analysis were observed. All data were subjected to General linear model procedure of (SAS version 9.3, 2011). The result revealed that the chickens kept on T3 showed the highest (P<0.05)final body weight (2390.71g±14.96g), feed intake (4264.54g±25.92), low and better feed conversion efficiency (1.77±0.002), followed by group of birds fed on T2 final body weight (2185. 23g±51.29g), feed intake (3945.32g±169.1) and feed conversion ratio (1.80 ±0.04). The group of chickens kept on T4 attained the lowest growth performance (final body weight 1936.42g±34.06, total feed in take 3645g± 59.37and feed conversionratio(1.84±0.028). The highest dressed weight, drumstick with thigh , breast meat, and back weight was obtained from the group of birds fed on T3. The group of chicken fed on T3 showed the highest crude protein percentage (22.95±0.132) of breast meat as compared with T1 (17.77±0.69). Blood analysis revealed that T3 has showed the highest Total white blood cells count and lymphocyte (18.91±1.7 x 103/ul; 75.83 ± 6.05 percent as compared with control (T1)13.13±1.02 x 103/ul, 61.056±*6.05 percent. The serum analysis of the broilers chickens fed different garlic level was significantly (P<0.05) different between the treatments. The low blood cholesterol content was observed in T3 and T4. The Group of chickens fed on T3 have chol(110.5mg/dl±10.83mg/dl),triglycerides(77.16mg/dl±12.15mg/dl), and T4 chol (108.66mg/dl±6.34mg/dl), triglyceride(104.16mg/dl±15.734mg/dl) as compared with T1 (control)185.33±28.28mg/dl,153.153 ±11.35mg/dl). There was significant (p < 0.05) increase in the level of high density lipoprotein in T3 (91.43±1.03 mg/dL) in comparison with other treatments.The partial budget analysis of the garlic supplementation illustrated that T2 and T3 had showed more net return (10347.55 ETB) and (11085.60ETB) as compared with control group (10000.4$_{ETB}$).The lowest net income was obtained from the birds fed onT4 (7431.50ETB). Thus, it's concluded that supplementation of garlic powder at1-3% level showed significant improvement in overall performance, haematological, biochemical profile and achieved best net return. Hence, to make efforts and more Comprehensive extra investigation should be desired on efficacy of garlic extract , garlic husk and leafs of the plant in the diferrant regions of the countries.*

Key word: Blood profile, Broiler chicken, Carcass yield,coob500,Garlicpowder,Growth performance, supplement.

1. INTRODUCTION

1.1. Background and Justification

The availability of feed is the key factor that limits poultry production in the world in general and in developing nations in particular. Feed is a major segment of production in poultry industry and thus efforts are usually made in poultry industry to increase the efficiency of feed utilization to minimize per unit cost of production (Ashayerizadeh *et al*, 2009). In livestock production it's intended to obtain maximum levels of production with minimum wastage of nutrients and at minimum feasible cost (Negash, 2017). Feed problem for poultry production in Ethiopia is not only the prices and availability but also their low quality (Mammo, 2012). In Ethiopia, nutritional factors are the prerequisite constraint to sustain livestock production. According to the survey conducted by Adriaan*et al*., (2012)poor production and high mortality rate areamong the major constraints of poultry production in the country.

Consequently, the more effective and promising approaches to increase feed efficiency in poultry industry is utilization of additives(Chen *et al*. 1997). Additives are substances that are added to nutritionally balanced diet which provoke response towards the exploitation of maximum genetic potential of the host in terms of growth and feed conversion efficiency. There are different types of additives like antibiotics, probiotics, prebiotics, plant extract, exogenous enzymes, antioxidants, coccidiostats etc. which are used to exploit the broiler industry (Dhama*et al*; 2007; Angelaski*et al*; 2013). In the concept of the production of healthy farm animals, using additives can regulate feed intake, stimulate digestive secretions, optimise digestion capacity and reduce risk of digestive disorders (Upadhaya and Kim, 2017).

A manipulation of gut function and microbial habitat of domestic animals with feed additive has been recognized as important tool for improving growth performances and feed efficiency of livestock. Substantial growth in poultry industry has been observed mainly due to the exploitation of various modern growth promoting strategies and appropriate disease preventive and control measures (Katariа*et al*., 2005; Angelakis*et al*., 2013). Natural feed additives exhibit antibacterial properties and protect the avian digestive tract against various pathogenic Bacteria.Plants and plant derived products have multiple effects on animal

including stimulateappetite, enhance digestive secretion, immuno-stimulant, bactericidal, antiviral, antioxidants and are termed as phytogenic (Hashemi and Davoodi, 2011).

On the other hand, antibiotics have ruled the poultry industry since several decades as a growth promoter. However, due to their over usage, bacteria has developed resistance against them thus threatening human community with the emergence of extremely drug resistant pathogens (Yadav *et al*., 2016). Besides negative effect of antibiotics, high cost of conventional medicines and vaccines coupled with the lack of knowledge on their use make these drugs usually out of reach of the small-scale farmers. Due to these negative effects, organizations such as the World Health Organization (WHO), the American Medical Association and the American Public Health Association have urged a ban on growth-promoting antibiotics (AGPs). In contrast, commercial interests have argued that their removal will have a significant impact on the cost of production and is unlikely to affect the risk to humans from antibiotic-resistant infections (Caswell *et al.*, 2003). This fact has made it necessary for the feed industry to use alternatives to antibiotics to maintain good production and health of poultry as well as livestock (Dhama, 2014).

Nowadays, nutritionists are shifting from chemical growth promoter to phytogenic growth promoters. Among the currently available poultry feed additives, natural herbs and plants have been widely advocated due to their reported widespread beneficial effects. Garlic is among those potential natural feed supplements and phytobiotics frequently used in animal nutrition; which has been reported as having a wide range of beneficial effects on the production performance and physiological biochemistry of broilers and laying hens (Demir, 2005; Singh, 2017). It gained the trust of many scientists and cultural remedies all over the world for the prevention and treatment of many diseases and is broadly dispersed and consumed as a spice and herbal medicine for thousands of years (Mahmoud *et al*., 2010). Because of its broad spectrum of action and availability, garlic has a special place to poultry breeders as well (Fadlalla*et al*., 2010; Stanacev*et al*., 2010a). Substantial evidences (Kim *et al*., 1997; Konjufca*et al*., 1997; Lewis *et al*., 2003)suggest that the active component of garlic has some beneficial effects for livestock, having hypocholesterolemic effects and growth-promoting and antioxidant activities.

Studies carried out on the chemical composition of the garlic shown that sulfur compounds such as Allicin are important constituents of the plant. Sulphur compound helps defend off many diseases and harmful microorganisms as they too cannot tolerate levels of sulphur that are harmless to the birds. It contains more than thirty three sulphur compounds, vitamins (A, B1, C), enzymes, minerals,Fiber, water, amino acids (Josling, 2005).

Hypo-cholestromic effect of garlic has positive advantage to realize consumer health, as a result, majority of people benefits greatly from poultry meat and eggs, which provide food containing high-quality protein, and a low level of fat with a desirable fatty acid profiles (FAO, 2010). But, the effects of active ingredients on performance and health of animals are in-consistent, since they are affected by a number of environmental and agronomical factors.No clear-cut effect of phytogenic compounds on performance parameters in different species of poultry has been reported (Rehman, 2015). Herbs are yet untapped resources to be used as poultry feed to overcome high cost of feed in poultry farming, exploring cost effective alternatives isvery crucial to poultry producers.In Ethiopia,disease remains one of the principal causes of poorlivestock performance (Teshale, *et al., 2004*). However, Ethiopian plants have shown very effective medicinal value for some complaints of human and domestic animals thus medicinal plants and knowledge of the peoples provide a vital contribution to livestock health care (Teshale*et al*.,2004.Yeneayehu, *et al.*, 2017)

The different survey studies in conducted Ethiopia indicated that the use of herbal plants for livestock has been practiced by farmers (Mesfin and Obsa., 1994,Endashaw., 2007)and they perceived that these herbs have positive effect on animal performance thus about eighty percent of the Ethiopia people and ninety percent of livestock depend on Traditional medicine for their health care (Regassa, 2013). Garlic is one of these commonly used herbs in the country both for human and livestock.

A research conducted byZena*et al*. (2017) tried to address effect of garlic and other herbs on carcass characteristics however it is limited to carcass parameters and the experiment conducted by Tesfaheywet*et.al.*, (2017) at Haramaya university also tried to address the impact of garlic powder on some blood parameterswhich was off course conducted on egg type chicken breed.However, little scientific investigation has been conducted whether herbs have positive effects or not on livestock in general and chicken in particular.

Generally, in search of cost effective feed additives for chicken, this research has been initiated and conducted other than exploring alternative feed resources, this research may give clue on cholesterol deposition condition in the carcass of chickens which is becoming a public concern currently.

1.2 General objective

To evaluate the effect of garlic supplementation on production performances, meat quality,blood parameters and lipid profile of coob 500 broilers

1.2.1. Specific objectives

- ☞ To evaluate effect of garlic supplementation on the growth performances *of coob500* broiler chicken
- ☞ To evaluate effect of garlic supplementation on mortality rates of coob500 broilerchicken
- ☞ To evaluate effect of garlic supplementation on carcass yield and quality parameters of coob500 broiler chicken
- ☞ To examine effect of garlic supplementation on the range of haematological and biochemical parameters of coob500broiler chicken
- ☞ To evaluate cost- benefits analysis of the experimental diet

Research questions

1. Does garlic supplementation has effect on growth performance of broilers?
2. Does garlic supplementation has effect on carcass qualities of broiler chickens?
3. What is the effect of garlic supplementation on hematological and biochemical parameters of chicken's product?
4. How feasible is using garlic as a supplement to chickens? (Cost benefit analysis)
5. At what level of supplementation is garlic useful to the broiler breedunder thestudy?

2. LITERATURE REVIEW

2.1 Agronomic and Therapeutic Property of Garlic

Garlic is one of the most ancient cultivated herbs, vegetative propagated from cloves and which is the most important bulb vegetables, used as spice and aromatic plant for foods and aids as medicinal plant. The seasonal and annual variations in rainfall severely impede the productivity of garlic.Brewster (1994); Lemma and Herath (1994) reported that garlic is one of the most widely cultivated Allium species and a wide array of climatic and soil adaptation it is more productive in regions with a mild winter with some rainfall followed by a sunny dry summer, which is good for maturity and harvesting the bulbs. Rubatzky and Yamaguchi (1997) indicated that garlic plants are very hardy tolerate too low and even some freezing temperatures, although in some areas of extreme cold it may not survive the winter Garlic production occurs in most countries ranging from the equator to about the 500 latitude and grows best within the range of 12-24^{0C} temperature (Nonnecke, 1989).

High temperatures are required for bulb development, but cooler conditions in the early stages favor vegetative growth and elevations from 500-2000 meters above sea level provide suitable growth condition (Rice et al., 1990). Excessive humidity and rainfall are detrimental to the vegetative growth and bulb formation. Insufficient moisture and water logging easily stress plants. Therefore, to attain maximum yield, moisture in the top 30 cm of soil should be maintained close to field capacity for growth (Brewster, 1994; Rubatzky and Yamaguchi, 1997).The plants are also influenced byday length. Long days and high temperatures during the growing season encourage bulb formation. Garlic is sensitive to moisture stress throughout the growing season. Any period of dry soil conditions, especially during bulbing will result in yield reductions. Where enough rainfall is not available, then irrigation is a requirement for this crop to provide satisfactory yields. Garlic grows best in well drained fertile soils that are high in organic matter.
http://www.nda.agric.za/docs/Brochures/prodGuideGarlic.pdf.

Even though, irrigation is available in all areas, it requires a huge financial and capital investment; as a result, rain fed agriculture may continue to play a major role in the near future, especially in areas with sufficient rainfall. Bulb crops require a supplemental irrigation

where rainfall is insufficient (Tilahun*et al*., 2011). Garlic is a high-value crop, which requires rich soil, good drainage, friable soil-preferably with high organic matter content, and water should not be deficient during bulb formation until two weeks before harvesting time. Excess supply of water two weeks before harvesting time affects the storage quality and the crop prefers a soil with a pH of 6.5-7.5 as it is sensitive to higher acidity (Bachmann, 2001; Potgieter, 2006). The most suitable soil types for garlic crop growth are sandy loam to sandy clay loam, and very fine sandy loam (silts) soils, deep mineral topsoil, well drained muck soils and relatively high (greater than 2.0%) in organic matter are ideally suited for growing bulb.Garlic is used as a seasoning in many foods worldwide, without garlic many of our popular dishes would lack the flavour, attractiveness and character that make interest to eat well.

Garlic (*Allium sativum*) is the most popular food ingredients used widely all over the world and herb known for its flavor and bitterness and most widely quoted for medicinal properties (Nagourney, 1998, Hertog and Katan 1998). The plant has a fan like hollow bluish-green leaves with the bulb at the base. On maturation, bulb swells, the foliage dies down in the autumn and the outer layers of the bulb become dry and brittle. The crop is harvested, dried and are ready for use or storage (Bisen and Emerald, 2016**).**Vegetable and fruits provide great amount of antioxidant phyto-chemicals like vitamins C and E, phenolic compounds (Flavonoids), vegetable pigments (anthocyaninsand carotenoids), sulphur compounds (Yang*et al*., 2004; Sharma *et al*., 2005). Garlic gain especial attention as a plant with exceptional disease preventative and therapeutic properties used in treatment of variety of disease such as toothache, constipation, parasitic infestation, arthritis, insect bites, and infectious diseases as natural antibiotic (Rivlrn, 1980). Garlic demonstrates a number of pharmacological effects *viz.* cancer chemoprevention, antibiotic, antihypertensive, anti-diabetic, antithrombotic and cholesterol- lowering properties (Srivastava, 1995).Garlic contains different chemicals having antimicrobial and antioxidant properties, Allyl sulphides exert multiple, antifungal, anti-inflammatory and immune-enhancing activity and can regenerate liver tissue (Amagase *et al*., 2001; Tatara*et.al*., 2005; Kandil*et al.,* 1987).

2.2 Garlic Production in Ethiopia

In Ethiopia garlic is the most known cultivated species and showed to be best cash income generating activity for farmers who have scarcity of land and small holder farmers.The increased population of the country has led to a new awareness of the importance of vegetable crops as source of food accompanied by the realization that many of them can supply essential nutritional and medicinal materials, which may not be readily available from other sources (Asfawand Eshetu, 2015). Regardless of its importance and increased production, garlic yield and quality is affected by various biotic and abiotic stresses, among which low and/or excess mineral nutrition, irrigation schedule or rainfall are the major ones (Jalel*et al*., 2007;Cheruth *et al*., 2008).Thus, efforts have been engaged in identifying production constraints, improving garlic cultivars and its production practices (Getachew and Asfaw, 2010).Garlic known by its quality traits, such as flavourof the plant thus to be utilized as spice. To broadcast the production and expandmaintaining of vegetative propagated crops in the gene bank requires more efforts than generatively propagated crops. Cryo-preservation isthe most efficient technique for these crops (Keller *et al.*, 2007).

In Ethiopia, small growers in the highlands grow garlic traditionally but due to obsolete cultural practices, yields are generally low (ENAIA, 2003). Diverse crop management problems and the nature of propagation accounted for the low yield of garlic in Ethiopia; major production constraints include lack of proper planting material (improved varieties), inappropriate agronomic practices, absence of proper pest and disease management practices and marketing facilities, and lower soil fertility status in many soil types particularly N and P nutrients (Getachew and Asfaw, 2000).

2.3 Secondary Metabolites of Garlic

Garlic contains an active ingredient called alliinwhich is converted by the enzyme allinase into allicin up on crushing the garlic aerobically (Lanzotti, 2006).The transiently formed compound,allicin, comprises 70–80% of the thiosulfates. Allicin instantly decomposes to other compounds, such as diallylsulphide (DAS), diallyldisulfide (DADS), dithiins and ajoene. At the same time, g-glutamyl cysteine is converted to S-allylcysteine (SAC), via a pathway other than the alliin–allicin pathway (Ran*et al*., 2011). The intermediate compound is

alkyl sulphonic acidwhich has the capacity to acidifythe digesta of animals and the sulphides released from allicin exert strong antibacterial and antioxidant activity (Sallam*et al*., 2004; Lanzotti, 2006; Bozin*et al.,* 2008).Allicin is thought to be a transient compound that is rapidly decomposed into other sulfur containing compounds and is not a genuine active compound of garlic. Processed garlic contains a wider variety of organosulfur volatiles than the intact garlic clove. Typical volatiles that have been identified in crushed garlic and garlic essential oil include DAS, DADS, diallyltrisulfide, methylallyl disulfide, methylallyltrisulfide, 2-vinyl-4H-1, 3-dithiin, 3-vinyl-4H-1, 2-dithiin, and (E,Z)-ajoenes(Amagase, 2006).

Chemical composition of garlic may be affected by Season, Soil type, Stage of maturity and Plant material (plant leafs, bulb, husk) to be used. Abundance of natural oil and watersoluble sulfur-containing organo-sulfur compounds is responsible for the characteristic flavor and pungency of garlic having several pharmacological significance whereas intact undisturbed bulbs of garlic contain only a few bioactive components. An odorless amino acid, alliin is found in intact garlic which gets converted by an enzyme allinase into allicin responsible for the characteristic odor when cloves are crushed (Block, 1997). The spontaneous decomposition results to form numeroussulfur -containing compounds, some of which are having chemo preventive activity.

Many researchers investigatedthe effects of regular feeding of garlic andits' provision on the performance of broilers. Most of these studies reported a statistically significant improvement in broiler performance and cumulative feed conversion ratio. Garlic increases growth and improves feed conversion ratio (Tollbaand Hassan, 2003). Addition of plant product to poultry diet had positively affected the growth performance and physiological activity of animals due to antioxidant activity, antimicrobial, antiviral and anticoccidialeffects and increase intestinal availability for absorption of essential nutrients, stimulating secretion of digestive enzymes, increasing motility of stomach and intestine (Aksit*et al*., 2006; Hashemi and Davoodi, 2010; Gregacevic*et al*., 2015).Provision ofgarlic extract continuously in commercial feed as a feed supplement caused a significant improvement in the body weight of broilers and their parameters (Brzóska.*et.al.*,2015).

2.4.1 Metabolic activities of garlic in chickens

Medicinal herbs had multiple additional potentials compared to antibiotic feed additives and can be used as alternative to antibiotic growth promoters in metabolic activities of animals. The supplementation of herbs in the animal diet was observed to have beneficial effects. Report of different researchers revealed that the inclusion of herbal supplement as alternatives of antibiotics showed significant difference in animal performance; enhance digestions, immune condition and blood profiles of chickens. Using of garlic in broiler diet with small dose affects lipid metabolism.Thomson *etal., (*2006) reported that raw garlic is more beneficial than the cooked form in reducing blood lipid and glucose levels, and could potentially play an important role in preventing atherosclerosis or diabetes.

The research conducted by Rafeeq *et.al*., (2017) revealed that supplementation of feed with *Allium sativum*in particular and *C. angustifolia*and *A. scoparia*to some extent had beneficial effects on performance parameters, gut microbial population and permeability through lipid bilayers of phosphor-lipid vesicles.In biological systems allicin (allyl 2-propene thiosulfinate) can penetrate very rapidly into different compartments of the cells and exert its biological effects (Miron *et.al.* 2000). Varmaghany*etal*.(2015) reported that inclusion of 5 g/kg garlic bulb in broiler chicken diets reduced the systolic blood pressure, right ventricle, total ventricle ratio, packed cell volume, total mortality, and ascites-related mortality under cold temperature condition.It is successfully applied in poultry production and exhibits very potent antiviral,bactericidal, antifungal, and anti-parasitic properties (Gautam and Garg, 2013).

2.4.2 Effect of garlic on growth performance of chickens

Phytogenic substances are supposed to increase performance of birds by stimulating secretion of digestive enzymes, leading to enhanced digestion and absorption (Geier, 2003; Recoquillay, 2006). Incorporation of garlic in animal diet can hasten the growth performances of animals (Singh *et al*., 2015; Elagib*etal*., 2013; Zekik,*et al.,* 2014). Moreover, the existence of active ingredients and phenolic compounds enable to reduce numbers of intestinal pathogens, thus minimizing nutrient loss and improving performance. Both effects may result in better intestinal health and may lead to more protein deposition in body tissues.

2.4.3 Effect of garlic on lipid metabolism in chicken product

Garlic supplement was affecting lipid and cholesterol metabolism (reduced plasma and liver cholesterol and reduced plasma triacylglycerol's) without having a significant effect on overall performance or breast muscle cholesterol (Konjufca, 1997). Garlic has lipotropic effec**ts** containing sulfur organic compounds including *S-Methyl cysteine sulfoxide* (SMCS) and *S-allylcysteine*suiloxide (SACS) is related to decreasing of blood lipid, liver protein and glucose. It is well known that dietary garlic effectively lowers serum cholesterol levels in experimental rats as well as in humans. Diallyldisulphide (DADS) which is principal sulphur compound in garlic is known to decrease plasma and liver tissue lipid levels, as it inhibits the enzymes Acetyl COA carboxylase (ACC) whosemost important function is to provide the malonyl-CoA substrate for thebiosynthesis of fatty acids and HMG COA reductase.

This action of DADS may be due to its capacity to reduce cellular NADH / NADPH as the breakdown of DADS requires NADH / NADPH. Such a reduction in NADH /NADPH decreases the fatty acid and cholesterol synthesis as their synthesis requires NADPH.It undergoes exchange reaction with –SH group containing compounds in the body.

The results demonstrated that garlic (*Allium sativum*) and wild garlic (*Allium ursinum)* may reduce serum cholesterol levels primarily by inhibiting cholesterol synthesis if taken in sufficient amount and that this effect arises from a mixture of multiple compounds from the sulfur-containing class of thiosulfinates, ajoenes and dithiines. Wild garlic extracts showed nearly identical efficiency to garlic extracts (Sendl *et al.,* 1992).

In farm animal different research had been conducted on efficacy of garlic as best alternatives of antibiotics in decreasing blood cholesterol, high density lipid and triglyceride. The regulation of lipid metabolism to reduce the abdominal fat content based on dietary composition and feeding strategy, as well as elucidating their effects on the key enzymes associated with lipid metabolism could facilitate the production of lean meat and help to understand the fat-lowering effects of diet and different feeding strategies (Fouad and El-Senousey, 2014).

The reduction of serum LDL and raising HDL cholesterol by increasing garlic powder inclusion had been observed (Toghyani*et al*., 2011) .This may in turn improve weight gain of the animals at a better cost of energy because lean growth is much more efficient than the accretion of body fat.It requires approximately four times the amount of energy to grow one pound of fat tissue as compared totheenergy required to grow one pound of lea tissue. (http://www.Nationalhogfarmer.com/mag/farming_understanding_lean_growthan).

Garlic has a dose-dependent inhibition effect on hepatic β-hydroxy-β-methylglutaryl coenzyme A (HMG-CoA) reductase, cholesterol 7α-hydroxylase, and fatty acid synthetase. Diets containing 1, 2, 4, 6 and 8% level of garlic reduced serum cholesterol by 18, 21, 21, 24, and 25%, respectively (Qureshi *et al*., 1983). Using of herbs as growth promoters in animal diet may not show any residual effects on consumers.Dietary garlic supplementation can reduce palmitic acid, short chain fatty acid (SFA), and serum and meat cholesterol content and increase unsaturated fatty acids (UFA) in chickens (Qureshi *et al*., 1983). Inhibition ofcholesterol synthesis by garlic supplementation is due to abundance of Compounds like allyl-disulfide or allyl-sulfhydryl groups (Singh and Porter, 2006).

2.4.4 Effect of garlic on meat and carcass quality

Meat quality has received a great deal of attention from food manufacturers, small traders, as well as public institutions and health centres. Food quality is considered to be the most difficult to define the concept of the food industry, which has become particularly acute problem (Brunso*et al*., 2004).However the quality of meat production is determined by sustainability and safety of food chain (Akkerman*et al*., 2010).The supply of meat which is wholesome, safe, nutritious, and of high quality to the consumer will ensure continued consumption of meat. In developed countries consumers are increasingly demanding meat products which are of high quality. In order for livestock industries to consistently produce high quality meat, there must be an understanding of the factors that cause quality to vary and implementation of management.

Appearance of meat was very imperative to determine quality of meatimportant appearance traitsof a given meatare colour, texture, fat colour, amount and distribution of fat as well as the absence of excess water in the tray. Once cooked, consumer satisfaction is largely

determined by how tender the meat is as well as its flavour/odour and juiciness (Glitsch, 2000).

Consumer desires meat to be valuable to their health in contributing nutrient (minerals, vitamins, high value protein, and possibly essential fatty acids). Composition of poultry meat are affected by many factors; feeding (Gardzielewska*et al*., 2005)and genotype of birds (Genchev*et al*., 2005; Alkan*et al*., 2010) are among these factors. In pursuit of improved broilers health and in order to fulfil consumer expectation in relation to food quality, poultry producers commonly apply natural feeding supplements, mainly herbs (Gardzielewska*et al*., 2003).

Now days, herbal products have been used as growth promoters.The ingredients found in herbs used as digestion stimulants and facilitates growth of broiler chicken(Frankic*et al*., 2009; Jo *et al*., 2009; Goodarzi*et al*., 2013). Supplementation of garlic at different level had been reported as effective in improving quality of meat.Zekic (2014) reported that inclusion of garlic powder in amount of 2% in broiler diet had significant influence on scientific quality of chicken breast meat. Fadlalla (2010) reported that using garlic at 0 .3% in broiler chicks feed resulted in significant positive effect on growth performance and carcass yield.

2.5 Effects of Garlic on Haematological and Morphological Characteristics Chickens

Hematological parameters are the numbers and morphology of the cellular elements of the blood like the red blood cells (erythrocytes), white cells (leucocytes), and the platelets (thrombocytes) ,hemoglobin and other that used for diagnosis and monitoring of disease (Merck , 2012).

Garlic was used for treatment of bird suffering from different microbial diseases due to pharmacological properties of garlic and its ingredients. Garlic has been shown to reduce risk factor of cardiovascular diseases ranging from improving blood circulation **(**Ernst, 1987).Garlic extracts significantly improved haemato-biochemical parameters in chicken (*Showkat et al.,* 2014).

Alliums at low levels in the diet improved the humoral immune response against Brucella abortus (non-replicating T-cell independent antigen) in chickens (Hanieh, *et al*, 2010). Garlic Extract stimulate the proliferation of lymphoid organ cell like spleen cells, release of

cytokines and phagocytises (the ability of Immune cells to engulf foreign agents) of peritoneal macrophages. Immune enhancing effects of commercial garlic preparations was studied and it was found that aged garlic extract was the most effective for improving immune cells, particularly macrophage and T-lymphocyte activity (Odiase *et al*, 2017) .

Garlic supplementation in the diet of birds was reported to enhance absorptive surface villus height and crypt depth, and facilitates epithelial thickness insmall intestine (Adibmoradi *et al*., 2006). These morphological alter in the bird's state improvement innutrient utilisation. Ramakrishma *et al*. (2003) reported that garlic supplementation possibly enhanced the activities of the pancreatic enzymes and balance micro flora for better utilization of nutrient.

Using garlic as feed additives in poultry improved intestinal morphological characteristics like villi length and small crypts in birds receiving 0.5% garlic powder containing diet as compared to control group (Saeid *et.al.*,2013; Singh*et al.*, 2017)

2.6. Mechanism of Garlic in Animal Cells

Beneficial effects of herbs in farm animals may arise from activation of feed intake and enhancing digestive secretions, immune stimulation, anti-bacterial, coccidiostatic, anthelmintic, antiviral or anti-inflammatory activity and inhibition or - particularly - antioxidant properties (Kiczorowska*et al.*, 2017).The mechanism of garlic to modulate gut micro flora include disrupting the cell membrane of the targeted pathogens by increasing membrane permeability, inducing leakage of vital intracellular constituents, and interrupting the cellular metabolism and enzyme kinetics of the targeted pathogen (Swamy, 2016). Poor performance and increase susceptibility to diseases in birds have been attributed to the pathogenic micro flora in the gut competing with the host for nutrients and causing sub-clinical infections (Tekeli *et al*., 2011).

Therefore, any mechanism that targets reduction of this competing microorganism would lead to improvement in the performances of the animals. Study by Oladele*et al*.,(2012) indicated that garlic has the ability to increase the digestive and absorptive capacity of the small intestine of commercial broilers by increasing the cryptal depth as well as the absorptive surface area of the intestine i.e. villi length and width. It is also suspected that garlic is very effective in regulation of lipid metabolism in a favourable manner with the aim for prevention

of atherosclerosis or coronary heart diseases of people who consumed meat products from garlic fed chicken.

Garlic may also thin the intestinal wall thereby facilitating nutrient absorption,due to presence of a compound known as allin,garlichas potency to change blood profiles of animals; the secondary metabolites of garlic like phenolic and sulphur compound actively interact with blood to bring biochemical change.The significance of allicin (derivative of allin) as a biological effectors molecule is dueto its high reactivity with low and high molecular weight thiols and its prominent antioxidant activity (Rabinkov, 1998; Ankri, 1997; Miron, 1998).The inhibitory activity ofGarlic (*Allium sativum*and its curative potency has been reported to be due to the presence of garlic active components like flavonoids, alkaloids, steroids and triterpenes. According to the report of Sofowora(1993) and Okigbo*et al.*,(2009b) flavonoids are one of the secondary metabolites of garlic which has potent water-soluble antioxidants and free radical scavengers, which prevent oxidation, cell damage, lower the risk of heart diseases. Alkaloids have been documented to possess analgesic, antispasmodic and bactericidal effects.

Garlic has antimicrobial properties due to inhibition characters of phenolic compounds of garlic. Delaha and Garagusi (1985) demonstrated that garlic has been proven to inhibit the growth of gram positive, gram-negative and acid-fast bacteria, as well as Toxin production. It is also effective against bacterial strains of Pseudomonas, Proteus, Escherichia coli, taphylococcus aureus, Klebsiella, Salmonella, Micrococcus, Bacillus subtilis, Mycobacteriu, and Clostridium, which may be due to the presence of flavonoids, alkaloids, steroids and triterpenes (Olusanmi, 2010).

2.7. Preparation of Garlic and Ways of Feeding Chickens

Garlic is fed to animals either as raw or dried cloves, after processing in the form of oil, garlic extracts and garlic powder with differences in chemical composition and bioactive compounds content between the various forms (Lanzotti*et.al*.,2014).Drying is one of the preservation methods in which water content and water activity of the fruits and vegetables are decreased by heated air to minimize biological, chemical and microbial deterioration (Papu*et. al.,* 2016). Unless care is taken quality of garlic may deteriorate.

Themajor quality problems faced during garlic drying are loss of flavor, discoloration and poor rehydration characteristics of the dried garlic.Drying garlic slices with a low–temperature heat in the oven should preserve the allin compound and enzyme allinase to give the powder allicin–potential content. When the allin and allinase disintegrate on contact in the intestinal

system, it gets converted into allicin.(https://www.researchgate.net/file.PostFileLoader.html?id...assetKe).

A lot of researchhas been done on the active ingredient and heat sensitivities of compounds in garlic. The product keeps its structure in proper conditions at low processing temperatures and thus the potential to form allicin remains almost intact. At high temperatures (i.e., 60^{oC}), however, enzyme denaturation as well as product collapse can cause a clear reduction in the potential to form allicin(Rati *et al*, 2007). The chemical composition, structure, and cellular arrangement of garlic powder at the end of the drying process were different from those of the fresh (López, *et.al*, 2013).Temperature had an important effect on hot air-drying and freeze-drying kinetics, the maximum allicin retention was obtained for freeze-drying whole cloves at 20^{oC}. Allicin content decreased as temperature increased in air drying but the influence of temperature on the loss of allicin was more pronounced for hot air-drying (Rati *et al*, 2007).

Garlic can be supplemented in to chicken diet in the form of either powder (Pourali, 2013; Issa, 2012) or extracts (Vivian *et al*., 2015, Safdar, 2016). Garlic powder contains many of the same components as raw garlic;one of the most well-known components allicin is linked to many health benefits. Mariam and Usha (2016) shownthat dried garlic powder contains good amount of vitamin C which is a powerful antioxidant and good amount of sulfur compound which has cholesterol lowering activities.

2.8. Inclusion Rate of Garlic in Chicken Diets

So far different inclusion rate hasbeen reported in the literature with different results. Fadlalla *et al*, (2010) reported that the optimum inclusion rate of garlic for growth performance and carcass yield was found to be 0.3%. However, it was also reported that adding higher amounts of additives may result in negative effect primarily through the depression of feed intake and other effects. Higher doses have depressive effect on consumption anddue to presence of

certain anti nutritional substances, reduce the daily gain (Melosevic*et .al*., 2013). Otunola *et. al.*, (2010) stated that garlic contained up to 4.6% of saponin and 1.2% of flavonoid in dry matter which is one of the factors causing the depressive effect on production performance of broilers. Increased repulsive odour and taste of garlic is also expected to reduce feed intake and there by performances of birds (Pourali*et .al.*,2010). Garlic at levels of 1% and 3% had no significant effects on relative weights of carcass, fat pad, or digestive organs among different treatments except for the small intestine (Raeesi*et al.*, 2010).

2.9. Economic Benefits of Garlic as Feed Additives in Broiler Diet

In poultry industry feed additives have been widely used for long period of time as contrivance to increase animal productivity which is related to growth, feed efficiency and health condition. About 80% of domestic animals have been fed synthetic compounds for the purpose of either medication or growth promotion (Lee *et al*., 2001). Cost of Feed accounts for 60-80% of the total expenses in poultry production. Any operation must have clear targets how to optimize feed efficiency and reduce feed cost and work daily towards those targets (Zekic*et al*., 2010)

The use of natural additives in poultry industry has got attraction, due to positive improvement of the herbal plants on productive performance, immune enhancement and highest return on investment. Accordingly, the effect of feeding broiler chicks on diets containing different levels of garlic powder as natural feed additive on productive performance, carcass characteristics and economic efficiency were studied by different scholars. It was reported that garlic supplementation tohave positive impacts on total return of the investments.

Moreover, the use of plant additives in broiler can improve the quality of product by decreasing bad cholesterol in broiler meat without adverse effect on human health. Economic feasibility of garlic had been reported by different authors even thoughit depends on dose of inclusion, part of plant used and availability of plant parts to the area.Safam *et al*., (2014)reported that the broiler diet with 3% level garlic powder shown the highest profitability ratio as compared to the control group.Singh (2017) reported thatSun dried garlic powder at 1.5% levels is an easy and economical alternative to antibiotic growth promoters

besides helping in production of consumer oriented meat.Zekic*et al. (*2014) concluded that the addition of commercial garlic powder in amount of 2% in broilers Chicken diet had significant influence on production performance, higher final body weight, as well as on the nutritive and technological quality of chicken breast meat. Okoleh and adeolu (2014) demonstrated that, Inclusion of 14g per kilogram of diet garlic powder found the least cost-benefit ratio, implying that it is the best diet from the economic point of view.

3. MATERIALS AND METHODS

3.1 Description of The Study Area

The experiment was conducted at Jimma University College of Agriculture and Veterinary Medicine (JUCAVM) poultry farm starting fromDecember toJune. Jimma town is found 350 km away from Addis Ababa and lies between 36°50´E longitude and 7°40´N latitude,1700 m.a.s.l. elevation: temperature (meanmax: 26.8^{0}C and mean minimum: 11.4 ^{0}C, humidity (mean maximum 91.4% and mean minimum39.92% (BPEDORS, 2000).

Jimma has a tropical rainforest climateunder the Kopen climate classificationit features a long annual wet season from March to October. The climate situation suits for livestock production which include large and small ruminants, poultry and beekeeping. In Jimma, south eastern Ethiopia, farmers produce garlic under rain fed condition during both winter (August-December) and summer (March-July) cropping seasons for consumption and commercial purpose (Getachew and Asfaw, 2000).

3.2. Experimental Design and Treatments

A total of 180 unsexed day-old broiler chicks (Cobb-500) were purchased fromAlema commercialpoultry farm in Bishoftu and transported to Jimma University College of agriculture and veterinary medicines. Healthy, active and alert chicks of similarbody weight(48.29g±0.166g) were used for this study. The initial weight of chicks were taken before onset of the experiments andthe chicks were in similar range of body weight and kept in similar management up to the end of the trial except treatment feed.

The experimental chicks were randomly divided into12 (4 dietary treatmentswith 3replication) experimental pens;in each experimental pen 15 chicks were randomly assigned. Finally the treatmentfeeds were allocated to the experimental chicks with completely randomised design(CRD).The arrangement and treatment allocation of the experiment is presented in table (1). The experimental feeds (treatments) were T1= control (basal diet without garlic powder), T2 = basal diet with 1 % garlic (10g garlic powder/1kg of feed), T3=basal diet with 3 % garlic (30g garlic powder/1kg of feed) and T4= basal diet with 5% garlic (50g garlic powder /1kg of feed). Basal diet was blended with the different level of

garlic powder by the aid of vertical blending machine at JUCAVM feed processing unit for 10 to 15 minutes.

Table 1.Experimental treatment allocation

Treatment	Replication	Chicks/rep	Chicks / treat
Commercial broiler ration + 0% (0gram of Garlic powder **(T1)**	3	15	45
Commercial broiler ration +1% (10 gram of garlic powder per 1 Kg of feed**(T2)**	3	15	45
Commercial broiler ration +3% (30 gram of garlic powder per 1 Kg of feed=**T3)**	3	15	45
Commercial broiler ration +5% (50 gram of garlic powder per 1 Kg of feed**(T4)**	3	15	45
Total	-	-	180

3.3 Experimental Ration

The commercial broiler rations were purchased from Alema koudijis feed plc which is located in Debrezeit. Commercial mash type feed was used throughout the experiment to make uniform with the supplement. Three phase of feeding system were used starter phase (0-10 days) which contained crude proteins (20.5%), crude fat (6.5%), crude fibre 5.5%, calcium (0.9%), Energy (3000kcal/kg andmoisture (10%). Grower phase which contained(11-22 days) crude protein (19%), crude fat (9%), crude fibre (5.5%), calcium (0.75%), Energy (3150 kcal/kg), moisture (10%) and finisher diets which contained (23-42 days) crude protein (18%), crude fat (6.5%, crude fiber (8%), calcium (0.65%), Energy 3250kcal/kg and Moisture 10% . The chemical composition of the commercial feed was taken from Alema koudijis feed plc.

3.3.1 Preparation of garlic powder

Garlic bulbs were purchased from Jimma market after which they were peeled with knife coarsely chopped and dried under the sun continuously for three days until constant weight is recordedand dried bulbs were grinded into powder using the feed grinder at JUCAVM with uniform size.

3.4. Management of the Experimental Chickens

All the experimental birds were reared under uniform management conditions for 42 days at JUCAVM poultry farm. The whole house was cleaned, disinfected with formalin and potassium per Manganate before thestart of the experiment. Houses were preheated before on set of chicks for 48 hours, both floor and ambient temperature was stabilized. The experimental pens were slightly littered with properly dried saw dust and covered by newspaper from (0-10 days) then after saw dust littered floor were used in the pen up to the end of the experiment. Good hygiene practice was maintained the litter was changed with dry one when necessary; drinker and a feeder were cleaned two times a day up to the end of the experimental period. The chicks were vaccinated against Marek's disease on one days, Newcastle disease (HB1) on day 7 and lasota on 21 day through ocular routesandother routine poultry management practices were carried out neatly and uniformly.

Ventilation, light, room temperature was adjusted as per the recommendation of (Cobb Broiler management guide, 2008). The lighting program consisted of a period of 23 hrs light by using infra-red followed by 1hr of darkness during brooding stage. The ambient temperature was gradually decreased from 34 °C to 24 °C on day 21 and then kept constant up to the end of the experiment.To avoid introduction of any disease disinfectant(formalin) for the footbath was in placed on entrance of the house and boot-change or wearing system was incorporated at each entry to the poultry house for bio security.

3.4.1 Feeding and watering practices

Feed was provided in mash form and placed on paper for the first two weeks and offered on hanging trays up to the end of the experiment. Feeders were arranged in the house in a uniform pattern so that it is accessible to chicks from all corners equally. The length of the feeder was raised - gradually throughout the growing period based on growth condition of the chicks. The chickens were fed starter, grower and finisher diets from day 0 - 10, 11-22, 23 to

42 respectively.Clean and fresh water was provided daily to chickens adlibtum andrefilled as necessary. Waterer was put on the ground in the first growth phase then hanged up to the end at the level of the birds' back to prevent from contamination.

3.5.Data Collection

3.5.1 Performance parameters

Body weight was recorded at 10, 21, and 42 days using degital balance; weight gain was computed by subtracting the initial weight from the final weight and dividing by the number of experimental days. Feed offered and refused were measured daily up to the end of experimental period and feed intake was calculated for each experimental group by subtracting feed offered from feed refused and FCR is usually used to calculate weight gain to feed eaten in chickensor inputs to out puts so its was calculated as;

$$\text{FCR} = \frac{\text{Total feed consumed (g)}}{\text{Body weight gain (g)}}$$

3.5.2. Mortality

Mortality rate of the chicken were recorded in each pen as it occurred. It is expressed as percent mortality at the end of the experiment.

3.5.3 Carcass yield

At the end of the study two broilers one male and one female were rondomly selected from each replication based on the group average weight for carcass evaluation. The birds were slaughtered as recommended by (Moran, 1995) after being starved for 16 hours except for water.

The dressedweights were estimated as:- commercial cut plus edible offal plus viscera.

Dressing percentage was calculated as percent of live weight it'smeasured by dividing dressed weight to live weight of the birds multiplied by hundreds.Each bird was slaughteredand bled for about three minutes.The weight of different commercial cut of the carcass (breast meat, drumstick with thigh, wing, neck, back), and different organ were measured (liver, heart, proventriculus, gizzard, pancreases, spleen, and small intestine)by using digital balance.

3.5.4Sensory evaluation

For sensory evaluation, fresh breast meat was slightly salted and roasted for30 minutes in a standard commercial oven. Ten panellists were selected from the students and staffs. Criteria were settled for recruitment: age between 20 and 45 years, willing to evaluate the meat with full interest, no information was given to panel members about the meat or the experimental treatments. Testing carried out on the same day and at the same time, all panellists were presented with a plate containing four sampled meat based on the treatments. Panellists were instructed to record their responses for each attributes and oriented to fill an evaluation form immediately following the test and identified the meat samples that they most preferred on vital traits (Flavour, Tenderness and Juiciness) by using five scale hedonic rating(Singh*et al*, 2014).

PH measurement: -ph. of the meat was determined at JUCAVM dairy laboratory. The pH meter was calibrated with standard buffers of pH 4.0 and 7.0 before insertion of electrodes and thenthe pH was measured by directly inserting the electrodes in the breast muscle using a pH meter (Mettler Toledo/ MB 220, UK) in each sample group (Olivo*et al*., 2001).

3.5. 5. Chemical analysis

Proximate composition of garlic and chicken breast meat (DM, crude protein, crude fat and crude ash) were determined at JUCAVM animal nutrition and post-harvest and food analysis laboratories according to (AOAC, 1995). Dry matter content of the sample was determined by oven drying at 105^{o}c for 24 hours. The total ash was analyzed by igniting dried samples in muffles-furnace at 550 ^{o}C for 24 hours and then the content was determined. Nitrogen was determined by using micro kjehldahl techniques. The amount of crude protein in the sample was calculated as 6.25*nitrogen. Ether extract was calculated by using Soxhlet Apparatus.

Vitamin C was determined using the method described by Sowa and Kondo (2003). Briefly, 1% starch indicator solution was prepared in a beaker by adding 0.50 g soluble starch to 50 ml distilled water-near boiling. The mixture was mixed well and allowed to cool before use. Iodine solution was prepared in a beaker by dissolving 5 g potassium iodide and 0.268 g potassium iodate in 200 ml of distilled water. Thirty ml of 3 M sulfuric acid was added to the solution and the solution was diluted to final volume of 500 ml with distilled water. Finally the solution was labelled as Iodine Solution. Vitamin C standard solution was prepared in a beaker by dissolving 0.250 g ascorbic acid in 100 ml distilled water and diluted to 250 ml with distilled water in a volumetric flask. Finally the flask was labelled as Vitamin C standard solution. Vitamin C of the sample was determined by titrating 10ml of the extract with Iodine solution until the end point was reached. Ten ml of the sample was taken to volumetric flask and 10 drops of 1% starch solution was added and shaken properly until the end point was reached. The endpoint of the titration is the first permanent trace of a dark blue-black colour due to the starch-iodine complex that persists after 20 seconds of swirling the solution. The volume of Iodine solution used up for titration was recorded by subtracting the starting volume from final volume. The titration was repeated with further extracts of sample solution until the results agreed with 0.1 ml and the average was used for final calculation. Finally the amount of vitamin C found in the samples was estimated from the volume of titrate required for standard solution.

3.5.5 Haematological and biochemical parameters

Two birds wererandomely selected from each group after which 2-5ml blood samples were withdrawn quickly through wing vein using a 5ml heparinised syringes and collected in a test tube with anti-coagulant EDTA for haematological analysis andwithout anti-coagulant for biochemical analysis. Subsequently, haematological parameters including haemoglobin concentration (HC), red blood cell count (RBC), white blood cell count (WBC), mean corpuscular haemoglobin concentration (MCHC), mean corpuscular haemoglobin (MCH), mean corpuscular volume (MCV) and lymphocyte, neutrophils, platelet count (PLC) wereanalysed using Auto-haematology analyser system (Sysmex XT-1800i, Germany). Biochemical parameters such as cholesterol (CHOL), triglycerides (TG), and high density lipoprotein (HDL) were analysed by using clinical chemistry analyser (Bioteqnique, Italy), from the serum blood at Jimma University.

3.5.6Partial budget analysis

Economic feasibility was calculated depending on the expense and gross income of the products. Partial budget analysis was conducted to determine the profitability of the supplementation of garlic powder in broiler ration. The analysis took into consideration of all variable cost like the cost of chicks, feeds, labour, garlic and other materials that were used. The analysis involved calculation of the variable cost and profits of the experimental diet . Net income (NI)) of the experimental group were calculated as the amount of money left when total variable costs (TVC) are subtracted from the total returns (TR) as follows (Knott *et al*. 2003):

NI = TR - TVC

The change in Net income (ΔNI) or Net return (ΔNR) were calculated by the difference between change in total return (ΔTR) and the change in total variable costs (ΔTVC) as follows (Knott et al. 2003):

ΔNI (= ΔTR - ΔTVC

The marginal rate of return (MRR) measures increases in net income (ΔNI) associated with each additional unit of expenditure (ΔTVC) and it was calculated as follows (Knott *et al*. 2003).

MRR= (ΔNI/ΔTVC) Where:

NR: net return.

TR: total return.

TVC: total variable cost.

3.6 Data Management and Statistical Analysis

All data gathered during the study period were coded and recorded in Microsoft Excel 97-2003. Preliminary data analysis like homogeneity test, normality test and screening of outliers was employed before conducting the main data analysis. All data analysis was subjected to General linear model procedure of SAS (version 9.3, 2011). Tukey's comparison test was employed to identify significant differencebetween the treatments at ($P<0.05$)the results were articulated as means and standard error of the means.

The model used**:**

$y_{ij} = \mu + Ti + e_{ij}$

Where:

Yij=the observation taken at the i^{th} feed levels

μ = overall mean

T_i = the effect due to i^{th} treatment (control group,1% garlic powder, 3% garlic powder and $5^{\%}$ garlic powder).

e_{ij} = random residual error

4. RESULTS AND DISCUSSION

4.1 Chemical Composition of Garlic Powder

The values of chemical analysis of garlic powder (moisture, dry matter, crude protein, crude fat, ash and vitamin content) arepresented inTable 2. The chemical composition of garlic for current result was moisture (66.8), dry matter (33.12), protein (5.474), fat (1.35), ash (2.99) and vit 'c' 0.49$m_{g/100g.}$The current result is slightly similar with the result of Raja *et al*,. (2014) who reported that the moisture and protein content of Tunisian garlic were 66% and 5.2 %, respectively. The crude protein content of current result is also slightly comparable with that of Puranik, *et al*., (2012) who reported that 6.3% protein for Indian garlic. However, the current crude protein content of garlic (5.474%) is lower than the report of Otunola *et al*. (2010) and Sajid*et al*., (2014) who reported that 15.33% and 7.87%,respectively for Nigerian garlic. The chemical composition of garlic was seems vary from country to country based on agroecology ,variety and others possible variation.

The value obtained in this study for ash (2.99%) content is placed within range of values obtained by Casado *et al*., (2004) who reported that, the ash content of garlic ranged between 2.65% and 8.40% for Spanish garlic. The moisture content of garlic in current work is comparable with report of Blumenthal and Mark(2000) and Odebunmi *et al*.,(2010) who reported 65% and 66.57%, respectively for Nigerian garlic. The variation on chemical composition of garlic might be due to the differences in their botanical origin, variety, agronomic factors, processing, and composition the plant material.

Table 2. Chemical composition of garlic

parametres	Percentage
Moisture	66.8
Dry matter	33.12
Crude protein	5.474
Crude Fat	1.35
Ash	2.99
Vitamin c	0.49$m_{g/100g}$

g=gram, mg=milligram

4.2. Growth Performance

4.2.1 Starter phase

The growth performance of broiler chicken fed different levels of garlic powder for starter phases (1-10 days) is summarizedin Table 3. The supplementation of different levels of garlic powder in broilers diet showed insignificant difference (p.>0.05) between treatments in all response variables except for feed intake. There was significant difference (p<0.05) between the treatment in feed intake. T3 significantly different from T1, T2 and T3but there is no significant difference between T1, T2 and T4 on feed intake during starter phase .The highest feed intake(359.20g±3.84) was recorded for T3 and the lowest was recorded for T1, T2, T4 (321.71g±3.3,T2 338.09g±4.84 and T4 333.43 g ±2.83 respectively. The improvement of feed intake on T3 might be due to positive influence of garlic in stimulating appetite of broiler chicken.Phytogenic substances have antioxidant propertiesand supposed to increase feed intake of birds through stimulating secretion of digestive enzymes, leading to enhanced digestion and absorption (Geier, 2003;Recoquillay, 2006; Kiczorowska *et al,* 2017).

The current result is supported by Raesi *et al*(2010) whoreported that addition of 1 and 3% garlic to basal diets at starter period had no significant effect on average daily gain, body weight. Singh *et al*, (2015) also concludedthat incorporation of garlic powder at 1.5% in broiler diet had better performance during starter and overall period than the control group. In ContraryIssa *et al*., (2012) reported that supplementationof Garlic powder at 0.2and 0.4 %during the first three weekshad no significant effect on feed intake of broilers.

Table3. Means and Standard errors of growth performance for starter broiler chicks fed different levels of garlic powder.

Response Variables	T1	T2	T3	T4	Overall mean	P- value
Initial body weight	48.67±0.134	48.37±0.195	48.19±0.152	47.93±0.17	48.29± 0.16	0.0702
Final body weight	232.42±4.56	233.54 ±5.54	237.55±5.19	240.79±5.39	236.07±5.19	0.6639
ADWG g/b/d	18.37±0.44	18.52±0.57	18.93±0.50	19.28±0.55	18.78±0.52	0.663
FI g/b	321.71±3.3 [b]	338.09±4.84[b]	359.20±3.84[a]	333.43±2.83[b]	338.1108±3.79	0.0008
ADFI g/b/d	32.17±0.33[b]	33.80±0.48[b]	35.92±0.38[a]	33.34±0.28[b]	33.81±0.37	0.0008
FCR(g/g)	1.38±0.03	1.39±0.02	1.372±0.03	1.38 ±0.03	1.38± 0.035	0.9715

([a], [b], [c])Means in the same row with the different superscript are significantly different (P<0.05) between the treatments, T1= 0% of garlic powder, T2= 1% of garlic supplementation, T3= 3% of garlic powder) T4= 5% of garlicpowder, FCE=feed conversion efficiency, g= gram, g/b/d (gram per bird per day), ADFI = average daily feed intake, ADWG =AverageDaily weight gain)

4.2.2 Growerphase

The mean growth performance of chickens at grower phase (11-22 days) is presented in Table 4. There is significance difference between the treatment at ($p<0.05$) on body weight, daily weight gain, feed intake and daily feed intake, T3 was significantly different from T1 however there is no significant different between T2, T3, and T4.The highest body weight(1033.77± 40.7g) and average daily gain g/b/d (52.61±2.02) was attained for group of birds fed on T3 whereas the lowest body weight and average daily weight gain g/b/d was attained for group of birds fed on T1 (979.22g±17.56, 46.54g±0.87).

The highest totalfeed intake wasobserved for group of chicken fed on T3 (1012.33±4.23 and the lowest was observed for group of chicken fed on T1 (924.66g±34.57) and T4 (914.80g±14.34).The positive effect of garlic powder supplementation on increasing body weight might be due to positive effect of garlicon increasing nutrient digestibility and altering the microbial composition of gastrointestinal flora.Peinado *et al*. (2013) found that the substances derived from garlic increased nutrient digestibility and the activity of intestinal mucosa enzymes in broiler chickens.Improvement of broilers performance can be achieved by supplementation of diets with garlic powder (Sivam, 2001, Lewis *et al*., 2003 ;).

The current result is supported by Brzóska *et al*. (2015) who reported the dietarysupplement at the levels of 1.545g and 2.75 g/ kg significantly increased growth performance compared to control group and Lucanov *et al*., (2015) also demonstratedthat dietary garlic powder supplementation from0.2 to 0.8% increase in live body weight throughout thefattening period

Table 4.Means and Standard errors of growth performance for grower broiler chicks fed different levels of Garlic powder.

Response Variables	T1	T2	T3	T4	overall mean	P- value
Final body weight	979.22±17.56^{b}	1008.44±12.22^{ab}	1033.77±40.7^{a}	1003.68±1.53^{ab}	1022.94± 1.45	0.025
ADWG g/b/d	46.54±0.87^{b}	48.43±0.61^{ab}	52.61±2.02^{a}	47.78±0.08^{ab}	48.7± 1.42	0.0193
FI g/b	924.66±34.57^{b}	989.11±5.32^{ab}	1012.33±4.23^{a}	914.80±14.34^{b}	960.2275±19.02	0.0166
ADFI g/b/d	92.4±3.45^{b}	98.91±0.53^{ab}	101.23±0.42^{a}	91.48±1.43^{b}	96±1.90	0.0166
FCR(g/g)	0.94±0.03	0.98±0.01	0.92±0.03	0.911±0.003	0.94±0.028	0.3778

(^{a}, ^{b}, ^{c})Means in the same row with the different superscript are significantly different (P<0.05) between the treatments. T1= 0% of garlic powder, T2= 1% of garlic supplementation, T3= 3% of garlic powder) T4= 5% of garlicSupplementation, FCE=feed conversion efficiency, g= gram, g/b/d (gram per bird per day) ADFI =average daily feed intake,ADWG (Average Daily weight gain.
FI= feed intake

4.2.3 Finisher phase

The growth performance of chickens supplemented with different garlic powder for finisher phase (23-42) wasindicated inTable 5. There was significantly different ($p<0.05$) in all response variables (body weight, daily gain, feed intake .daily feed intake, feed conversion efficiency. The highest performance was attained by the group of birds fed on T3 whereas the lowest performance was obtained for the chickens fed on T4.The group of chickens fed on T3 during finisher phase (22-42days) attained significantly higher ($p<0.05$) final body weight (2390.71g±14.96), average daily weight g/b/d (64.5196±0.97and average daily feed intake g/b/d (140.01g±1.20)followed by group of birds fed on T2which attained final body weight of (2185.23g±51.29g), and average daily weight gain of (59.04±2.48g).The birds fed on T4 obtained the lowest final body weight1936.42g± 34.069, average daily weight gaing/b/d(46.64.41±1.69g), average daily feed intake(116.72g±2.5).Totalfeed intake g/bird andaverage daily feed intakeg/b/d of chickens in all phases showed significant difference ($p<0.05$) between the treatments. T3 significantly different from T4 however there is no significant difference between T3, T 1 and T2.

A group of chickens fed on T3attained significantly ($P<0.05$) higher feed intake (4164.54g±25.92g) and average dailyfeed intake g/b/d(101g±0.61). The birds fed on T4 obtained the lowest feed intake(3645 ±59.37g), average dailyfeed intake g/b/d (86.78g±1.41).Feed conversion ratio was significantly ($P<0.05$) improved in birds fed T3 as compared with control however T2 and T4 was no significant difference with control group. The best and low feed conversion efficiency was recorded for group of birds fed onT3 (1.77±0.002) as compared with T1 (1.916±0.02).

The improvement of growth parameters on T3might be due to the presence of bioactive compounds of garlic. On the other hand, the reduction on production performance of the chickens on T4 provided with increased garlic supplement might be attributed to the fact that higher level of garlic may have depressive effect on feed intake,due to presence of certain anti-nutritional substances (Melosevic*et .al*. 2013).Garlic contain antinuitritional factors which inhibits digestive enzymes if it supplemented above required. Otunola *et. al.*(2010)Stated that garlic contained up to 4.6% of saponin and 1.2% of flavonoid in dry

matter which is one of the factors causing the depressiveeffect on production performance of broilers. Increased repulsive odour and taste of garlic is also expected to reduce feed intake and there by performances of birds (Pourali*et .al;*2010).

Improvement of feed conversion ratio in T3 can be attributed to active ingredients in garlic that promotes the gut micro flora which in turn improve digestion, enhance the utilization of nutrients. The better-feed conversion ratio can be attributed to the antibacterial properties of the garlic powder which resulted in better absorption of the nutrients in the gut and leading to improvement in feed conversion ratio (Tollba and Hassan 2003).

The current work is in line with the report of Raesi *et.al*. 2010; Elagib *et.al*. , 2013; Varmaghany.*et.al*. (2014) who reported that the best production performance were achieved by the group of chicken fed the diet supplemented with 1% and 3% of garlic powder and the lower performance were attained by the group of birds fed 5% level garlic powder (Elagib*et.al* , 2013). Zekic (2014) and Ramiah*et. al*. (2014) reported that inclusion of commercial garlic powder in amount of 0.5 and 2% in broilers chicken diet had significant influence on production performance of in broiler chicken.The current finding is in contrary with the report of Pourali *et al*. (2010) who reported that garlic supplementation at 0.2, 0.4, 0.6, and 1.0% had insignificant influence on growth performance of chicken.Onibi *et al. (*2009) andFadlalla *et al.* (2010) also reported that garlic powder had no significant effect on the body weight gain and feed conversion ratio of birds which is opposite to the current finding.

Table 5.Means and Standard errors of growth performance for finisher broiler chicks fed different levels of garlic powder.

Response Variables	T1	T2	T3	T4	Overall Mean	P- value
Final Body Weight	2017.97±61.35^{bc}	2185.23±51.29^{b}	2390.71±14.96^{a}	1936.42±34.06^{c}	2132.58±44.10	0.0004
ADWG g/b/d	51.93±3.11^{b}	59.04±2.48^{bc}	64.5196±0.97^{a}	46.64.41±1.69^{c}	55.48±2.51	0.0066
FI g/b	2744.50±158.68^{ab}	2739.99±158.68^{ab}	3080.59±26.52^{a}	2567.97±59.37^{b}	2816.071±74.99	0.0335
ADFI g/b/d	127.753±5.3^{ab}	127.5±7.75^{ab}	140.01±1.20^{a}	116.72±2.35^{b}	128±4.66	0.0058
FCE(g/g)	1.39±0.024	1.28±0.05	1.28±0.04	1.32±0.015	1.32± .03	0.1123
Overall(1-42)						
Feed Intake	3869.60± 147.26^{ab}	3945.32± 169.1^{ab}	4164.54± 25.92^{a}	3645± 59.37^{b}	3923.894±116.9	0.0337
ADWGg/b	46.89±1.46^{ab}	50.87±1.21^{b}	55.77±0.36^{a}	44.96±0.81^{c}	49.62± 1.05	0.0004
DFI g/b	92.13±3.5^{ab}	93.93±4.02^{ab}	101±0.61^{a}	86.78±1.41^{b}	93.42±2.78	0.0394
FCR	1.96±0.02^{a}	1.84±0.04^{ab}	1.77±0.002^{b}	1.88±0.022^{ab}	1.84±0.028	0.0231

(^{a}, ^{b}, ^{c})Means in the same row with the different superscript are significantly different (P<0.05) between the treatments. T1= 0% of garlic powder, T2= 1% of garlic supplementation, T3= 3% of garlic powder) T4= 5% of garlicSupplementation, FCE=feed conversion efficiency, g= gram, g/b/d (gram per bird per day) ADFI =average daily feed intake,ADWG =Average Daily weight gain.

4.3 Mortality Rate

Overall Mortality rate of chickens supplemented With different level of garlic powder indicated that group of chicken fed on T3 was recorded low mortality rate (2.22%) and high mortality rate was recorded for group of chicken fed on T4(6.44%) whereas the group of chicken fed on T1 and T4 recorded (4.4%).

The lowest mortality rate value on T3 could be due to dose dependent effect of garlic in enhancing immune cells inchicken. Garlic has been extensively studied for its medical properties and proven to exert an Immuno-modulating effect through activating the immune system (Kyo *et al*., 2001). Garlic derived products have shown broad antibiotic properties against gram-positive and gram-negative bacteria and have been effective against many common pathogenic intestinal bacteria (Tatara *et al*., 2008).The current value is supported by report of (Brzóska *et al*., 2015) who revealed that regular supplementation of garlic powder in commercial broiler diet reduced bird mortality.

4.4. Effect of Garlic Powder on Carcass Yield

The effect of supplementation of different levels of garlic powder onbroilers carcass yield is presented in Table 6. Supplementation of garlicfor broilers resulted significant improvement ($p<0.05$) on dressed weight, breast meat, drumstick with thigh, back and neck between the treatments. The highest dressed weight (2.13±0.09kg), drumstick with thigh weight (0.525±0.024kg), breast meat weight(0.61±0.02kg), and back weight (0.28±0.013kg) was obtained from the group of birds fed on T3 followed by the group of birds fed on T2. The lowest breast meat (0.43±0.027kg), drumstick weight (0.411±0.02kg) and back weight (0.20±0.013) were attained by the birds fed on T4. The improvement of carcass yield observed in T3 and T2 might be due to presence of phenolic and antioxidant compound of the garlic which favours secretion of digestive enzymes in gut and feed intake of the chicken. Garlic powders improve pancreatic enzymes activity and activate the digestive progression which enhances absorption of nutrients (Ramakrishna *et al.*, 2003;Adibmoradi, 2006).

Moreover, the affirmative influence of garlic supplementation on meat can be associated to the presence of volatile compounds, phenolic content and antioxidant active compounds (Canogullari*et al.*, 2010). The low result recorded on T4 might be due to reverse effect of garlic when supplemented at high dose. Oboh, (2004)reported that supplementation of garlic powder at high dose beyond 4% leads adverse effect on growth performances of broiler chickens.

The current value in line with that of Fadlala (2010)who reported that using garlic as supplement for broiler chicks resulted a significant positive effect on growth performance and carcass yield. The current result is higher than the value reported by Elagib *et .al.* (2013) the group of birds supplemented with 3% garlic powder found dressed weight (1062.3g), breast weight (0.25kg), and dressed percentage (82.74%).

In contrary, It was reported that feeding of garlic powder at levels of 1.5, 3 and 4.5% had no effect on poultry performance (Konjufca *et al.*, 1997) and Singh *et al.*, (2014) also reported that supplementation of sun dried garlic powder for broiler had no significant effect on carcass characteristics.

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Table 6.Meansand standard errors of carcass yield of broiler chicks fed different levels of garlic powder

Parameters	T1	T2	T3	T4	P-value
Live weight kg/b	2.10± 0.094	2.23±0.084	2.3± 0.085	2.03± 0.089	0.225
Dressed weight kg/b	1.582± 0.088^{ab}	1.683±0.07^{ab}	1.81± 0.09 ^{a}	1.487± 0.075^{b}	0.024
Dressing percentage	75.3±1.57	75.47± 3.2	78.69± 1.046	73.25± 1.48	0.225
Breast meat weight(kg)	0.56±0.04^{ab}	0.58±0.04^{ab}	0.61±0.02^{a}	0.43±0.027^{b}	0.005
Drumstick with thigh(kg)	0.461±0.01^{ab}	0.465±0.016^{ab}	0.525±0.024^{a}	0.411±0.02^{b}	0.005
back(kg)	0.25±0.01^{ab}	0.24±0.015^{ab}	0.28±0.013^{a}	0.20±0.013^{b}	0.011
wings(kg)	0.12±0.005	0.148±0.03	0.148±0.006	0.125±0.005	0.471
neck(kg)	0.04±0.003^{b}	0.058±0.005^{ab}	0.067±0.005^{a}	0.05±0.0025^{b}	0.005
Leg(kg)	0.081±0.008	0.091±0.008	0.085±0.003	0.08±0.005	0.672
Head(kg)	0.072±0.007	0.082±0.006	0.078±0.004	0.07±0.004	0.671

(a, b c) Means in the same row with the different superscript are significantly different at (P<0.05) T1= 0% of garlic powder, T2= 1% of garlic powder, T3=3% of garlic powder, T4=5% of garlic powder. KG= kilogram, b= bird

4.5. Chemical Composition of Meat

The chemical composition (moisture content, protein, fat and minerals) of breast meat of broiler chickens supplemented different level (proportion) of garlic powder is presented in Table 7. Crude protein (CP) content of breast meat in this experiment revealed significant ($p<0.05$) difference between the treatment groups. There is no significant difference between the treatment in other response variables (fat, ash, dry matter and moisture percentage) of chicken breast meat at ($p>0.05$). The group of birds fed on T3 significantly different from T1 and T4 on crude protein percentage hence the highest cp (22.95±0.132) percentage was found for group of birds fed on T3 followed by group of chicken fed on T2 (20.03±1.34) as compared to group of chickens (17.77±0.64) fed on control (T1). The highest crude protein percentage found in T3 and T2 might be due to the existence of active ingredients and phenolic compounds enable to reduce numbers of intestinal pathogens, thus minimizing nutrient loss and improving performance. Both effects may result in better intestinal health and may lead to more protein deposition in body tissues. Garlic has positive effect on amino acid absorption and balance in the body of chickens (Brzóska*et al*, 2015).Issa and Omar

(2012) also reported that supplementation of garlic can improved protein digestibility in broiler chicken.

The current result in line with earlier report of Dzinic *et al.* (2013) and Zekic *etal.*(2014) who reported that the addition of 2% garlic had high crude protein content in breast meat (22.86%) for Hubbard chickens and (22.9%) for (Coob500)broiler chickens. Brzoska *et al*., (2015) also reported that inclusion of garlic feed additives at 2.75g per kg of the diet increased the crude protein (23.30%) content of breast muscles in garlic fed groups for Ross 308 broiler chicken.

Table 7**.**Chemical composition of chicken breast meat of broiler fed on different level of garlic powder.

			Breast meat (%)		
parameters	T1	T2	T3	T4	P-value
Moisture	75.08±1.735	73.50±1.33	71.21±0.86	75.85±1.28	0.1497
DM	24.91±1.735	26.49±1.33	28.786±0.86	24.140±1.28	0.1497
Fat	4.43±0.80	3.50±0.21	2.90±0.45	3.26±0.44	0.52
CP	17.77 ± 0.643^{b}	20.03 ± 1.34^{ab}	22.95 ± 0.132^{a}	17.34 ± 0.69^{b}	0.0079
Ash	2.70±0.30	2.95±0.22	2.92±0.132	2.95±0.18	0.5272

(a b c) the similar superscript along the column shows significant($p<0.05$) difference between the treatments T1=0% garlic powder, T2= 1% of garlic powder, T3 =3% of garlic powder, T4 =5% of garlic powder , DM=dry matter CP=crude protein.

4.6. Sensory Evaluation of Meat

Sensory evaluation of the breast meat evaluated by ten panellists is presented in Table 8.

There was significant difference ($p<0.05$) between the treatments in terms of sensory evaluation (tenderness, juiciness, flavour). According to the score given by panellists, T3 and T2 were more preferred than others in tenderness flavour and juiciness whereas T4 was less preferred in flavour, juiciness as compared with other treatments. Overall acceptability of sensory evaluation of breast meat was significantly ($p<0.05$) improvedon group fed on T3 and T2 whereas the lowest sensory evaluationscore wasobserved for group fed on T4. These eating parametres are the major attributes of meat quality to determine consumer satisfaction up on this T3 and T2 were more pereffered than T1 and T4.

Improvement of meat sensory evaluation might be due to the positive effects of garlic attributed to meat quality in T2 and T3. The lowest sensory value recorded for T4 might be due tosome repulsive odour of garlic observedongroup of chickens fed on T4. Antioxidants of

plant origin have been reported to improve the lipid stability and enhance the sensory properties of poultry meat. Mohamed *etal*., (2012)Argued thattheantioxidant properties of natural antioxidants of plant origin are mainly attributed to their phenolic contents.

Enhancement of sensory evaluation in the current workis supported by the report of Kim *et al*. (2009) who observedpositive influence of garlic supplementation on consumer preference traits of poultry meat. Singh *et al*., (2014) and Lukanov *et al*., (2015)reported that inclusion of garlic at 0.4%, 0.8% and 1.5% in broiler diets had acquired the better acceptability of broiler meat than the control group. The current result disagreed with report of Fadlala (2004) who reported that incorporation of garlic powder with different level had not significant improvement on meat sensory evaluation of broiler chicken.

The measured ph value of the sampled meat was indicated in significant difference among the treatment but the value seems slight decrease with increasing garlic level, this might be due to high permeability of allicin in chicken blood(Talia *et. al.,* 2000), the ph value of the meat slightly decreased with in advances of garlic level. This result was in line with report of Kim *et al*. (2009) reported a linear decrease in pH with increasing levels of dietary garlic.

Table 8. Means and standard errors of Sensory evaluation and ph measurements for breast meat

Parameters	T1	T2	T3	T4	p-value
Tenderness	3.10 ± 0.27^{b}	3.50 ± 0.16^{ab}	4.0 ± 0.14^{a}	3.90 ± 0.1^{a}	0.0056
Flavour	3.20 ± 0.29^{ab}	3.40 ± 0.16^{a}	3.70 ± 0.15^{a}	2.60 ± 0.16^{b}	0.0037
Juiciness	3.20 ± 0.20^{ab}	3.70 ± 0.21^{a}	3.70 ± 0.15^{a}	3.0 ± 0.14^{b}	0.0171
Overall acceptability	3.16 ± 0.11^{b}	3.5 ± 0.11^{ab}	3.8 ± 0.088^{a}	3.16 ± 0.089^{b}	0.0001
pH	6.045	6.02	5.945	5.725	-

(a, b c) Means in the same row with the different superscript are significantly different at ($P<0.05$).T1= 0% of garlic powder, T2= 1% of garlic powder, T3=3% of garlic powder, T4=5% of garlic powder.

4.7. The Effect of Garlic Powder on Organ Size of Broiler Chickens

The mean values of organs for heart, liver, gizzard, spleen, pancreases, proventriculas and small intestine size of broiler chickens were not affected by supplementing garlic powder in all levelsacross the treatments at ($p>0.05$).

4.8. Haematological Parameters

The effect of different levels of garlic powder supplementationon blood parameters of broiler chicken is presented in Table 10. In the current study, supplementation of garlic for broiler chickens resulted in positive effects on some haematological parameters. Total white blood cells, lymphocytes, mean corpuscular haemoglobin, haemoglobin, and hematocritic were significant- tly ($p<0.05$) improved in group of birds fed on T3 as compared with control group. In this trial, group of birds fed on T3 showed the highest total white blood cells count and lymphocyte (18.91±1.22 $x10^3$/uL and 75.83%±6.05) as compared with T1 (13.13±1.02$x10^3$/uL total white blood cells count and61.056%±6.05 lymphocyte). However, there was no significant difference ($p>0.05$) between treatments for MID (basophils, monocytes,eiosinophils), platelates, mean corpuscular hemoglobin concentration, mean cell volume and red blood cells. Improvement of haematological parameters in T3 could be due to dose dependent effect of garlic due to presence of the aromatic compound of garlicand strong stimulating effect on the immune system (Demir *et al*., 2005). The increasement of total white blood cells observed in T3 showed the group of chicken fed on this group has better body deffence than the other groups.

The present studyis supportedby report of Fadlala (2010) who stated that 0.3% supplementation rate of garlic was found to be the best and optimum rate in improving total white blood cells, blood serum constituent content.The same results was obtained by Rahimi *et al*. (2011) and Eid and Iraq (2014) who showed that addinggarlic in feed of broilers improved haemoglobinconcentration.Ademola (2004) also revealed that supplementation of garlic powder increase in total white blood cells as compared to control birds.

Tesfaheywet*et al*. (2017)also reported that mixing of layer diets with 1-3% garlic powder in practical layer diets improved some haematological parameters and total immunoglobulin

which could contribute to improved blood circulation and immunity of white leghorns chickens.

In contorary, Elagib *etal*., (2013) reported thatsupplementation of garlicpowder on broiler diet had not significant effect onblood parameters. Furthermore,Ologhobo *et al*. (2008) and Onyimonyi *et al*., (2012) reported that incorporation of garlic powder into the ration of broilers did not bring significant changes onthe usual haematological counts of the birds.

Table 9. Mean and standard errors of Haematological parameters for chicken supplemented with different levels of garlic

Parameters	T1	T2	T3	T4	P-value
TWBC(X 10^3/μL)	13.13±1.029^{b}	13.6±1.10^{b}	18.91±1.70^{a}	12.48±0.90^{b}	0.0050
LYP (%)	61.056±7.901 ^{ab}	50.33±6.29^{b}	75.833±3.62^{a}	60.83±5.61^{ab}	0.05
MID (%)	24.886±4.95	21.89±2.27	11.8±2.71	20±1.90	0.2314
NETROPHILS (%)	14.05±3.76	27.83±7.54	12.36±7.60	19.17±3.6	0.1421
MCHC(g/dl)	57.66±8.39	60.83±5.36	64.83±5.36	60.33±3.84	0.9053
MCH(pg)	65.83±3.73^{ab}	56.50±4.85^{b}	82.166±4.20^{a}	55.00±9.83^{b}	0.1138
HG g/dl	10.10±0.51^{b}	13.58±0.86^{ab}	17.33±1.74^{a}	14.41±1.66^{ab}	0.0081
PLATELATES X 10^3/ml	21.98±2.24	26.50±2.3	21.66±2.30	19.500±2.97	0.2627
HCT%	30.90±2.59^{a}	26.16±3.14^{ab}	25.10±2.37^{ab}	17.80±2.83^{b}	0.0247
MCV (fl)	102.80±2.08	102.75±1.64	104.50±0.56	101.33±1.62	0.5801
RBC(10^6/μl)	2.248±0.38	1.619±0.60	1.878±0.28	1.74±0.22	0.7151

(a, b c) means in the same row with the different superscript are significantly different at ($p<0.05$). T1 = 0% of garlic powder, T2 = 1% of garlic powder, T3= 3% of garlic powder, T4 = 5% of garlic powder,TWBC= total white blood cells, LYP= lymphocytes, MID= mid-range absolute count, MCHC= Mean corpuscular hem globulin concentration,MCH=mean corpuscular hemoglobin, Hct = Hematocrit, MCV=mean cell volume, HG=Hemoglobin, RBC=Red blood cells. Fl= fino liter, dl= desi liter, pg= pico gram

4.9. Biochemical Parameters

The effect of supplementation of different level (proportion) of garlic powder on lipid profile of broiler chicken is indicated in Table 11 .The serum analysis of the broiler chicks fed on T3 indicated a significant reduction on blood cholesterol and triglyceride (110.5±10.8mg/dl) and 77.16±12.15mg/dl, respectively), followed by T4 (108.6mg/dl±6.34mg/dl blood cholesterol and 104.16±15.734mg/dltriglyceride) as compared to T1(185.33mg/dl±28.28) blood cholesterol and 153.153±11.35 mg/dl triglyceride.High density lipoproteinwas significantly ($p < 0.05$) increased for group of birds fed on T3 (91.43±4.03mg/dl) as compared withcontrol (60.06±5.16).The significant change of lipid content in the experimental chicken might be

due to the effect of Allicin in garlic whichaids as specific inhibitor of the acetyl CoA synthetase and fatty acid that contribute in the cholesterol and lipids biosynthesis (Stanacev*et al*., 2012).

Moreover, Osman (2006) and lanzoti (2005) reported that Allicin and its derivative compounds;saponins, flavonoid, and quercetin are the main active substances responsible for the hypolipidemic and hypocholesterolemic effects of garlic. Compounds such as allyl-disulfide or allyl-sulfhydryl groups in garlic could be responsible for the inhibition of cholesterol synthesis by garlic (Singh and Porter, 2006). Garlic powder contains various levels of alliin (Amagase*et al.,* 2001)which contain vitamin (vitamin C, thiamine, riboflavin and niacin), selenium and potassium (USDA, 2014).Furthermore, the result obtained in this current work is dose dependant effect on biochemical parameters hencesupplementation of garlic powder at optimum levelin broiler diet have a potency to change lipid profile of the chicken decreased total blood cholesterol, triglyceride and high density lipoprotein level.

The current study is supported by the work of Onibi *et al.* (2009) who reported that using garlic powder as supplement for broilers had some beneficial effect on lipid content of chickens' meat particularly when the proportion is increased.Motasem*et al*., (2018) reported that addition of garlic in highbred broiler chicken diet reduced the blood cholesterol, Albumin, Triglyceride and HDL levels as compared with control group. Moreover, similar result was obtained by Prasad *et al*, (2009); Isa and Omar (2012) who reported thatdietary supplementation of garlic powder at 1.5% and 3.0% level was found to cause a significant decrease in the mean values of total cholesterol, triglycerides, and increases HDL as compared to control broilers.Toghyani *et al*. (2011) demonstrated that garlic and cinnamon exhibited hypocholisteromic and hepatoprotective properties.

Table 10. least square means and standard errors of Serum lipid parameters of broilers supplemented with different levels of garlic powder

Parameters	T1	T2	T3	T4	Pvalue
Cholesterol(mg/dl)	185.33±28.28^{a}	162.33±21.91^{ab}	110.5±10.83^{ab}	108.5±6.34^{b}	0.0231
Triglyceride(mg/dl)	153.50±11.35^{a}	113.1619.96^{ab}	77.16±12.15^{b}	104.16±15.734^{ab}	0.0166
High density Lipoprotein(mg/dl)	60.06±5.16b	65.23±3.80^{b}	91.43±4.03^{a}	64.3±6.68^{b}	0.00011

(a, b c) Means in the same row with the different superscript are significantly different at (P<0.05). T1 (0% of garlic powder), T2 (1% of garlic powder), T3 (3% of garlic powder) T4 (5% of garlic powder), mg/dl (milligram per desi litter

4.10. Partial Budget Analysis

Cost benefit analysis of experimental feeds supplemented with different levels of garlic powder is summarized in Table 11.The result revealed that T3 (11085.60ETB) and T2 (10347.55 ETB) were achieved better net income as compared with T1 (10000.4ETB). The lowest net income was obtained from the birds fed onT4 (7431.50ETB). The better net income achieved on T2 and T3 might be due to positive influence of garlic supplementation on economically important traits ofbroiler chicken. Motasem *et.al*, (2018) also reported that Incorporation of garlic powder in broiler diet as feed additive significantly enhanced growth, economic and productive performance of broiler chicks.

The lowest net return obtained on T4 might be due to the adverse effect of garlic supplementation at high dose on growth parameters that directtopoor performances of broiler chickens and ultimately leadto lowest net return and negative marginal rate return. Garlic was reported to cause adverse effect beyond 4% level in feed (Oboh, 2004).The current result is in line with that of Varmaghany*et al*., (2014) and Zekic*et al.* (2014) who reported that mixing broiler diet with 3% and 2% level garlic powder had significant improvement on production performance which is expressed in terms of higher final body weight, nutritive andqualitymeatand highest profitability ratio.

Table 11.Partial budget analysis of experimental diet

		N= 170			
	unit	Treatment			
Variable cost		T1	T2	T3	T4
T. feed consumed	kg	174.13	177.54	190.60	169.03
Total feed cost	ETB	2002.52	2041.25	2191.90	1943.50
Total garlic consumed	kg	0.00	1.74	5.00	7.50
Garlic cost	ETB	0.00	313.20	900.00	1350.00
Garlic preparation cost	ETB	0.00	69.00	200.00	300.00
Total variable cost	ETB	2002.52	2423.45	3291.90	3593.50
Total carcass Yield	kg	80.02	85.14	95.85	73.50
Total return	ETB	12003.00	12771.00	14377.50	11025.00
Net return	ETB	10000.4	10347.55	11085.60	7431.50
Change in total return	ETB	-	768.00	2374.50	-978.00
Change in total variable cost	ETB	-	420.93	1289.38	1590.98
Change in net return		-	347.07	1085.12	-2568.98
Marginal rate of return		-	1.21	1.19	-0.62

T1 (0% of garlic powder), T2 (1% of garlic powder), T3 (3% of garlic powder) T4 (5% of garlic powder), kg =kilogram, ETB= Ethiopian Birr.

5. CONCLUSIONAND RECOMMENDATION

The result pointed out supplementation of garlic powder for broilerchickensas feed additive significantly improved productiveperformance;body weight, average daily weight gains, feed intake, average daily feed intake, feed conversion ratio, carcass yield, and better meat quality, enhance blood profile,decreases mortality rate and achieve better economic return. Supplementation of garlic powder also significantly enhanced the haematological parameters particularly total white blood cells, lymphocytes, mean corpuscular haemoglobin andhaemoglobin. It also improved Lipid content lower cholesterol, triglyceride, and increased high density lipoprotein.

The cost benefit analysis of the experimental diets indicated that incorporation of garlic powder at 1% and 3% showed better net return however the group of chicken supplemented with 5% showed low net return and negative marginal rate.Thus, it is concluded that supplementing of garlic powder at 1% - 3% level showed significant improvement in overall performance, haematological, biochemical profile and achieved best net return.

Hence, to increase productivity and to keep the chicken healthiness the use of garlic powder at suggested dose should be the best option. To make efforts and more Comprehensiveextra investigation should be needed for the future on efficacy of garlicextract , garlic huskand leafs of the plant in diferrant regions of the countries.

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7. APPENDIXES

Appendix Table 1.ANOVA table for mean square body weight of chickens

Source of Variation	DF	MS			
		IBW	10	21	42
Treatment	3	0.289	44.206ns	8499.03*	121015.75**
Error	8	0.083	80.81	1587.8	5835.45
Total	11	-	-	-	
CV%		0.59	3.80	3.89	3.58

DF= degree of freedom, MS= mean squares. IBW= Initial body weight, CV= coefficient of variation, '**'* indicates highly significant and significant difference at ($p<0.01$ and $p<0.05$), ns donates no significant difference.

Appendix Table 2. ANOVA for mean square feed intake of chickens

Source of variation	DF	MS			
		1-10	11-21	22-42	1-42
Treatment	3	735.85**	6877.44*	131672.8*	178378.2*
Error	8	43.17	1085.88	34788.42	40862.61
Total	11				
Cove%		1.94	3.431	6.623	5.151

SV=source of variation, DF= degree of freedom, MS= mean squares. CV= coefficient of variation, '**'* indicates highly significant and significant difference at ($p<0.01$ and $p<0.05$), ns donates no significant difference.

Appendix Table 3.ANOVA for mean square average feed intake of chickens

SV	DF	Mean Square			
		1-10	11-21	22-42	1-42
treatment	3	735.85ns	6877.44ns	131672.82*	178378.21*
Error	8	43.17	1085.88	34788.42	40862.6
Total	11	-	-	-	-
CV%		1.94	3.431	6.62	5.15

SV=source of variation, DF= degree of freedom, MS= mean squares. CV= coefficient of variation, '**'* indicates highly significant and significant difference at ($p<0.01$ and $p<0.05$), ns donates no significant difference.

Appendix Table 4.ANOVA for mean squares daily gain of chicken

Source of variation		MS			
	DF	1-10	11-21	22-42	1-42
Treatment	3	0.51ns	21.34*	183.59**	68.58**
Error	8	0.813	3.95	20.98	3.31
Total	11				
CV%		4.80	4.08	8.25	3.66

DF= degree of freedom, MS= mean squares. CV= coefficient of variation,'**' '* 'indicates highly significant and significant difference at ($p<0.01$ and $p<0.05$), ns donates no significant difference

Appendix Table 5.ANOVAfor mean square Feed conversion efficiency

Source of Variation		MS			
	DF	1-10	11-21	22-42	1-42
Treatment	3	0.0002ns	0.003ns	0.0080 ns	0.0132**
Error	8	0.0035	0.0023	0.0029	0.0025
Total	11	-		-	
CV%		4.324	5.184	4.077	2.74

DF=degree of freedom, MS=Mean square, CV=coefficient of variation '**' donates highly significant at ($p<0.01$), ns donates no significant difference

Appendix Table 6.ANOVA for mean square of carcass (commercial cut)

Source of variation		MS						
	DF	breast	drumstick	wing	back	neck	leg	head
Treatment	3	0.037*	0.0129**	0.00135^{ns}	0.0071*	0.0006**	0.00015^{ns}	0.000
Error	20	0.007	0.0022	.00156	0.00149	0.00011	0.00028	0.000
Total	23							
Cv		16.13	10.23	19.1	15.70	19.58	19.99	19.14

DF:degree of freedom, MS =Mean square * Donates significant difference at ($p<0.05$), ns indicate no significant difference

Appendix Table 7.ANOVA for mean square Dressing weight, live weight, dressing weight percentage

Source of variation	DF	MS		
		LW	DW	DWP
Treatment	3	0.0876ns	0.157*	38.045ns
Error	20	0.047	0.04	24.09
Total	24	-	-	-
Cv		9.99	10.40	5.50

DF=degree of freedom, LW= Live weight, DW= Dressed weight, DWP= Dressed Weight Percentage, MS Mean square * Donates significant difference at ($p<0.05$), ns indicate no significant difference.

Appendix Table 8.ANOVA for mean square Chemical composition. Of breast meat

SV	DF	MS				
		Moisture	Dm	Fat	Cp	Ash
Treatment	3	12.59ns	12.60ns	1.289ns	18.480**	0.045ns
Error	8	5.39	5.38	0.82	2.244	0.1458
Total	11					
CV		3.142	8.89	25.73	7.63	13.237

Sv= source of variation, DF=degree of freedom, =, Dm= Dry matter, cp=crude protein, MS Mean square * Donates significant difference at ($p<0.05$), ns indicate no significant difference.

Appendix Table 9.ANOVA for mean square Sensory evaluation

Source of variation	DF	MS			
		Tenderness	Flavour	Juiciness	Overall
Treatment	3	1.69**	2.15**	1.26*	0.95**
Error	36	0.341	0.402	0.32	0.10
Total	39				
cv		16.12	19.67	16.83	9.45

SV= source of variation, DF=degree of freedom, MS=Mean square, '**' donates highly significant at ($p<0.01$), ns donates no significant difference

Appendix Table 10. ANOVA for mean squares of organ

Source of Variation		MS					
	DF	Heart	Liver	Spleen	Gizzard	Proventriculas	Pancreases
Treatment	3	3.73ns	41.01ns	3.60ns	5.280ns	1.740ns	2.53ns
Error	20	4.06	55.51	1.48	42.95	1.999	1.66
Total	24						
CV		17.28	15.9	11.26	15.84	16.26	22.80

DF=degree of freedom, MS=mean square, 'ns' donates no significant difference, CV=coefficient of variation

Appendix Table 11. ANOVA for mean square weight of small intestine

Source of variation	DF	MS			
		duodenum	jejunum	ileum	overall
Treatment	3	5.769ns	7.50ns	4.55ns	28.9ns
Error	8	2.940	20.63	5.60	17.674
Total	11				
CV		12.17	15.84	13.50	6.97

DF=degree of freedom, MS=mean square, 'ns' donates no significant difference

Appendix Table 12.ANOVA for mean square Length of small intestine

Source of variation	DF	MS			
		duodenum	jejunum	ileum	overall
Treatment	3	3.66ns	69.63ns	33.0ns	168.52ns
Error	8	3.25ns	109.5ns	37.5ns	193.6ns
Total	11				
CV		6.111	11.76	10.91	7.97

DF=degree of freedom, MS=mean square, CV= coefficient of variation's' ns donates no significant difference

Appendix Table 13. ANOVA for mean square haematological parameters

Source of Variation	DF	MS										
		WBC	LYP	NITR	MID	HG	MCH	MCHC	PLA	RBC	MCV	HCT
Treatment	3	52.25**	220.19*	262.44ns	61.04ns	85.62**	935.28*	172.69ns	51.867 ns	0.442ns	10.07 ns	176.04*
Error	20	8.98	676.37	129.30	94.93	76.47	227.95	185.48	36.185	0.96	15.01	45.45
Total	23	-	-	-	-	-	-	-	-	-	-	-
Cv%		20.5	24.21	22.02	19.811	13.31001	23.26	21.45	26.84	22.52	3.768	26.9

DF= degree of freedom, WBC= white blood cells, NITR= Nitrophils, MID= mean absolute count, HG= Haemoglobin, MCH= Mean corpuscular haemoglobin, MCHC= mean corpuscular haemoglobin concentration, PLA= Platelets, RBC=red blood cells, MCV= Mean cell volume, HCT= Hematocritic,Mean Square, '* '**' donates significant difference at ($p<0.01$ and $p<0.05$), ns donates no significant difference.

Appendix Table 14.ANOVA for mean square cholesterol, triglyceride and low density lipid.

Source of variation	DF	MS		
		cholesterol	triglyceride	High density lipoprotein
Treatment	3	7567.93*	5996.66*	1226.00**
Error	20	2156.74	1383.90	153.22
Total	24			
CV		21.56	23.21	17.61

CV= Coefficient of variation, DF=degree of freedom, MS Mean square * Donates significant difference, 'ns' indicate no significant differenceat ($p<0.05$).

Appendix Table 15. Five point hedonic scale measurement for sensory evaluation

Five point Hedonic Scale	Interpretation
5	like a lot
4	like a little
3	neither like nor dislike
2	dislike a little
1	dislike a lot

To calculate the score for each product each descriptor was assigned a score value: like a lot = 5, like a little = 4, neither like nor dislike = 3, dislike a little = 2, dislike a lot = 1.

Appendix 16. Format sheet hedonic rating scale

Sample code	Tenderness	flavour	juiciness	Overall acceptability

Appendix 17. Variable cost for partial budget analysis of experimental diet

list of materials	unit	per unit cost
Garlic cost	kg	45
Preparation cost	kg	10
Total fresh garlic used	kg	56
Commercial feed cost	I quin	1158.33
Chicken meat cost	1kg	150EBR

Quint= Quintals, EBR= Ethiopian Birr, KG= Kilogram,EBR: Ethiopian birr.Current cost of meat was obtained from cost of live Jimma:(https://www.numbeo.com/cost-of-living/in/Jimma-Ethiopia. Four kg of fresh garlic was used to produce one kg of garlic powder

7.1 APPENDIX

Appendix Picture1**.** A photo of Management practices for broiler chickens fed diferant level of garlic powderduring starter , grower and finisher phase

A) starter phase B) Grower phase

C)Finisher phase

Appendix Picture2. A photo when sample blood was taken from chickens for haematological and biochemical analysis

Appendix Picture3. A photo of Carcass yield for broiler chickens fed diferrant level of garlic powder

Commercial cut