بسم الله الرحمن الرحيم

SUDAN UNIVERSITY OF SCIENCE AND TECHNOLOGY
COLLEGE OF GRADUATE STUDIES

Response of Broiler Chicks fed on Dietary Garlic Essential Oil as Natural Growth Promoter Alternative to Antibiotics

استجابة كتاكيت اللاحم المغذاة على زيت الثوم كمحفز طبيعي بديلا للمضادات الحيوية

By :

Zolikha Mohammed Alhassan Ahmed

B.Sc. (Agric), 2007. , Sudan University of Science a Department of Animal Production nd Technology.

A Thesis Submitted in partial fulfillment for the Requirements of Sudan University of Science and Technology for Degree of M.Sc

Supervisor:

PROF.DR. KAMAL ABDELBAGI MOHAMMED

Department of Animal Production, College of Agricultural Studies, Sudan University of Science and Technology.

2014

إستهلال

قال تعالى:

وَوَرِثَ سُلَيْمَانُ دَاوُودَ وَقَالَ يَا أَيُّهَا النَّاسُ عُلِّمْنَا مَنطِقَ الطَّيْرِ وَأُوتِينَا مِن كُلِّ شَيْءٍ إِنَّ هَذَا لَهُوَ الْفَضْلُ الْمُبِينُ ﴿النمل16﴾

Table of contents

Tables List

Dedication

I dedicate this research report affectionately to the following:

My parents

My family (husband and our son)

My sisters and brothers

who

never failed to be there with every possible assistance

Acknowledgment

Firstly and lastly thanks to **ALLAH** who gave me persistence, and patience to complete this work. No words can adequately express my deep gratitude to my supervisor **Prof.Dr. Kamal Abdelbagi** for generously providing and for patience, constant support, advices and insight was invaluable to me. He is always available not only for consultation but also to solve any difficulties. Then I wish to express grateful thanks to administration of **Sudan University of Science and Technology,** college of **Agricultural Studies** for allowing me to conduct my research and providing any assistance requested. Gratitude also extended to **all people and friends** that assisted me in this research. For their excitement and willingness to provide feedback made the completion of this research an enjoyable experience.

ABSTRACT

This experiment was conducted to evaluate the response of broiler chicks fed on graded levels of garlic essential oil as natural growth promoter alternative to antibiotic. Experimental parameters covered growth performance, carcass dressing percentage, subjective meat quality and economical appraisal. The experimental design used was the complete randomized design (CRD). A total number of (140), 7 day-old, 100gm initial weight unsexed Ross 308 strain of broiler chicks were randomly divided into five experimental groups with four replicates, each of seven chicks. The first group A fed on basal diet without feed additives (negative control), the second group B were fed on basal diet with antibiotic (Neomycin, 20gm/kg) as positive control diet, the other groups C, D and E were fed basal diets supplemented with garlic essential oil at levels of 0.1, 0.2 and 0.3 respectively. The basal diet was formulated to meet the nutrients requirements of broiler chicks according to *(NRC, 1994).* Experimental diets were fed for 6 weeks. The results indicated that there were no significant ($p > 0.05$) differences among all treatment groups in the values of body weight gain, feed intake, feed conversion ratio, carcass dressing percentages and subjective meat quality attributes. No mortality were recorded throughout the experimental period. The economical evaluation showed that all levels of dietary garlic essential oils were economically feasible, but the values of profitability ratio (1.27) of group E (0.3% garlic oil) was the highest of the tested groups.

ملخـص الدراســـة

أجريت هذه الدراسة لتقييم مدى إستجابة كتاكيت الدجاج اللاحم المغذاة على مستويات متدرجة من زيت الثوم كمحفز طبيعي للنمو بديلا للمضادات الحيوية. شملت قياسات التجربة الأداء الإنتاجي، نسبة تصافي الذبيحة، الصفات الإنطباعية النوعية للحم والتقييم الإقتصادي. صممت هذه التجربة بإستخدام النظام العشوائي الكامل. تمّ إستخدام 140 كتكوت عمر 7 أيام بوزن إبتدائي 100جم غير مجنسة من سلالة الروس 308 ، تمّ تقسيمها عشوائيا إلى خمسة مجموعات تجريبية، كل مجموعة ضمت أربعة مكررات، بكل مكرر سبعة كتاكيت. تمت تغذية المجموعة الأولى (A) على عليقة أساسية بدون أي اضافة (عليقة قياسية سالبة)، المجموعة الثانية (B) تغذت على العليقة الأساسية مع المضاد الحيوي (النيومايسين 20ملجم/كجم) كعليقة قياسية موجبة، أما المجموعات الأخرى D,C وE فقد تمت تغذيتها على العليقة الأساسية مضافا إليها زيت الثوم بمستويات 0.1، 0.2 و 0.3%، على التوالي. تم تكوين العليقة القياسية لتقابل الإحتياجات الغذائية للدجاج اللاحم الصادرة من *(NRC, 1994)*. تمت التغذية على العلائق التجريبية لمدة 6 أسابيع.

اثبتت النتائج المتحصل عليها بانه لا توجد فروقات معنوية ($p>0.05$) بين كل المجموعات التجريبية في قيم وزن الجسم المكتسب، العليقة المستهلكة، معدل التحول الغذائي، نسبة التصافي للذبيحة وصفات اللحم الإنطباعية النوعية للدجاج اللاحم . لم تسجل أي حالات للنفوق خلال فترة التجربة.

اظهر التقييم الإقتصادي بأن كل المستويات الغذائية لزيت الثوم كانت مجدية اقتصاديا ولكن قيمة الربحية النسبية (1.27) في المجموعة E (0.3% زيت ثوم) كانت الأعلى بين المجموعات المختبرة.

Chapter one

INTRODUCTION

The fast growing nature of broilers and their short generation interval has been associated over the years with the use of antibiotic growth promoters at sub-therapeutic doses in animal feeds in order to improve performance through controlling the zoonotic pathogens in the gut *(Dieumou et al., 2009).* At the present time, there is increasing pressure to reduce or eliminate the use of antibiotics as growth promoters due to the negative human health issue of antibiotic resistance. On the other hand the proposed ban of antimicrobial growth promoters in the European Union in 2006 and voluntary reduction in their use while in other countries the work has focused on the alternatives growth promoters to be used in poultry feed. Several compounds such as enzymes, organic acids, probiotics, prebiotics and phytogenics are used to improve the performance. Recently aromatic plants and their associated essential oils or extracts are being concerned as potentially growth promoters.

Most essential oils consist of mixtures of compounds such as phenolics and polyphenols, terpenoids, saponines, quinine, esters, flavone, flavonoids, tannins, alkaloids and non-voltiles residues; and their chemical composition and concentration of compounds is variable. These compounds have many effects as antimicrobial, stimulating animal digestive system, antioxidants, anticoccidail increase production of digestive enzymes and improve utilization of digestive products by enhancing liver functions *(Ziarlarimi et al., 2011).*

Garlic (Allium sativum) is widely used in all parts of world as a spice and herbal medicine for the prevention and treatment of a variety of diseases ranging from infections to heart diseases. It has long been considered that garlic has several beneficial effects for human and animals, exhibiting antimicrobial, antioxidant properties *(Konjufca et al., 1997);* antiviral *(Weber et al., 1992);* and antifungal *(Ankri and*

Mirelman, 1999). Garlic supplement to broiler chicks has been recognized for its strong stimulating effect on the immune system in addition to its positive effects on digestion in birds due to the very rich aromatic essential content of garlic *(Demir et al., 2005)*. Previous researchers suggested that those functions are mainly to the bioactive compounds such as allin, daillyLsulphides and allicin *(Amagase and Milner, 1993)*. Undoubtedly, garlic essential oils which may be used as alternative to antibiotic have a wide range of potential uses.

Therefore this study was conducted to evaluate the effects of various levels of dietary garlic essential oil as natural growth promoters on the growth performance, carcass dressing percentage and subjective meat parameters of broiler chicks.

CHAPTER TWO

LITERATURE REVIEW

2.1.Feed additives:

Feed is major components, affecting net return from the poultry business, because 80% of the total expenditure in term of cash is spent on feed purchase *(Javed et al., 2009).* To insure more net return and to minimize high expenditure on feed many research strategies have been practiced such as introducing feed supplements and feed additives *(Pervez, 1992).*

The term "additive" is applied by the feed compounder, in abroad sense, to all products other than those commonly called feed stuffs that may be added to the ration with the object of obtaining some special effects. Additives are usually included in the feed mixture in very small quantities and require very careful weighing, handling and mixing. Those of special interest in formulation of poultry feeds include amino acids, antioxidants, antibiotics, drugs to prevent or control disease, pigments, trace elements and vitamins *(Ray and Fox, 1979).*

Amino acids, trace minerals and vitamins have already been considered. The remainder may, for convenience, be considered as falling into two groups. The first group comprises those additives that have specific nutritional role, and includes fifteen or more growth promoting substances alone, the second group covers those compounds concerned with the prevention and control disease and, have, the number used has so far topped sixty. Antibiotics may be included in both groups *(Allam, 2000).*

2.2.Growth promotant antibiotics (GPAs):

Poor performance and increase susceptibility to disease in birds have been attributed to the pathogenic microflora in the gut competing with the host for nutrients and causing sub-clinical infections *(Tekeli et al., 2011)*. Research attentions have also been given to ways of controlling sub-clinical infections especially those caused by pathogenic microflora. Those objectives have reportedly been achieved through the use of various Growth Promotant Antibiotics (GPAs) *(Verstegen and Schaafsma, 1999); Cummings and Macfarlane, 2002)*. Most growth promoters are antimicrobial compounds, administrated at sub-therapeutic doses in animal feed to suppress sub-clinical infections *(Brander et al., 1991)*.

The growth promoters effect of antibiotics was discovered in the 1940s, when it was observed that animals fed dried mycelia of Sterptomyces aureofaciens containing Chlortetra cycline residues improved their growth *(Dibner and Richards, 2005)*. The United States Food and Drug Adminstration approved the use of antibiotics as animal feed additives without veterinary prescription in 1951 *(Jones and Rickeo, 2003)*. Also in the 1950s and 1960s, each Eurpean State approved its own national regulation about the use of antibiotic in animal feeds *(Castanon, 2007)*.

GPAs have well been reported for their inhibitory actions on proliferation of pathogenic microflora and the negative effects of their toxic metabolites *(Van Immerseel et al., 2004 and Comelison et al., 2006). National Office of Animal Health (2001)* has specifically reported on the inhibitory potentials of GPAs against the proliferation of enteric pathogens including Salmonella spp; Campylobactor sputorum, C.Perfringens;

Escherichia coli and Enterococci species. In addition, several reports have established their indirect positive effects, as stimulant of digestive enzymes, on feed digestion, nutrients absorption and consequential improvement of growth performance *(Gunal et al., 2006 and Hafez, 2011).* Despite the seemingly satisfactory results obtained in poultry industries with GPAs, increased antimicrobial resistance *(Jang et al., 2007)* and other related health problems to consumers were reported *(Kato et al., 2001 and Donoghue, 2003).* This situation led to the pan of these products by the European Union in January, 2006, thereby giving room to research for natural alternatives.

2.3 Nutritional Strategies and Feed Additives:

After the use of most antibiotics growth promoter as feed additives been banned by the Eu. Due to cross-resistance against pathogens and residues in tissues, Scientists has searched for alternatives to antibiotics, in this view, variety of substances are used in conjunction with or as alternatives to antibiotics in poultry diets. Herbs and spices, essential oils extracted from aromatic plants, enzymes, organic acids, probiotics and prebiotics, all shown promising results for use in organic poultry production *(Griggs and Jacob, 2005; Mustafa, 2011).*

2.3.1 Herbs, Spices and plant extracts

Herbs, spices and various plants extracts have received increasing attention as possible antibiotics growth promoters replacement. There is evidence to suggest that some of these components have appetite, stimulating properties (methol from peppermint), antibacterial effect (caracrol from oregano) or provide antioxidant functions (cinnamadhyde from cinnamon) *Revington, (2002).* In different herbs a wide variety of active, phytochemicals, including the flavonoids, terpendoid, lignans,

sulfides, polyhenolics, cartnoids, coumarins, saponins, plant sterols, curcumin and phthalides have been identified *(Mehmet et al., 2005).*

Research interest has focused on various herbs that possess hypolipidermic, antiplatelet, antitumor, or immune-stimulating properties that may useful adjuncts in helping reduce risks of cardio vascular diseases and cancer. In addition to their antimicrobial activity *(Elayyar et al., 2001; Singh et al., 2002; Valero and Salmeron, 2003);* they possess biological activities such as that of antioxidants *(Lopez-Bote et al., 1998; Botsoglou et al., 2002)* and as hypocolostomies *(Craig, 1999)* and stimulate effect on animal digestive system *(Jamroz and Kamel, 2002; Ramakrishna et al., 2003)*, to increase production of digestive enzymes and improve utilization of digestive products through enhanced liver functions *(Langhout, 2000; Hernandez et al., 2004).*

2.4 Garlic (Allium sativum)

2.4.1 Scientific classification:

According to *Wikipedia (2013)* the garlic is classified scientifically as follow:

Kingdom:	Plantae
Clade:	Angiosperms
Clade:	Monocots
Order:	Asparagales
Family:	Amaryllidaceae
Subfamily:	Allioideae
Genus:	Allium

Species:	A. sativum
Binomial name	Allium sativum

Allium sativum, commonly known as garlic, is a species in the onion genus, Allium. Its close relatives include onion, shallot, leek, chive and rakkyo With a history of human use of over 7,000 years, garlic is native to central Asia *(Ensminger, 1994)* and has long been a staple in the Mediterranean region, as well as a frequent seasoning in Asia, Africa, and Europe. It was known to Ancient Egyptians, and has been used for both culinary and medicinal purposes *(Simonetti, 1990).*

2.4.2 Botanical description:

A perennial herb with a bulb divided into segments (cloves), basal linear leaves and an erect stem terminated by an umbel with numerous small bulbils between the purplish-white flowers. The flowers cluster is enclosed by a sheath (spathe) of papery bracts. The fruits is a capsule with black seeds do not ripen in cultivated plants *(Singh and Panda, 2005).*

2.4.3 Constituents of bulb (clove):

a) Enzymes: Allinase, peroxidase, myrosinase and others (eg. Catalase, superoxidase, dismutase, aginase and lipase) *Koch and Lawson, (1996).*

b) Voltile oils (essential oils): 0.1 – 0.36%, sulfur containing compounds including alliin, compound produced enzymatically from alliin including allicin (diallyl ehisosulfinate), allylpropyl disulfide, diallyl disulfide, diallyl trisulfide, ajoene and vinyldithiines (secondary products of alliin produced non-enzymatically from allicin); S-allylmeracaptocysteine (ASSC) and S-

methylmeracaptocysteine (MSSC); terpens include citra, geranoil, linalool alfa and beta-phellandrene *(Sendl, 1995)*.

Accoding to results of gas chromatography coupled with mass spectrometry (GM/MS) analysis *Dieumou et al., (2009)* found that the garlic essential oils contain the following chemical compounds: 1-propene (0.7%), 1-propene, 3,3-thiobis-sulfide (1.4%), methyl-trans-propenyl-disulfide (1.1%), disulfide, diet-2-propenyl (37%), trisulfide, methyl-2-propenyl (5.6%), 2-vinyl-4h-1, 3-dithiin (0.9%), trisulfide, di-2-propenyl (49.6%) and diallyl tetrasulphide (1.8%).

c) Other constituents: proteins (eg. glutamyl, peptides), amino acids (eg. arginine, glutamic acid, asparatic acid, methionine, threonine) minerals, vitamins, trace elements, lipids, prostaglandins (A_2, D_2, E_2, F_2) *Sendl, (1995)*.

Allicin and other sulfur containing compounds are formed from alliin by enzyme allinase when garlic is crushed or chopped. (Alliin and allinase are separated while the cell of a garlic bulb are intact, but crushing and chopping damage the cell of bulb, allowing alliin and allinase to come into contact with each other). It considered that one mg alliin equivalent to 0.45mg allicin *(Rashid and Khan, 1974)*. Commercial garlic preparation are often standardized on content of sulfur containing constituents, particularly to alliin or on allicin yield. Garlic powder contains not less than 0.45% allicin calculated with reference to the dried drugs *(Joanne et al., 2007)*.

2.4.4 Uses:

2.4.4.1Food use

Garlic is used extensively as food and as ingredient in food. It listed by the Council of Europe as natural source of food flavoring (Category NI) this category indicates that there are no restriction on the use of garlic in foods. Previously, garlic has been listed as GRAS (Generally Recognized As Safe) *Joanne et al., (2007).*

Garlic along with cinnamon is used as a fish and meat preservative, and displays antimicrobial property at temperature as high as 120 degree Celsius; the combination can also be used to preserve fried and deep fried foods, and in the future might be used in an inner layer of plastic. *(Shivendu et al., 2012; Vipul et al., 2012; Pankaj et al., 2012 and Madhumite et al., 2012).*

2.4.4.2 Medicinal use:

Garlic is stated to possess diaphoretic, antiseptic, bacteriostatic, antiviral, hypotensive and anthelmintic properties, and to be a promoter of leukocytosis. Traditionally, it has been used to treat chronic bronchitis, respiratory catarrh, recurrent colds, whooping cough, bronchitis asthma, influenza and chronic bronchitis *(Durak et al., 2002; Chan et al., 2007; Lissiman et al., 2012; Lemar et al., 2005 and Ried et al., 2010).* Modern use of garlic and garlic extracts is focused in their reputed antihypertensive, anti-atherogenic, antithrombotic, antimicrobial, fibrinolytic, cancer preventive and lipid lowering effects *(Joanne et al., 2007).*

2.4.5 Pharmacological actions

2.4.5.1Anti-atherosclerotic and cholesterol and lipid-lowering effects:

The effects of garlic and its constituents on cholesterol biosynthesis *in vitro* and in animal's models of hypercholesterolemia are well documented *(Koch and Lawson, 1996).*

Several in vitro studies shown that garlic and its sulfur containing constituents inhibit cholesterol biosynthesis in cultured hepatocytes *(Liu and Yeh, 2001).* In other in vitro studies, garlic extracts were shown to inhibit fatty acid and triglyceride synthesis *(Yeh and Yeh, 1994).*

The step (s) in the cholesterol biosynthesis pathway inhibited by garlic, and the constituents of garlic causing inhibition have not been definitively established. Several mechanisms of action for the effect of garlic constituents on cholesterol and lipids synthesis have been proposed, including inhabitation of hydroxymethylglutaryl-CoA (HMG-CoA) reuctase activity and other enzymes, such as lanosterol-14-demethylase, involved in cholesterol biosynthesis *(Koch and Lawson, 1996).* Other proposed mechanisms include reduction in triacylglycerol biosynthesis via a reduction in tissue concentration of NADPH, increase in hydrolysis of triacylglycerol via increase lipase activity and inactivation of enzymes involved in lipid synthesis via an interaction with enzyme thiol groups *(Fulder, 1989 and Adoga, 1987).* More recently, fresh garlic extract and the constituents S-allylcystein, diallyl trisulfide and diallyl disulfide were shown to inhibit human squalene monooxygenase,

an enzyme catalyzing a step in cholesterol biosynthesis *(Gupta and Poster, 2001).* Another *in vitro* study reported that S-allylcystein, S-propylcystein and S-ethylcystein inhibit triglyceride biosynthesis in part by decreasing de novo fatty acid synthesis via inhibition of fatty acid synthase *(Lu and Yeh, 2001).*

The anti-atherogenic, anti-therosclerotic and cholesterol- and lipid-lowering effects of garlic and its constituents have been documented in several animals models (eg. Rabbits, rats, chickens and pigs) of atherosclerosis, hypercholesterolaemia and hyperlipidaemia *(Koch and Lawson, 1996).* For example a reduction in both blood and tissue lipid concentrations in hypercholesterolaemic animals fed a diet supplemented with dried garlic powder, garlic oil, or allicin has been documented *(Kamanna and Chandrasekhara, 1982).* Several studies showed that the addition of garlic and its essential oils to broiler diet as growth promoters reduced significantly the serum level of cholesterol and triglyceride *(Rahimi et al., 2011; Ademola et al., 2009; Meraj, 1998; Onibi et al., 2009 and Pesti, 1997).*

2.4.5.2 Antimicrobial effects:

Antimicrobial activity including (anti-bacterial, antiviral, anti-fungal, antiprotozoal and anti-parasitic activities) is well documented for garlic (*Shalaby et al., 2006; Duraka et al., 2002 and Racesi et al., 2010).*

The *in vitro* antimicrobial studies of garlic considered to allicin which is (+)-S-mrthyl-L-cystein sulfoxide, has equated to 15 IU of pencillin *(Jimoh et al., 2013).*

In vitro studies have shown that allicin significant antibacterial activity against several species including Bacillus subtilis, Staphylococcus aurus, Staphylococcus faeclis,

Escherichia coli, Proteus mirabilis, Salmonella typhi and Vibrio cholera *(Ahsan and Islam, 1996).*

In other *in vitro* studies garlic essential oil and four diallyl sulfide constituents, including diallyl disulfide, showed activity against antibiotic resistant Pseudomonas aeruginosa and Klebiella pneumonia *(Tsao and Yin, 2001)* and against S.aureus, Methicillin-resistant S.aurus, Candida spp and Aspergillus spp *(Tsao and Yin, 2001).*

It has been documented that garlic extracts exert a differential inhibition between beneficial intestinal microflora and potentially harmful enrobicbacteria *(Rees et al., 1993).* Inhibition observed in E.coli was more than 10 times greater than that seen in Lactobacillus casei for the same garlic dose *(Skyrme, 1997).* Exactly why this differential inhibition shoud occure is not clear, but it may be due to differing composition of bacteria membranes and their permeability to allicin *(Mirson et al., 2000).*

Broad-spectrum activity against fungi has been documented for garlic including Microsporum, Epidermophyton, Trichophyton, Rbodotorula, Torudopsis, Trichosporon, Cryptococcus neoformans and Candida, including Candida albicans *(Adctumbi and Lau, 1983).*

Garlic extract has been reported to be more effective than nystatin against pathogenic yeast especially Candida albicans *(Adctumbi and Lau, 1983).* Inhibition of lipid synthesis is through to be an important factor in the anti-candidal activity of garlic, with a disulfide-containing component such as allicin through to the main active components. Garlic has been found to inhibit the growth and toxin production of Aspergillus parasiticus *(Joanne et al., 2007).*

In vitro antiviral activity against parainfluenza type3. Herbs simplex type1 and influenza B has been documented. Activity was attributed to allicin or an allicin derivative. Garlic was reported to be in effective towards coxsackie B1 virus *(Joanne*

2.4.5.3 Antioxidant effect

Antioxidant properties have been documented for garlic *in vitro* and *vitro* (Animals) *Koch and Lawson, (1996).* Garlic constituents inhibit the formation of free radicals, support endogenous radical scavenging mechanisms, enhance cellular antioxidant enzymes (eg. Superoxide dismutase, catalase, glutathione proxidase), protect low-density lipoprotein from oxidation by free radicals, and inhibit the activation of oxidant-induced transcription factor nuclear factor Kappa (NI-kB) *(Koch and Lawson, 1996 and Borck, 2001).*

2.4.5.4 immunomodulatory activity:

Allicin (diallylthiosulfinale) is the most abundant compound representing about 70% of all thiosulfate present in crushed garlic was found to inhibit tumor metabolism and enhance the immune response *(Summiyoahi, 1997).* The Allium Species show immune enhancing activities and include promoting of lymphocyte synthesis, cytokine release, phagocytosis and natural killer cell activity *(Kyo et al., 1998).*

Dorhoi et al., (2006) that the essential oils of garlic substantially improve the inherent cell immunity of poultry, *Haq et al., (1999)* showed that higher garlic supplement increase level of titer anti NDV, as well, *Gabor et al., (1998)* found a significant rise in serological response of broilers when using garlic extract of 1gmL-1 in drinking water for 20 days.

2.4.6 Use of garlic and its extracts as growth promoter in broiler nutrition:

Soliman et al., (2000), found that addition of dried garlic to the diet at level 3% improved significantly the productive performance of broiler chicks.

EL-Gamry et al., (2002) studied the effect of feeding broiler chicks on diets containing various levels 0, 2, 4, 6 and 8% of fresh garlic on the performance of chick. The results showed that the chicks fed on garlic at levels 2 and 4% gained significantly more weights with better feed conversion ratio, whereas those fed on garlic at level of 2% consumed significantly more feed compared to other groups.

The results of *Hertrampt, (2001); Wiliams and Losa, (2001); Tuker, (2002); Thakar et al., (2004) and Sarica et al., (2005)* showed no significant effect of garlic extracts on performance trails of broiler chicks.

Tollba and Hassan, (2003) found that garlic as natural feed additives, improved broiler growth and feed conversion ratio and decreased the mortality rate.

Ahmed, (2005) reported higher weight gain of broiler chicks fed on ration supplemented with garlic as natural growth promoter.

Ziton, (2009) studied the effects of various levels of dried as natural growth promoter on the productive performance of broiler chicks. Five groups of chicks were fed on the experimental diets. The first group (A) fed on basal diet (negative control). The second group (B) fed on basal diet supplemented with antibiotic

(Neomycin at level of 20mg/kg). The others groups C, D and E were fed on the basal diet supplemented with dried garlic at levels 2, 3 and 4% respectively. The results indicated that the garlic groups had significantly better weight gain and feed conversion ratio than the control groups, whereas, the differences between garlic groups and antibiotic group were not significant. The feed intake and dressing percentage were not affected significantly by the dietary treatments. The control group significantly exhibits higher mortality rate compared to either garlic groups or antibiotic groups, when no mortalities were recorded.

Javed et al., (2009) studied the effect of aqueous extract of zingiber officinal, Carum apticum, Wlthania sominfera, Trigonella, Foeenum graecum, Silybum marianum, Allium sativum and Berberis lyceum on growth performance of broiler chicks. Aqueous extracts of those plants was mixed at the rate of 5, 10 and 15ml/Lit with water afford to group B, C and D respectively. The experiment was extended for 35 days. Main weight gain was significantly high ($p< 0.05$) in group C with better feed conversion ratio, while mean feed intake was significantly high in control group. No mortality was recorded in this trail.

Javandel et al., (2008) investigated on the favorite dosage of garlic as feed additives in broiler ration. In this experiment the garlic was added to the basal diet at levels 0, 0.125, 0.25, 0.50, 1 and 2%. The results showed that birds fed diets with 0.125, 0.25% garlic levels had a significantly higher daily feed intake than birds fed 0.5% dietary garlic at 1-21 days of age. At 22-42 days of age and the whole period (1-42 days of age) garlic level did not affect the daily feed intake. No significant difference recorded for daily weight gain of experimentally birds at 1-21 days of age. But at 22-42 days of age and whole period of the experiment the birds

fed control diets (free of garlic) and the diet containing the highest garlic level (2%) had a significantly lower daily weight gain in compare to other groups. At 21 days of age the birds fed diet supplemented with 0.5% garlic dosage had a lower feed conversion ratio than the control birds, but at 22-42 days of age and whole period birds fed control showed a higher feed conversion ratio in compare with fed diets containing 0.125, 0.5 or 190 garlic dosage. No significant differences were detected in carcass percentage and interior organs between experimental diets.

AL-Homidan, (2005) evaluated the efficacy of using different levels of Allium cepa, Allium sativum, and Zingiber officinal on broiler performance. A. cepa bulbs, A.sativum bulb and Z.officinale rhizome were fed to broiler chicks at level 2 and 6% for 7 weeks. A.sativum (garlic) diets showed the highest weight gain and 6% A.sativum did not adversely influence bird's health, enterhepatonephropathy was observed in the chicks fed 6% A.cepa (onion) and 6% Z.officinale (ginger) diets.

Raeesi et al., (2009) investigated on the effect of different levels of dried garlic powder at 0. 0.5, 1 and 3% on the growth performance of broiler chicks. The results showed 1 and 3% garlic supplemented group in finisher period had better performance as compared to other groups. Carcass yield was higher in groups supplemented with garlic than control groups.

Rahimi et al., (2011) evaluated the effects of garlic extracts and antibiotic-virginiamycin on growth performance of broilers. The basal diets (A) served as control group. The basal diet was supplemented with virginiamycinat at level 15 pp and garlic extract at 0.1% to formulate diets B and C respectively. The results indicated that there were no significant differences

between garlic extracts and virginiamycin diets in feed conversion ratio and feed intake, while the chicks fed virginiamycin gained significantly more weight than those fed garlic extracts diet. The results also showed no significant differences between garlic extracts and control groups in all productive performance parameters throughout the experimental period.

Dieumou et al., (2012) studied the comparative effects of garlic organic extracts and antibiotic-sterptomycin sulphate on growth performance of broiler chicks. The basal diet was supplemented with: no supplement (control), garlic organic extract (GOE) at levels of 40 and 60 ppm/kg and streptomycin sulphate at level 30 ppm/kg administrated by oral gavages from day 13 to day 47 of experiment. The results showed that the growth performance did not differ significantly between the groups fed on diet supplemented with streptomycin sulphate and those fed (GOE), but were significantly ($P < 0.05$) better than the values obtained from birds fed on control diet. They concluded that diets supplemented with (GOE) at 40 ppm could be used as alternative to antibiotic additives for broiler production.

Fayed et al., (2011) evaluated the effect of garlic supplementation in diets as growth promoter on productive performance of broiler chicks. The chicks were fed on three experimental diets; 1 control diets (basal diets); 2 and 3 basal diet supplemented with 1kg/ton and 0.5kg/ton raw garlic powder, respectively. The results indicated that bird fed on ration supplemented with 0.5kg/ton garlic gained the highest live weight among treatment groups and the best feed conversion ratio although they consumed the same feed. There was no significant differences in mortality rate due to treatment.

Amouzmehr et al., (2013) evaluated the effect of various levels 0, 3 and 6% of garlic extracts on the performance of broiler chicks for 42 days. The results showed that there were no significant differences among the treatment groups in weight gain, feed intake and feed conversion ratio over the entire trail.

Dieumou et al., (2009) studied the effect of ginger and garlic essential oils on growth performance of broiler chicks. Fed on 4 doses of essential oils 0, 10, 20, 40 and 60mg/kg day. The trail tasted for seven weeks and results indicated no significant differences in feed intake, body weight and feed conversion ratio among the treatment groups. The treatment effects of the garlic essential oils in this experiment had a positive impact on the gut microflora as it reduced their loads as compared to the control, contributing to some extent to heath maintenance.

CHAPTER THREE

MATERIALS AND METHODS

This experiment was conducted during winter season (18th October –29th November 2012). The ambient temperature averaged 21.5ºC – 33ºC (appendix1) during the experimental period (6weeks).

3.1Experimental Chicks:

A total number of 140 one day commercial unsexed broilers of Ross-308 strain were obtained from (Arab Poultry Breeders Company**,** Ommat-Sudan), and transported to the student poultry premises, Faculty of Agricultural Studies, Sudan University of Science and Technology, Shambat.

The chicks were adapted to the premises and fed over 7 days before start of the experiment. At the end of adaptation period, all chicks were weighed with an average initial weight of 100g. The chicks were then assigned randomly into five dietary treatment groups (A, B, C, D and E) in completely randomized design (CRD), each group was divided into five replicates, each of 7 chicks. Ground brooding/rearing system was adopted for 6 weeks experimental period. Chicks were bought vaccinated against Marek's disease, with on farm vaccinated against Gumboro disease at 11 days of age through drinking water and Newcastle disease at 22 days of age using Lasota strain. Soluble multi-vitamin compounds (Pantominovit-pantex Holland B.V. 5525 ZG Duizel-Holland) given to the chicks before 3 days of vaccination and 3 days after vaccinations in order to guard stress.

3.2. Housing:

An open wire mesh-side poultry house was used. The house was constructed on a concrete floor with corrugated metal sheets roof and a solid brick western-easter wall up to 3 meters the eaves and 4-5 meters for apex. 20 pens, $1m^2$ each, inside the house, were prepared using wire mesh partitioning. Each pen was equipped with one feeder and drinker to allow ad Libitum consumption of feed and water. Light was provided approximately 24 hours in a form of natural light during the day and artificial light during the night. Five bulbs (60 watt) were used for this purpose. The house was cleaned and well disinfected before the commencement of the experiment.

3.3. Experimental rations:

Garlic oil was used in this experiment was purchased from Omdurman market, Khartoum state. The chicks were fed on 5 dietary treatments. The first group A fed on basal diet (negative control) without growth promoters. The second group B fed on basal diet containing an antibiotic (Neomycin 20mg/kg) as chemical growth promoter (positive control). The other groups C, D and E were fed on the basal diet supplemented with garlic oil as natural growth promoter, at levels 0.1, 0.2 and 0.3% respectively. The basal diet was formulated to meet the nutrients requirements of broiler chicks according to the *(NRC, 1994).*

The ingredients percent composition and the calculated chemical analysis of the experimental diet were presented in **Tables (1,2)**. Experimental diets were fed for 6 weeks.

3.4 Data Collected:

3.4.1 Performance data:

Average body weight, weight gain and feed intake (gm) for each group were determined weekly throughout the experimental period. Health of the experimental stock and mortalities were closely observed and recoded daily.

3.4.2 Slaughtering Procedure:

At the end of the experiment five chicks were selected randomly from each group and weighed individually after an overnight fasting with only water allowed, then they were slaughtered by severing the right and left carotid and jugular vessels, trachea and esophagus. After bleeding they were scalded in hot water, hand-plucked and washed. The head was removed closed to skull, feet and shanks were removed at the hock joint.

Evisceration was accomplished by posterior ventral cut to completely remove the visceral organs. The hot carcass were weighed for calculation the dressing percentage. The legs were separated from each carcass then they were deboned, the meat was frozen and stored for sensory evaluation.

3.4.3 The taste panel:

Frozen deboned legs cuts were thawed at 5-7 ºC before cooking for sensory evaluation. The meat was trapped in aluminum foil, placed in roast pan and cooked at 176.7 ºC in conventional preheated electrical oven to about 80 ºC internal muscle temperature. The cooked meat was allowed to cool to room temperature for about 10 minutes. The samples were kept warm until served. Trained

panelists were instructed to eat crackers drink water between samples testing to clear the plate and pause for 20 seconds between all samples evaluated; flowing recommended procedure *(Hawrysh et al., 1980)*. The sensory panel evaluated the chops for tenderness, flavor, colour and juiciness using an eight-point scale (**Appendix2**).

3.5. Experimental Design and Statistical Data Analysis:

Completely randomized design was used in this experiment. The data were tabulated and subjected to One-way Analysis of variance (ANOVA) by using the SAS computer program *(SAS, 1994)*. The significant differences (LSD) was used for treatment means separation as outline by *Steel and Torrie (1986)*. All values were presented as means and standard error. The level significantly set up $P < 0.05$.

Table1. The ingredients percent composition of experimental diets

Ingredient%	Diets				
	A	B	C	D	E
Sorghum (Fetarita)	65.00	65.00	65.00	65.00	65.00
Groundnut cake	14.15	14.15	14.15	14.15	14.15
Sesame cake	15.00	15.00	15.00	15.00	15.00
***Concentrate**	05.00	05.00	05.00	05.00	05.00
D.C.P	00.60	00.60	00.60	00.60	06.00
Salt	00.25	00.25	00.25	00.25	00.25
Total	100.00	100.00	100.00	100.00	100.00
Feed additives	-	20	-	-	-
Antibiotic (Neomycin, mg/kg					
Garlic oil%	-	-	0.1	0.2	0.3

*crude protein 40% ; crude fat 3.90% ; crude fiber 1.44% ; calcium 10% ; available phosphorus 6.40% ; energy 1950 K cal/Kg ; Methionine 3% ; Methio + cystin 3.3% ; lysine 10 – 12 % ; crude minerals 39.30% ; sodium 2.77% ; linoleic acid 0.24% ; Nacl 6% ; Vitamins: vit. A 200.000 I.U/Kg ; D3 70.000 I.U/Kg ; Experiment 400 mg/Kg ; K3 30mg/Kg ; B1 50 mg/Kg ; B2 150 mg/Kg ; B6 50mg/Kg ; B12 180 mcg/Kg.D Pantothenic acid 155 mg/Kg ; Niacine 440 mg/Kg ; folic acid 8 mg/Kg ; choline chloride 5.800 mg/Kg ; Antioxydant (BHT) 1000 mg/Kg .

Trace Elements; Manganise 1600 mg/Kg ; zinc 1600 mg/Kg ; Iron 580 mg/Kg ; copper 450 mg/Kg ; Iodine 55 mg/Kg ; selenium 8 mg/Kg ; Cobalt 9 mg/Kg ; Molbden 20 mg/Kg.

Table (2) Calculated chemical analysis of experimental diets

Components	Diets				
	A	B	C	D	E
Dry matter	94.85	94.85	94.85	94.85	94.85
Crude protein	22.70	22.70	22.70	22.70	22.70
Crude Fiber	04.35	04.35	04.35	04.35	04.35
Ether Extract	03.35	03.35	03.35	03.35	03.35
Ash	04.65	04.65	04.65	04.65	04.65
Nitrogen.Free Extract	59.80	59.80	59.80	59.80	59.80
Calcium	01.06	01.06	01.06	01.06	01.06
Total phosphorous	00.79	00.79	00.79	00.79	00.79
Available phosphorous	00.50	00.50	00.50	00.50	00.50
ME. Kcal/Kg	3117	3117	3117	3117	3117

Calculated according to Ellis (1981).

CHAPTER FOUR

RESULTS

4.1 Response of broiler chicks to dietary garlic oil (GO)

4.1.1 Performance

The effect of feeding different levels of dietary garlic oils is shown in **Table 3**. All groups started in similar body weight (100 gm). The result showed the Treatment effect on weight gain was not significant ($p>0.05$).

However chicks in groups (B, C, D and E) gain more weight than that obtained by group (A) No significant ($p>0.05$) differences were observed between the treatment feed intake, but chicks in groups (B, C, D and E) were consumed more in compared with group (A). Feed conversion ratio (FCR) was not effected significantly by the dietary treatment and the mean values are closely similar in all experimental groups.

No mortality were detected in all treatment groups all throughout the experimental period.

The results indicated no significant differences ($p>0.05$) between all treatment groups in carcass dressing percentage as shown in **Table 3.**

4.1.2. Panel test (subjective meat attributes)

The effect of dietary treatment on subjective meat attributes is shown in **Table 4**. The mean average subjective meat quality score values of colour, tenderness, juiciness and flavor of leg cuts (thigh and drumstick) did not differ significantly ($p>0.05$) among the dietary treatment and score given for all attributes are above moderate acceptability level.

Table 3. The effect of different dietary amount of garlic oil and the antibiotic on the performance of broiler chicks for 6 weeks

Items	Groups					$Lsd_{0.05}$	SE±
	A	B	C	D	E		
Initial weight g/bird	100	103.55	104.39	102	100		
Final Weight g/bird	1578	1660	1643.00	1654.00	1662.00		
Weight Gain g/bird	1478	1556.45	1538.00	1552.00	1562.00	190.50^{ns}	61.84
Feed Intake g/bird	2950.00	3135.00	3100.00	3102.00	3130.00	386.70ns	125.50
Feed Conversion Ratio	1.87	0.187	1.88	1.87	1.87	0.09744^{ns}	0.03162
Dressing%	69.63	69.65	69.64	69.65	69.67	6.088^{ns}	1.867
Mortality	00.00	00.00	00.00	00.00	00.00	00.00	00.00

Means in a raw do not different significantly (p>0.05).

Lsd = least significant difference

SE ± = standard error

n.s = not significantly difference (p>0.05)

A = negative controlled group

B = positive controlled group

C = 0.1% garlic essential oil

D = 0.2% garlic essential oil

E = 0.3% garlic essential oil

Table 4. The effect of different dietary amount of garlic oil and the antibiotic on percentage of subjective values of broiler chicks (6 weeks)

Items	Groups						
	A	B	C	D	E	$Lsd_{0.05}$	SE±
Tenderness	5.87	5.89	5.88	5.90	5.91	5.9243^{ns}	0.2824
Flavor	5.53	5.54	5.55	5.57	5.57	5.7194^{ns}	0.2206
Colour	5.85	5.87	5.86	5.87	5.88	1.017^{ns}	0.312
Juiciness	5.51	5.52	5.52	5.54	5.55	5.151^{ns}	0.3531

Means in a raw do not different significantly (p>0.05).

Lsd = least significant difference

SE ± = standard error

n.s = not significantly difference (p>0.05)

A = negative controlled group

B = positive controlled group

C = 0.1% garlic essential oil

D = 0.2% garlic essential oil

E = 0.3% garlic essential oil

4.1.3 Economic appraisal

The total cost, returns, net profit and profitability ratio per head of broiler chicks fed different levels of garlic essential oil and antibiotic for 6 weeks are shown in **Table 5**. Chicks purchase, management and feed cost values (SDG) were the major inputs considered. The selling values of meat is the total revenues obtained. The results of economical evaluation indicated that the dietary groups C, D and E gained more net profit than that of groups A and B. the value Profitability ratio (1.27) of group E was the highest of the tested groups.

Table 5.The total cost, revenue and net profit of broiler chicks fed on different levels of garlic essential oil and antibiotic for 6 weeks

Items	Groups				
	A	B	C	D	E
Cost					
Chick purchase	3	3	3	3	3
Total Feed cost	8.4	8.9	8.8	8.9	8.9
Management	3	3	3	3	3
Total cost of production	14.4	14.9	14.8	14.9	14.9
Revenue					
Live weight	1576.9	1662.5	1642.7	1653.9	1662.1
Dressing percentage	69.63	69.65	69.64	69.65	69.67
Average weight	1.098	1.158	1.144	1.152	1.158
Price/ Kg of bird	18	18	18	18	18
Total Revenue	20.77	21.27	21.97	22.23	23.00
Profit					
Total Revenue	20.77	21.27	21.97	22.23	23.00
Total cost of production	14.4	14.9	14.8	14.9	14.9
Total Profit	6.37	6.37	7.17	7.33	8.1
Profitability Ratio	1	1	1.12	1.15	1.27

⁂*Total cost calculated according to October 2012*
⁂*A current (May 2012) price of meat 18 (SDG)/Kg*

CHAPTER FIVE

5.1 DISCUSSION

This experiment was conducted to evaluate the response of broiler chicks fed graded levels of garlic essential oils as natural growth promoter alternative to antibiotic. The garlic essential oils was added to the basal diets at level 0.1, 0.2 and 0.3%, and Neomycin antibiotic added to the basal diet at level 20 mg/kg as positive control diet.

In this study the apparent health of experimental stock was good throughout the experimental period. The general behavior of the stock also was good. The ambient temperature during the experimental period fell within the thermoneutral zone has extracted no heat on the experimental birds. No mortalities were recorded among the different treatment groups throughout the experimental period, this may be due to the hygienic situation of the experiment. In this study birds were kept in clean disinfected environment following all hygiene regulations program. Similar results were obtained by *Javed et al., (2009) and Fayed et al., (2012).* However, *Tollba and Hassan (2003)* reported that garlic as natural feed additive in broiler diets decreases the mortality rate due to its active ingredients which are acts as anti-microbial agents.

Although birds which received garlic essential oils and antibiotic diets had greater weight gain than those fed negative control diet; the weight gain did not show significant differences between dietary treatment groups. These results are in accordance with the reports of *Sarica et al., (2005); Cross et al., (2002) and Amouzmehr et al., (2013).* Who found no significant differences in weight gain of chick fed with garlic essential oil compared to

the control group. Also *Konjufca et al., (1997); Botsoglu, (2001 and 2004) and Blolukbasi et al., (2006)* reported non-significant effect of garlic powder supplementation on weight gain of broiler chicks. These result did not agreed with those of *Dieumou et al., (2012)* who found the broiler chicks fed on either garlic extract or streptomycin sulphate diets gained significantly more weights than those fed control diets. *Similarly, AL-Homidan, (2005); Tollba and Hassan (2003); Ziton, (2009) and Fayed et al., (2012)* found that the dietary garlic powder improved significantly the weight gain of broiler chicks. These authors attributed the improvement in weight gain obtained by dietary garlic and its extracts groups to allicin active ingredients in garlic which promotes the performance of intestinal flora, thereby improving digestion and enhancing the utilization of energy, leading to improve the growth of birds.

The feed intake in this study tended to be higher in the chicks fed on garlic essential oil or antibiotic diets compared with negative control group, but the differences were not statistically significant. This result is equally in harmony with the findings of *Dieumou et al., (2009); Amouzmehr et al., (2013); Thakar et al., (2004); Tucker, (2002) and Williams and Losa, (2001)* who showing no significant effect of garlic essential oils on the feed intake of broiler chicks. In contrast, *Dieumou et al., (2012)* found that addition of garlic essential oil and streptomycin sulphate to the diet improved the feed intake of broiler chicks. *Like-wise Racesi et al., (2009)* reported that the diet supplemented with garlic powder at level 1-3% had significantly had better feed intake compared with control diet.

The feed conversion ratio in the present study was not affected significantly by the experimental diets. This results are consistent with the findings of *Rahimi et al., (2011); Dieumou et*

al., (2009) and Sarica et al., (2005), who reported chicks fed with garlic essential oils diet had the same feed conversion ratio with control group, whereas *Dieumou et al., (2012)* reported that use of garlic essential oil improved significantly the feed conversion ratio in broiler chicks. Also, *Ziton, (2009)* found that addition of garlic powder in broilers diet improved significantly the feed conversion ratio of the chicks. They attributed the better feed conversion ratio to the anti-bacterial properties of the garlic and its extracts, which resulted in better absorption of the nutrients in the gut and finally leading to improvement in feed conversion ratio.

Treatment effect in this study was not significant on carcass dressing percentage. These results are in line with the findings of *Amouzmehr et al., (2013) and Dieumou et al., (2012)* who reported that garlic essential oil did not have any significant effect on carcass dressing percentage of broiler chicks. In contrast, *Dieumou et al., (2012)* reported that carcass dressing percentage of broiler chicks fed on diets supplemented with either garlic essential oil or streptomycin sulphate were better significantly than values obtained from those fed on control diet.

No significant differences were observed between all treatment groups in subjective meat quality attributes (colour, Flavor, juiciness and tenderness) and all score being at above moderate values. However, *Eugèiuszr and Edyta, (2007)* inform that 5gm/kg diet of dried garlic contributed to the increase sensory assessment of chicken meat.

The results in this study showed that application of garlic essential oils and antibiotic, had no significant effect on performance, carcass dressing percentage and meat quality parameters. Although, this experiment was performed in

disinfected condition that may have resulted in a decreased the efficiency of these growth promoters. However, the results cited in literature are highly variable about the degree of improvement in growth performance and carcass characteristics of broiler obtained by dietary garlic extract as growth promoters. This may be due to the variation in the efficiency of the garlic extract additive which depend on many factors including, birds materials, dose used, management, genetic variation of garlic, age of plant and environmental factors such as climate and soil *(Mohan, 2004; Barreto et al., 2008 and Pourali et al., 2010).*

The results of economical evaluation of experimental diets showed that the addition of garlic essential oil at various inclusion levels in the diet of broiler was economically profitable, but the values of profitability ratio (1.27) of the test group E (0.3%, garlic oil) was the highest of the test groups. *Amal, (2012)* found that addition of Black cumin, Limon grass, Spearmint and Halfa bar essential oil to the broiler diet economically was feasible.

5.2 CONCLUSION AND RECOMMENDATIONS

5.2.1 Conclusion:

- The results of present study indicated that the use of garlic essential oil at various inclusion levels in the diet had no significant effect on body weight gain, feed intake, feed conversion ratio and mortality rate of broiler chicks.
- Adding garlic essential oil at all inclusion levels in the diet made no changes in carcass dressing percentage and subjective meat quality attributes of broiler chicks.
- Using garlic essential oil at different levels in broiler diet economically feasible.

5.2.2 Recommendations:

- Practical implication
- Application of garlic essential oil in the diet had no significant effect on the performance of broiler chicks reared under well disinfected condition in this study.
- More effective influences of dietary garlic essential oil could probably be seen in broilers rearing in less hygienic situation.
- All levels of garlic essential oils added to the broiler diets in this study were recommended economic-wise, but the level of dietary garlic oil 0.3% was more profitable.

- Suggestion for future research:
  - More trails are needed to clarify the effects of garlic and its extract on productive performance, carcass characteristics, digestive system development, immune system, intestinal microflora and blood constituents of broilers with regard to varied management conditions, including different stress factors, types and sources of garlic, oil extraction methods, optimal dietary inclusion levels, dietary ingredients and nutrients contents.

  - The future research also should be focused on the use of other herbs and spices and their organic extracts, enzymes, probiotics, prebiotics, synbiotics and organic acids as natural growth promoters in broilers production.

REFERENCES

Adctumbi, M. and Lau, B.H. (1983). Allium sativum a natural antibiotic. Med. Hypoth. 12:227-237.

Ademola, S.G.; Farinu, G.O. and Babatunde, G.M. (2009). Serum lipid, growth and Haematological parameters of broiler fed garlic, ginger and their mixture. World Journal of Agriculture Science. 5(1): 99-104.

Adogo, G.L. (1987). The mechanism of the hypolipidemic effect of garlic oil. Biochem Biopbys Res. Comu. 142:1046-1052.

Ahmad, S. (2005). Comparative efficiency of garlic, turmeric and Kalongi as growth promoters in broiler. M.Sc. thesis, Department of Poultry Sciences, University of Agriculture, Faisalabad. Pakistan.

Ahsan, M. and Islam, S.N. (1996). Garlic a broad spectrum antibacterial agent effective against common pathogenic bacteria. Fitoterapia. 67:374-376.

AL-Homidan, A.A. (2005). Efficiency of using different sources and levels of Allium cepa, Allium sativum and Zingiber officinale on broiler chicks performance. Saudi Journal of Biological Sciences. 12(2):96-102.

Allam, S. (2000). Poultry Breed and Husbandry. (18th edition). The Egyptian Anglo Library-Freed street, Cairo, Egypt.

Amagase, H. and Milner, J. A. (1993). Impact of various sources of garlic and their constituents on 7, 12-dimethylbenz (a) anthracene binding to mammary cell DNA. Carcinogenesis, 14:1627-1631.

Amal, O.A. (2012). Use of essential oils in broiler nutrition as growth promoters, Ph.D. thesis. College of Agriculture Studies, Sudan University of Science and Technology.

Amouzmehr, A.; Daster, B.; Nejad, J.G.; Sung, K.; Lohakare, J. and Forghani, F. (2013). Effect of garlic and thyme extracts on growth performance and carcass characteristics of broiler chicks. Poultry Industry Technical articles. Nutrition. Article. (170).

Ankri, S. and Mirelman, D. (1999) Antimicrobial properties of allicin from garlic. Microbes infect. Feb., 1(2):125-129.

Barreto, M.S.R.; Menten, J.F.M.; Racanici, A.M.C.; Pereira, P.W.Z. and Rizzo, P. (2008). Plant extracts as growth promoters in broilers. Rev. Bras. Cienc. Avic (Brazilian Journal of Poultry Science). 2:109-115.

Blolukbasi, S.C.; Erhan, M.K. and Ozkan, A. (2006). Effect of dietary thyme oil and vitamin E on growth, lipid oxidation, meat fatty acids composition and serum lipoproteins of broilers. S. Afr. Anim. Sci. 36:189-196.

Borck, C. (2001). Antioxidant health effects of aged garlic extract. J. Nutr. (Suppl.3):1010-1015.

Botsoglou, N.A.; Florou-Paner, P.; Christaki, E.; Fletouris, D.J. and Spais, A.B. (2001). Effect of dietary oregano essential oil on performance of chickens and on iron-reduced lipid oxidation of breast, thigh and abdominal fat tissue. Br. Poult. Sci., 43:230-233.

Botsoglu, N.A.; Florou-Paner, P.; Christaki, E.; Fletouris, D.G. and Spais, A.B. (2004). Effect of mixture of herbal

essential oils or tocopheryl acetate on performance parameters and oxidation of body lipid in broiler. S.Afr. Anim. Sci. 34:52-61.

Brander, G.C.; Pugh, D.M.; Bywater, R.J. and Jenkins, W.L. (1991). Veterinary Applied pharmacology and Therapeutic. Tindall. London.

Castanon, J.I.R. (2007). History of the use of antibiotic as growth promoters in Euro feeds. Poultry Science., 86(11): 2466-2471.

Chan, K.C.; Yin, M.C. and Chao, W.J. (2007). Effect of diallyltrisulfide-rich garlic oil on blood coagulation and plasma activity of anticoagulation factors in rats. Food Chem Toxicol. 45(3):502-507.

Comelison, J.M.; Yan, F.; Watkins, S.E.; Rigby, L.; Segal, J.B. and Waldroup, P.W. (2006). Evaluation of hops (Humulu) antimicrobial in broiler diets. Int. Poult. Sci., 5: 134-136.

Craig, W.J. (1999). Health-promoting properties of common herbs. Am., J. Clin. Nutr., 70(suppl):491-499.

Cross, D. E., Acamovic, T., Deans, S. G. and Mcdevitt, R. M. 2002. The effect of dietary inclusions of herbs and their volatile oils on the performance of growing chickens. Br. Poult. Sci. 43:33-35

Cummings, J.H and Macfarlane, G.T. (2002). Gastrointestinal effects of prebiotics. Br.J.Nutr., 87:145-151.

Demir, E; Kiline, K; and Yildirim, Y. (2005) use of antibiotic growth promoter and two herbal natural feed additives with and without exogenous enzymes in wheat base broiler diets. South Africa Anim. Sci., 35:61-72.

Dibner, J.J. and Richards, J.D (2005). Antibiotic growth promoters in agriculture; History and mode of action. Poultry science, 84:634-643.

Dieumou, F. E.; Teguia, A.; Kuiate, J. R.; Tamokou, J. D.; Fonge, N.B. and Donogmo, M.C. (2009) Effect of ginger (zingiber officinale) and garlic (Allium sativum) essential oils on growth performance and gut microbial population of broiler chicks. Livestock Research for rural Development. 21(8): 21-33.

Dieumou, F.E.; Teguia, A.; Kuiate, J.R.; Tamokou, J.D.; Doma, U.D.; Abdullahi, U.S. and Chiroma, A.E. (2012). Effect of diets fortified with garlic extract and streptomycin sulphate on growth performance and carcass characteristics of broilers. International Journal of Livestock & Production. 3(4):36-42.

Donoghue, D.J. (2003). Antibiotic residues in poultry tissues and eggs human health concerns. Poultry Science. 82(4):618-621.

Dorhoi, A.; Dobrean, V.; Zahan, M. and Virag, P, (2006). Modulatory effects of several herbal extracts on avian peripheral blood cell immune responses. Phytother Res., 20:352-358.

Durak, i.; Ozturk, H.S.; Olcay, E. and Guven, E. (2002). Effect of garlic extract supplementation on blood lipid and antioxidant parameters an atherosclerotic plaque formation process in cholesterol-fed rabbits. J. Herbs Phamacother 2(2): 19-32.

Elayyar, M.; Draughon, F.A.; Golden, D.A. and Mount, J.R. (2001). Antimicrobial activity of essential oils from plants against

selected pathogenic and saprophytic microorganisms. J. Food. Protect., 64:1019-1024.

EL-Gamry, A.A.; EL-Mallah, G.M.; Yamny, A.T. (2002). The effect of incorporation yeast culture, Nigella sativa and fresh garlic in broiler diets on their performance. Egyptian Poultry Science. 22:445-459.

Ellis, N. (1981). The nutrients composition of Sudanese animal feeds. Bulletin (1): Northern and Central Sudan. Central Animal Nutrition Research Laboratory. Kuku Research Centre, Khartoum-North, Sudan.

Ensminger, A.H. (1994). Foods and nutrition encyclopedia. Volume 1. CRC. Press. 1994. ISBN 0-8493-8980-1.p750.

Eugeiuszr, R. and Edyta, K. (2007). Herbs in animal feeding. Herba Polonica. 53(3):360-365.

Fayed, R.H.; Razik, A.A. and Ouf, G. (2011). Effect of dietary garlic supplementation on performance, carcass traits and meat quality in broiler chicken. XVISAH Congress, Viena.

Fulder, S. (1989). Garlic and the preventation of cardiovascular disease. Cardiol Protect. 7: 30-35.

Gabor, S.; Vilmos, P,; Bela, N.; Istvanne, E.; Gyrogy, N.; Gabor, S.; Gyorgy, B. and Szabolcs, R. (1998). New type of immune-stimulant to increase antibody production in response to viral and bacterial vaccines. Magyar Aliatorvosok Lapja, 120:719-721.

Griggs, J.P. and Jacob, J.P. (2005). Alternative to antibiotics in organic poultry production. J. App.Poult.Res. 14:750-756.

Gunal, M.; Yali, G.; Kaya, O.; Karahan, N. and Sulak, O. (2006). The effects of antibiotic growth promoter and probiotic supplementation on performance, intestinal micoflora and tissue of broiler. Int.J.Pout.Sci., 5:149-155.

Hafez, H.M. (2011). Enteric diseases of poultry with special attention to Clostridium perfringens, Pak.Vet.J., 31:1-6.

Haq, A.; Meraj, K.A. and Rasool, S. (1999). Effect of supplementing Allium sativum (garlic) and Azadirachtu indica (Neem) leaves in broiler feed on their blood cholesterol, triglycerides and antibody titer. Int. j. Agric. Biol. 1(3):125-127.

Hawrysh, Z.J.; Steedman-Doglas, C.D.; Robble, A.R.; Harding, R.T. and Sam, R.M. (1980). Influence of low glucosinolate (C.V.Tower) rapseed meal on the eating quality of broiler chickens. Poult. Sci. 59:550-557.

Hernandez, F.; Madrid, J.; Garcia, V.; Orengo, J. and Megias, M.D. (2004). Influence of two plant extracts on broiler performance, digestibility and digestive organ size. Poultry Science, 83:169-174.

Hertrampt, J.W. (2001). Alternative antimicrobial performance promoters. Poultry. Int. 40:50-52.

Jamroz, D. and Kamel, C. (2002). Plant extracts enhance broiler performance. In non-ruminant nutrition antimicrobial agents and plant extracts on immunity, health and performance. J. Anim. sci80(E.suppl-1):41.

Jang, I. S.; Constituents, Y.H.; Kang, S.Y. and Lee, C. (2007). Effect of a commercial essential oil on growth performance, digestive enzymes activity and intestinal microflora population in

broiler chickens. Animal Feed Science and Technology. 134:304-315.

Javandel, F.; Navidshad, B.; Seifdavati, J.; Pourrahimi, G.H. and Baniyaghoub, S. (2008). The favorite dosage of garlic meal as a feed additives in broiler chickens rations, Pakistan Journal of Biological Sciences, 11(13):1746-1749.

Javed, M.; Durrani, F.R.; Hafeez, A.; Khan, R.U. and Ahmed, I. (2009). Effect of aqueous extract of plant mixture on carcass quality of broiler chicks. Arpan Journal of Agriculture and biological Science. 4(1):37-40.

Jimoh, A.A.; Ibitoye, E.B.; Dabai, Y.U. and Graba, S. (2013). In vivo Antimicrobial Potentials of garlic against Clostridium perfringens and its promotant effects on performance of broiler chickens. Pakistan Journal of Biological Sciences. 16(25):1978-1984.

Joanne, B.; Anderson, L.A. and Phillipson, J.D. (2007). Herbal Medicines-third edition, published by the Pharmceutical Press. Lambeth High Street, London SE17JN, UK.

Jones, F.I. and Ricke, S.C. (2003). Observation on the history of the development of antimicrobials and their use in poultry feeds. Poultry Science. 82:613-617.

Kamanna, V. and Chandrasekhara, N. (1982). Effect of garlic (Allium sativum) on serum lipoproteins cholesterol levels in albino rats reduced hypercholesterolemic by feeding cholesterol. Lipids, 17:483-488.

Kato, Y.; Kuwabate, T.; Itoh, T.; Hiuva, M.; Shegimatsu, A. and Hara, T. (2001). A possible relationship between abortions

and placental embolism in pregnant rabbits given human granulocyte colon-stimulating factor. J. Toxicol Sci. 26:39-50.

Koch, H.P. and Lawson, L.D. (1996). Garlic the Science and Therapeutic Appication of Allium sativum L. and Related Species, 2nd edn. Baltimore, Maryland: Williams and Wilkins.

Konjufca, V.H.; Pasti, G.M. and Bakalli, R.I. (1997). Modulation of cholesterol levels in broiler meat by dietary garlic and chopper. Poult. Sci., 76: 1264-1271.

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

Kyo, E.; Uda, N.; Suzuki, A.; Kakimoto, M.; Ushijima, M.; Kasuga, S. and Itakura, Y. (1998). Immunomodulation and antitumor activities of aged garlic extract. Phytomedicine, 5:259-267.

Langhout, P. (2000). New additives for broiler chickens. World Poultry-Elsevir, 16(3):22-27.

Lemar, K.M.; Passa, O. and Aon, M.A. (2005). Allyl alcohol and garlic (Allium sativum) extract produced oxidative stress in Candida albicans. Microbiology (Reading. Engl.) 151(pt10).

Lissiman, E.; Bhasale, A.L.; Cohen, M. (2012). Garlic for the common cold. Cochrane Dutabase Syst Rev.3.

Lopez-Bote, L.J.; Gray, J.L.; Gomaa, E.A. and Flegal, C.L. (1998). Effect of dietary administration of oil extracts from rosemary and age on lipid oxidation in broiler meat. Br. Poult. Sci., 39: 235-240.

Lu, L. and Yeh, Y.Y. (2001). Water-soluble organosulfur compounds of garlic inhibit fatty acids and triglyceride synthesis in altered rat hepatocytes. Lipid. 36:395-400.

Madhumite, R.; Ramalingam, C.; Yogeshwar, D. and Bedi, J. (2012). Bioedible coating of meat using garlic, cinnamon and turmeric. European Journal of experimental Biology, 2(5):1439-1443.

Mehmet, C.; Talat, G.; Bestami, D. and Nihat, O. (2005). The effect of Anise oil (Pimpinella anisuml.) on broiler performance. International Journal of Poultry Science. 4(11): 851-855.

Meraj, I.C.A (1998). Effect of garlic and neem leaves supplementation on the performance of broiler chickens. M.Sc. Thesis, Dept of poult.Sci., University of agriculture, Faisalabad, Pakistan.

Miron, T.; Rabinkov, A.; Mirelman, D.; Wilckek, H. and Weiner, L. (2000). The mode of action of allicin: its ready permeability through phospholipids membranes may contribute to its biological activity. Biochem. Biophys. Acta. 1463:20-30.

Mohan, T. (2004). Pharmacological screening of some medicinal plants as antimicrobial and feed additives. M.Sc. thesis. Virginia Polytechnic Institute and state University, Blackburg, Virginia. U.S.A.

Mustafa, A.M. (2011). Response of broiler chicks to diet containing live yeast as probiotic natural feed additives. M.SC.

College of Agricultural Studies, Sudan University of Science and Technology.

National Office of Animal Health, (2001). Antibiotics for animals, an overview, http://www.noad.co.uk/issues/briefin.

NRC, National Research Council (1994). Nutrient Requirements of Poultry. (9th rev. Ed). National Academy Press. Washing, D.C., USA.

Onibi, G.E.; Oluwatoyin, E.; Adebisi, A.; Fajemisin, N.; Ayode, V. and Adetun, J.I. (2009). Response of broiler chickens in terms of performance and meat quality to garlic (Allium sativum) supplementation. African Journal of Agricultural Research. 4(5):511-517.

Pankaj, S.; AL-Tamimi, B.; AL-Nassri, N. and AL-Mamari, R. (2012). Effect of temperature on antibiotic properties of garlic (Allium sativum L) and ginger (Zingiber officinale) African Journal of Biotechnology 11(95):16192-16195.

Pervez, A. (1992). Response of broiler chicks to different feed additives. M.Sc. thesis NWFP Agriculture University, Peshawar, Pakistan.

Pesti, G. (1997). Poultry meat with lower cholesterol. Poult. Int. 36:31.

Pourali, M.; Mirghelenj, S.A. and Kermanshahi, H. (2010). Effects of garlic powder on productive performance and immune response of broiler chickens challenge with Newcastle disease virus. Global Veterinaria. 4(6):616-621.

Racesi, M.; Hosèini-Aliabad, S.A.; Roofchaee, A.; Shahneh, A. and Pirali, S. (2010). Effect periodically use of garlic (Allium

sativum) powder on performance and carcass characteristics in broiler chickens. World Academy of Science, Engineering and Technology. 68:1213-1219.

Rahimi, S.; Zadeh, Z.; Torshizi, M.A.; Omidbagi, R. and Rokin, H. (2011). Effect of the three Herbal extracts on growth performance, Immune system, blood factors and intestinal selected bacterial population in broiler chickens. J. Agric. Sci. Tech. 13:527-539.

Ramakrishna, R.R.; Platel, K. and Srinivasan, K. (2003). In vitro influence of species and spice activate principles on digestive enzymes of rate pancreas and small intestine. Nahrung., 47:408-412.

Rashida, A. and Khan, H.H. (1974). The mechanism of hypotensive effect of garlic extract. J. Pak Med. Ass. 35:337-362.

Ray, F. and Fox, S. (1979). Practical Poultry feeding. First edition. British Library Cataloguing in Publication Data-London.

Rees, L.P.; Minney, S.F.; Plummer, N.T,; Slater, J.H. and Skyreme, D.A. (1993). A quantitative assessment of the antimicrobial activity of garlic (Allium sativum). World. J. microbial. Biotechnol. 9:303-307.

Revington, B. (2002). Multi-state Poultry Feeding and Nutrition Conference. PP-1-14, Feeinfo, Indianpolis, India, USA.

Ried, K.; Frank, O.R. and Stocks, N.P. (2010). Aged garlic extract hypertension: a randomised controlled trail. Maturitas 67(2): 144-150.

SAS Institute. (1994). SAS/STAT user's guide. Version 6.1, 3rd Ed. SAS Inst., Cary, NC.

Sarica, S.; Ciftci, A.; Demir, E.; Kiline, K. and Yildirim, Y. (2005). Use of antibiotic growth promoter and two herbal natural feed additives with and without exogenous enzymes in wheat based broiler diets. South Africa Animal Science. 35:61-62.

Sendle, A. (1995). Allium sativum and Allium ursiuon: part1. Chemistry, analysis, history, botany. Phytomedicine, 4: 323-339.

Shalaby, A.M.; Khattab, Y.A. and AbdelRahman, A.M. (2006). Effect of garlic (Allium sativum) and chloramphenicol on physiological parameters and survival of Nile tilapia (Oreochromis niloticus). J. venom. Anim. Toxins. Trop. 51:36-39.

Shivendu, R.; Dasgupta, N.; Saha, P.; Rakshit, M. and Ramalingam, C. (2012). Comparative study of antimicrobial activity of garlic and cinnamon at different temperature and its application on preservation of fish. Adv. Appl. Res. 3(1): 495-501.

Simonetti, G. (1990). Schuler, S., ed. Simon and Scuster's Guide to herbs and species. Simon and Scuster, Inc. ISBN 0-671-73489-x.

Singh, G.I.P.; Kapoor, S.K.; Pandey, U.K. and Singh, R.K. (2002). Studies in essential oils, Part 10, antimicrobial activity of volatile oils of some spices. Phytother Res. 16:680-682.

Singh, M.P. and Panda, H. (2005). Medicinal herbs with their formulations. Volume 1-Allium sativum-Daya Publlshing House-Delhi-110 035.

Skyrme, D.A. (1997): the antimicrobial activity of Allium sativum. Ph.D. thesis Gradiff University.

Steel, R.G.D. and J.H. Torrie. (1986). Principles and Procedures of Statistics: A Biometrical Approach (2nd Ed.). McGraw Hill Co. Inc., NY, USA.

Soliman, N. (2000):"Histological and histochemical studies on the effect of garlic (Allium sativum) extract on the liver and lung of albino rat." M. Sc. Thesis, Histology Dept., Fac. Med., Ain Shams University, Cairo, Egypt.

Sumiyoahi, H. (1997) new pharmacological activities of garlic and its constituents (Review). Folia Pharmacological Japonica. 110 suppl, 1: 93-97.

Tekeli, A.; Kutlu, H.R.; and Celik, L., (2011). Effect of Z.officinale and propolis extracts on the performance of broiler chicks. Curr.Res.Poult.Sci., 1:12-23.

Thakar, N.M.; Chairman, D.M.; Mcelroy, A.R.; Novak, C.L. and Link, R.I. (2004). Pharmacological screening of some medicinal plants as antimicrobial and feed additives. M.Sc. Dissertation. Department of Animal Science. Virginia Polytechnic Institute and state University Blacksburg, Virginia. U.S.A.

Tollba, A.A. and Hassan, M.S. (2003). Using some natural additives to improve physiological and productive performance of broiler chicks under high temperature conditions. Black cumin (Nigella sativa) or garlic (Allium sativum). Poult. Sci. 23:327-340.

Tsao, S.M. and Yin, M.C. (2001). In vitro activity of garlic oil and four diallylsulfides against antibiotic-resistant Pseudomonas

aeruginosa and Klebsiella pneumoniae. Antimicrob Chemother. 47:665-670.

Tuker, L. (2002). Botanical broilers: plant extracts to maintain poultry performance. Feed Int. 32:26-29.

Valero, M., and Salmeron, M.C. (2003). Antimicrobial activity of all essential oils against Bacillus ceveus in tyndallized carrot broth. Int .J. Food Microbial, 85:73-81.

Van Immerseel, F.; DeBuck, J.; Pasmans, F.; Huyghebaert, G.; Haesebrouk, F., and Ducatelle, R. (2004). Clostridium emerging threat from animal and public health. Avian Pathol., 33:537-549.

Verstegen, M.W.A. and Schaafsma, G.J. (1999). Some developments on alternatives for antibiotics as growth prom gastrointestinal physiology today and tomorrow, Jansman A.J.M. and Husiman (Eds). Wageningen University: 6556-6573.

Vipul, V.; Singh, R.; Tiwari, R,; Sirvastava, N. and Verma, A. (2012). Antibacterial activity of extracts of citrus, Allium and Puncia against food born spoilage. Asian Journal of Plant Science and Research. 2(4); 503-509.

Weber, N.D., Anderson, D.O.; North, J.A.; Murray, B.K. and Lawson, L.D. (1992). In vitro virucidal effects Allium sativum (garlic) extract and components. Planta Med., 58:417-423.

Wikipedia, the free encyclopedia, (2013). htt:// en. wikipedia. org/ wiki/ Garlic.

Wiliams, P. and Losa, R. (2001). The use of essential oils and their compounds in poultry nutrition. World poultry-Elsevier. 17:14-15.

Yeh, Y.Y. and Yeh, S.M. (1994). Garlic reduces plasma lipids by inhibiting hepatic cholesterol and triacylglycerol synthesis. Lipid. 29:189-193.

Ziarlarimi, A.; Irani, M.; Gharahveysi, S. and Rahmani, Z. (2011). Investigation of antibacterial effects of garlic (Allium sativum), mint (Menthe spp.) and onion (Allium cepa) herbal extracts on Escherichia coli isolated from broiler chickens. African Journal of Biotechnology Vol. 10(50), pp. 10320-10322.

Ziton,A.A . (2009) responseof broilerchicks todiet containing garlic asnaturalnfeed additive M.Sc. thesis.college of Agricultural studies and Technology

Appendix1

Weekly maximum and minimum experimental temperature during the period

October 18th – November 29th 2012

Weeks	Temperature ºC	
	Maximum	Minimum
1	35	23
2	35	23
3	33	22
4	32	21
5	32	21
6	31	19
Average temperature	33	21.5

Source: Shambat meteorological station

Appendix2

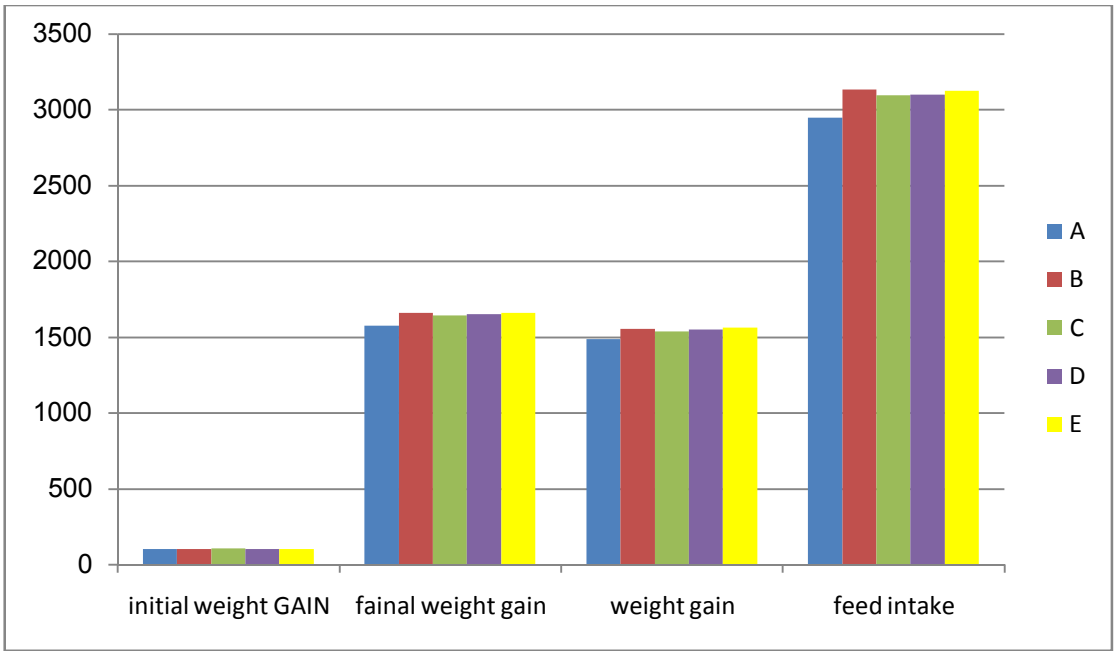
Card used for judgment of subjective meat quality attributes

Sensory Evaluation Card

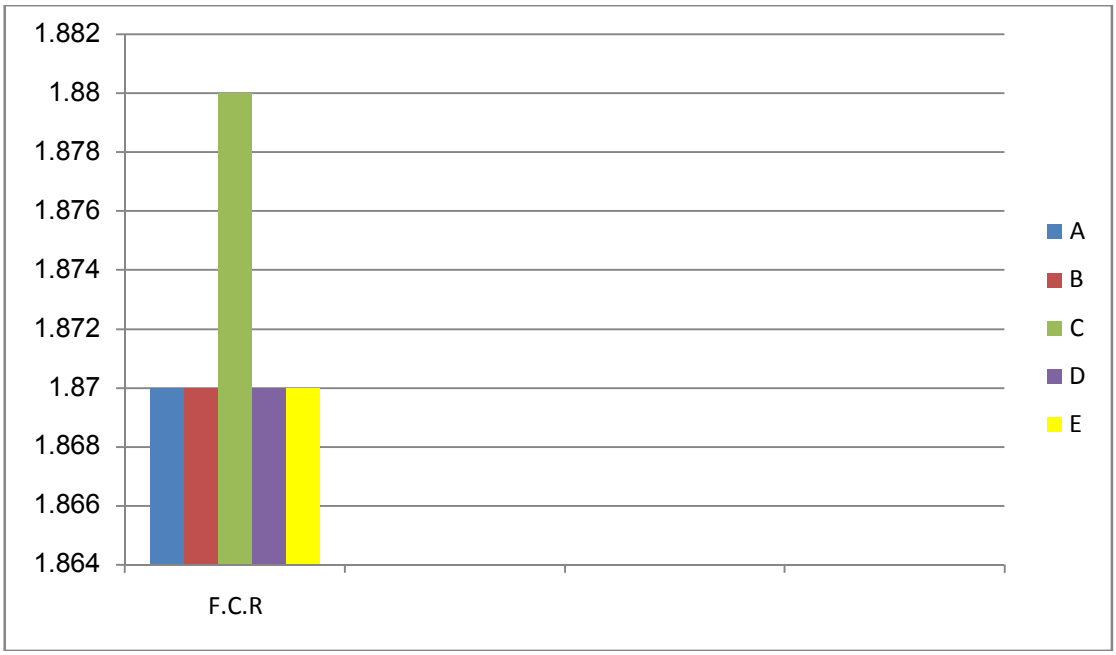
Name: ……..
Date:……..

Serial	Sample Code	Tenderness	Flavor	Colour	juiciness
		8-Extermely tender	8-Extermely intense	8-Extermely desirable	8-Extermely juicy
		7- very tender	7-very intense	7-very desirable	7-very juicy
		6-moderatelty tender	6-moderately intense	6-moderately desirable	6-moderately juicy
		5-slightly tender	5-slightly intense	5-slightly desirable	5-slightly juicy
		4-slightly tough	4-slightly bland	4-slightly undesirable	4- slightly dry
		3- moderately tough	3- moderately bland	3- moderately undesirable	3- moderately dry
		2- very tough	2- very bland	2- very undesirable	2- very dry
		1- extremely tough	1- extremely bland	1- extremely undesirable	1- extremely dry

Appendex(3);Figure **1. The effect of different dietary amount of garlic oil and the antibiotic on the initial weight gain ,fainal weight gain and feed intake of broiler chicks for 6 weeks**



Appendex(4);Figure 2. The effect of different dietary amount of garlic oil and the antibiotic on the feed convertion ratio of broiler chicks for 6 weeks



Appendex(5) ;Figure 3. The effect of different dietary amount of garlic oil and the antibiotic on percentage of subjective values of broiler chicks (6 weeks)