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MASTER THESIS

NİĞDE ÖMER HALİSDEMİR UNIVERSITY
GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES

T.R.
NİĞDE ÖMER HALİSDEMİR UNIVERSITY
GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES
DEPARTMENT OF ANIMAL PRODUCTION AND TECHNOLOGIES

EVALUATION OF DIETARY SUPPLEMENTATION OF GARLIC POWDER (*ALLIUM SATIVUM*) ON THE GROWTH PERFORMANCE, CARCASS TRAITS AND MEAT QUALITY OF JAPANESE QUAILS (*Coturnix Coturnix Japonica*)

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SEPTEMBER 2020

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Master Thesis

Supervisor

Professor Dr. Sibel CANOĞULLARI DOĞAN

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Hassan JALAL tarafından **Prof. Dr. Sibel CANOĞULLARI DOĞAN** danışmanlığında hazırlanan "**Karma yeme katılan sarımsak tozunun (*allium sativum*) japon bıldırcınlarının (*Coturnix coturnix japonica*) performans, karkas özellikleri ve et kalitesine etkilerinin değerlendirilmesi**" adlı bu çalışma jürimiz tarafından Niğde Ömer Halisdemir Üniversitesi Fen Bilimleri Enstitüsü Hayvansal Üretim ve Teknolojileri Ana Bilim Dalı'nda Yüksek Lisans tezi olarak kabul edilmiştir.

(The study titled "**Evaluation of dietary supplementation of garlic powder (*Allium sativum*) on the growth performance, carcass traits and meat quality of Japanese quails (*Coturnix coturnix japonica*)**" and presented **by Hassan JALAL** with the help of supervisor **Prof**. **Dr. Sibel CANOĞULLARI DOĞAN,** has been found as Master thesis by the jury at the Department of Animal Production and Technologies of Niğde Ömer Halisdemir University Graduate School of Natural and Applied Sciences.)

Başkan (Head): Prof. Dr. Sibel CANOĞULLARI DOĞAN (Niğde Ömer Halisdemir University)

Üye (Member): Prof. Dr. Ahmet ŞAHİN (Kırşehir Ahi Evran University)

Üye (Member): Dr. Öğretim Üyesi Sema YAMAN FIRINCIOĞLU (Niğde Ömer Halisdemir University

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Prof. Dr. Murat BARUT

DIRECTOR

THESIS CERTIFICATION

I proclaim that all information present in this thesis is derived and compiled keeping in view the scientific and academic rules and that this study is jotted down considering academic rules and regulations. Moreover, any help and resources that i have seek in compiling this thesis are duly mentioned wherever required.

Hassan JALAL

ÖZET

KARMA YEME KATILAN SARIMSAK TOZUNUN (*Allium sativum*) JAPON BILDIRCINLARININ (*Coturnix Coturnix Japonica*) PERFORMANS, KARKAS ÖZELLİKLERİ VE ET KALİTESİNE ETKİLERİNİN DEĞERLENDİRİLMESİ

JALAL, Hassan
Niğde Ömer Halisdemir Üniversitesi
Fen Bilimleri Enstitüsü
Hayvansal Üretim ve Teknolojileri Anabilim Dalı

Danışman : Prof. Dr. Sibel CANOĞULLARI DOĞAN

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Bu çalışma, sarımsak tozunun (*Allium sativum*) Japon bıldırcını karma yemlerine katkısının büyüme performansı, karkas özellikleri ve et kalitesi üzerindeki etkisini değerlendirmek amacıyla yapılmıştır. Çalışmada 240 adet bıldırcın civcivi 4 muamele grubuna ayrılmış ve her grup her birinde 15 bıldırcın bulunan 4 tekerrürden oluşturulmuştur. Gruplara deneme yemleri şu sırayla verilmiştir: A grubundaki bıldırcınlar kontrol grubu olup bazal yemle beslenmiştir. Bununla birlikte B, C ve D gruplarına sırasıyla % 0.5, 1 ve% 2 sarımsak tozu verilmiştir. Araştırma sonunda %1 sarımsak tozu katkılı grup diğerlerine kıyasla daha yüksek canlı ağırlık, canlı ağırlık kazancı ve yemden yararlanma oranına sahip olmuştur ($P<0.05$). Sarımsak tozu katkısı karkas özelliklerini ve abdominal yağı etkilememiştir ($P>0.05$). Sarımsak tozu katkılı gruplarda pH, tiyobarbitürik asit (TBA), peroksit ve toplam psikrofilik bakteri sayısı kontrol grubuna göre daha düşük bulunmuştur ($P<0.05$). Sarımsak tozu katkılı gruplarda duyusal özellikler önemli düzeyde daha yüksek gözlenmiştir ($P<0.05$). Karma yeme % 1 ve %2 düzeyinde sarımsak tozu katkısının bıldırcınların performansı ve etin raf ömrü üzerinde önemli bir etkiye sahip olduğu ve sağlık ve çevresel riskleri önlemek için sentetik katkı maddelerinin yerini alabileceği sonucuna varılmıştır.

Anahtar Kelimeler: Bıldırcın, performans, sarımsak tozu, sentetik katkı maddelerinin, etin raf ömrü.

SUMMARY

EVALUATION OF DIETARY SUPPLEMENTATION OF GARLIC POWDER (*Allium Sativum*) ON THE GROWTH PERFORMANCE, CARCASS TRAITS AND MEAT QUALITY OF JAPANESE QUAILS (*Coturnix Coturnix Japonica*)

JALAL, Hassan
Niğde Ömer Halisdemir University
Graduate School of Natural and Applied Sciences
Department of Animal Production and Technologies

Supervisor : Prof. Dr. Sibel CANOĞULLARI DOĞAN

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This study was conducted to assess the effect of dietary supplementation of garlic powder (*Allium sativum*) on the growth performance, carcass traits and meat quality of the Japanese quail. In this study, 240 quail chicks were distributed into 4 treatment groups and each group was further sub-divided into 4 replicates containing 15 quails in each. The experimental diet was given to the groups in the following order: Birds in group A treated as a control and was fed the basal diet. However, group B, C and D were offered 0.5, 1 and 2% garlic powder respectively with basal diet. The group C showed higher live weight, body weight gain and improved feed conversion ratio ($P<0.05$) as compared to others. Supplementation of garlic powder did not influence on the carcass traits and abdominal fat ($P>0.05$). pH, thiobarbituric acid (TBA), peroxide, and total psychrophilic bacteria were lower in garlic supplemented groups than the control group ($P<0.05$). Sensory characteristics were observed significantly higher in garlic supplemented groups. It is concluded that 1-2 % garlic powder supplementation in diet had a significant influence on the performance of quail and shelf life of the meat and it can replace synthetic additives to prevent health and environmental risks.

Keywords: Quail, performance, garlic powder, synthetic additives, shelf life of meat.

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SYMBOLS AND ABBREVIATIONS

Symbols	Abbrevations
%	Percentage
℃	Degrees Celsius
cm	Centimetre
g	Gram
$K_2S_2O_8$	Potassium Persulfate
kg	Kilogram
KI	Potassium Iodide
L	Litre
mg	Miligram
ml	Mililitre
Na_2Co_3	Sodium carbonate
ppm	Parts Per Milion

Abbreviations	Descriptions
BHT	Butyl Hydroxy Toulene
GAE	Gallic Acid Per Equivalent
P	Significant
PV	Peroxide Value
SE	Standard Error
SEM	Standard Error Mean
SOD	Super Oxide Dismutase
TBARS	Thiobarbituric Acid Reactive Substances
TEAC	Trolox Equivalent Antioxidant Capacity
TPC	Total Phenolic Contents
WHC	Water Holding Capacity.
LBW	Live Body Weight
FCR	Feed Conversion Ratio

BWG	Body Weight Gain
FI	Feed Intake
LDL	Low Density lipids
ND	Newcastle Disease
IBD	Infectious Bursal Disease
DOC	Day Old Chick
LDL-C	Low Density Lipoprotein-Cholestrol
HDL	High Density Lipoprotein-Cholestrol
AST	Aspartate Aminotransferase
NOHU	Niğde Ömer Halisdemir University
RPM	Resolution Per Minute
TDS	Total Digestible Solvents
PCA	Plate Count Agar

CHAPTER I

INTRODUCTION

Quail farming has always been espoused due to high yielding potential with a short incubation period of 17 days. Quails are preferred over other game birds due to its smallest size for production purposes. They are mostly located in Asia, Europe, America and Australia but their lucrative breeds are bred worldwide for meat and eggs purposes. Japanese quail (*Coturnix japonica*) is preferred for commercial use and getting immense popularity due to its production potential. Being the finest meat producing bird, Japanese quail achieves a live weight of 200 grams at the age of 4 weeks. Irrespective of quality, Japanese quail farming is also convenient as it gives better production and prodigious turnover rate at minimal maintenance cost (Ray et al., 2014). The estimated weight of this breed is 200-260 grams (Ahmad, 2014). Japanese quail is of immense important due to remunerative value in egg formation as their laying capacity up to 290-300 eggs in the first laying year (Jatoi et al., 2015). Quail products have innumerable health benefits and cure to many diseases as in ulcers and gastritis (Udeh et al., 2018). Many diseases can also be treated using quail meat such as white plague, chlorosis, bronchial asthma, hypoglycemia. Eradication of heavy metals is also assisted by the use of quail products (Chi et al., 1982). They aid in annihilating stones of kidney, liver and gall bladder. Quail products have antineoplastic effects, revival after blood stroke, strengthening of cardiac muscle and act as aphrodisiac agents (Udeh et al., 2018).

People investing in the poultry industry are more likely to earn faster than investing in other domesticated animals. Poultry industry is the most propitious across the globe and provides animal source protein with more biological value. The human population is increasing rapidly which means world population is going to reach 10 billion in 2050 and more than 11 billion in 2100 which is a matter of great concern as concomitantly existing animal protein shortage gap is also increasing amid different people. Synthetic chemical products are being used by researchers to meet protein demand in the poultry industry. Antibiotics hold immense importance and are extensively used in broilers as growth promoters (Miles et al., 2006). Broilers have rapid growth capability and small generation gap so antibiotics encourage broilers to perform efficiently and increase

carcass quality together with less fat ratio and more protein amount in meat (Kinsella et al., 1990; Nettleton, 1991). *Salmonella, Eschercihia coli* (*E.coli*), *Campylobacter,* and *Enterococci* species are the zoonotic infectious agents that can easily be reduced by using a synthetic chemical in broiler's diet. Generally, birds administered with such antibiotics results in better performance but the residues of antibiotics are observed in their meat and eggs (Issa and Omer, 2012) that can be a health hazard for humans (Rahmatnejad et al., 2009). People are more interested in food that carries increased bioactive or functional components with better health benefits (Cofrades et al., 2008). Regarding the foodstuff, quantity and quality are targeted in recent years. The user is at great peril of developing diseases like cardiovascular disorders, obesity and cancer due to the high intake of fat in meat (Hygreeva et al., 2014). An increased amount of polyunsaturated fatty acids in poultry meat are sensitive to oxidative degradation. Oxidation of lipids is a major complication in meat processing, cooking and frigidarium. Oxidation of lipids promotes a decrease in food standards, taste, shelf life of foodstuffs and affects organoleptic properties. Antioxidants do not allow the oxidation of lipids which aids in assuring the quality of food products (Pawel et al., 2005). Natural or synthetic antioxidant avoids oxidative damage and accelerates storage life of poultry feed. Many underdeveloped countries are still using synthetic antioxidants and antimicrobials to increase the storage life of food products and to prevent unfavourable reactions. Some countries are preferring the use of natural preserving agent over synthetic due to the toxic effect of synthetic antioxidants on health (Capitani et al., 2015). Natural antioxidants and antimicrobials are obtained from animals, plants and microorganisms that are proved to be secured, influential and admissible, which are constantly being inquired (Hygreeva et al., 2014). Researchers are investing in natural and genuine content without any detrimental effects on humans and animal health and managing to work on such supplements by keeping health issues in mind. In order to acquire nutritious food products, it is essential to make it from desirable healthful ingredients and decrease the number of unhealthy products (Decker and Park, 2010). It is beneficial to use natural products over artificial because of their authenticity and purity. Animal nutritionists and food technologists are thriving to work on the making of products having low fat and low sodium with natural antioxidants and antimicrobials, supplemented with omega-3 and omega-6 fatty acids (Hygreeva et al., 2014). Among the replacement of chemical products, aromatic plants are very important

and such plants are supposed to have phenolic compounds in them. Among phenolic compounds especially flavonoids are more potent in plants (Shaidi et al., 1992).

Many plants are having phenolic compounds like garlic, ginger, oregano, parsley, cinnamon, fenugreek seeds, rosemary etc. The reason behind using herbs is that they have strong antimicrobial action, anti-oxidative characters, hypocholesterolemic effects, electrifying effects on the gastrointestinal tract, antiepileptic effects and myorelaxant (Elgayyar et al., 2001; Botsoglou et al., 2002; Jmaroz and Kamel, 2002). Giving phytobiotic products and their elixirs in animal feed enhance the overall capabilities of animals (Alcicek et al., 2003). Every country has its own way of living and history regarding the utilization of herbs as preventives and treatments.

Among herbal products, garlic is a well-known medicinal plant. Garlic is frequently used in many countries. Every country or domain has its way of using garlic as it is one of the best vegetable used as a medicinal herb and spice. Garlic has antibacterial properties and is extensively used in many diseases (Premavalli et al., 2020). Many pieces of research have been signified by different institutions on garlic due to its effective medicinal attributes. Garlic is frequently used as a natural feed additive in poultry due to its innumerable advantages and value specifically for broiler growers. The reason is antiseptic, non-inflammatory, germicidal, parasiticidal and immune-modulating properties of garlic. Garlic is used as medicine, antioxidants, antihypertensive, anti-platelet, antilipemic, flavouring agent in a variety of food, and withdrawal of heavy metals is done by garlic (Rehman et al., 2015). Garlic is a great substitute of synthetic chemical products such as antibiotic growth promoters in broilers with exceptional effects on development, digestibility, palatability and carcass characteristics (Bampidis et al., 2005).

From the past 10 years, the activity of garlic is being studied against different food-related pathogens that spoil food (Unal et al., 2001). The main ingredient of garlic is allicin that putrefies many volatile organosulfur composites with bioactive (Kirkpinar et al., 2014). Hence, the supplementation of garlic powder to the quail diet could positively influence on the meat quality of quails. Anyhow, literature about the efficacy of dietary supplementation of garlic powder on quail meat quality is very less. Therefore, the aim of the current study was to scrutinize the effectivity of garlic as an

alternative to medicinal growth promoters in Japanese quails to examine its effect on growth performance, carcass traits, the colour of meat, pH, lipid oxidation and sensory properties of quail meat.

CHAPTER II

LITERATURE REVIEW

2.1 General Information

Garlic (*Allium sativum*) is a member of the family alliance and very familiar member among 600 species including onion, shallot and leek (Rehman, 2003). Garlic is categorized into 2 categories like hard necks (ophioscordon) and soft necks (sativum) (Borek, 2001). Garlic is ploughed in the Middle East and utilized as flavouring agents or as a therapeutic plant. It is an important component consumed by humans in their diet. Garlic was fed to the workers of pyramids in Egypt as an immune booster that is safe to consume and also enhances performance (Rivlin, 2001). In middle ages, garlic was appreciated and prized due to the medicinal properties and was assumed as an illusion against evils. Garlic is used either in powdered form or chopped to give aroma to tomato sauces, stews and salad dressings in southern European and Asian menu. Garlic is indigenous to central Asia and naturally grown in Italy and Southern France. Garlic is commercially available in different forms like garlic oil, powdered garlic and tablets. They are extensively utilized for certain medicinal ambitions such as a drop in blood pressure and enhancing lipid profile (Elkayam et al., 2003) Garlic has been approved scientifically for many purposes as an antimicrobic, anti-lipemic, anti-atherosclerosis and anti-diabetic (Marilynn, 2001). Regardless of allicin, which is the most active component of garlic, there are many others like Ajoene, S-allyl cysteine, diallyl sulfide. Garlic is significant a source of organosulfur composites that are accountable for the aroma and flavour including positive effects on health (Block, 1985). There are 33 constituents of sulphur in garlic with multiple enzymes and approximately 17 amino acids and mineral. Selenium is a great example of it. Sulphur present in garlic is a source of its smell and medicinal properties (Chowdhury et al., 2002). Allicin and diallyl sulphides have fruitful effects on health. Main ingredient of garlic is allicin that putrefies many volatile organosulfur composites with bioactive (Chang and Cheong, 2008). Moreover, garlic has many positive effects on the immune system and cardiovascular system apart from antibacterial properties (Sumiyoshi, 1997). From the past 10 years, the activity of garlic is being studied against different food-related pathogens that spoil food (Unal et al., 2001).

Garlic is extensively utilized across the world as a flavoring and medicinal herb that protects against infections or different heart problems by treating several diseases (Javandel et al., 2008). Garlic is found helpful in lowering in serum and liver cholesterol serums and it is bacteriostatic and decreases oxidative stress (Horie et al., 1992). It was observed that feeding garlic decreases mortality rate, better feed conversion ratio (FCR) and enhances the growth of the poultry (Tollba and Hassan, 2003). Powdered garlic is being studied for its beneficial effects on poultry by observing its anti-bacterial, anti-coccidial, immune-boosting and growth-promoting properties

2.1.1 Garlic as an antibacterial agent

The very first evidence of garlic antimicrobial properties was discovered in 1721 in France during plague outbreak. Four workers were employed to get rid of dead bodies and no one gets infected. Later research revealed that they had used garlic and wine tincture (Hann et al., 1996).

Allicin, diallyl sulfide and diallyl trisulfide are components of garlic which possess biological influence (Ankri and Mirelman, 1999). Garlic has alliin, which converts to allicin by the presence of an enzyme called alliinase when it is sliced (Fenelli et al., 1998). The most effective ingredient of garlic is allicin as it gives garlic an aroma and taste and has medicinal properties (Chowdhury et al., 2002). Garlic is operative against different forms of pathogens like gram-positive, negative and acid-fast bacteria. Garlic is effective against *Micrococcus, Bacillus subtulis, Staphylococcus aureus, Pseudomonas, Proteus, Klebsiella,* Salmonella *and E.coli, Mycobacterium and Clostridium* (Rehman et al., 2015). Different diseases of poultry can also be treated by using garlic in the feed like colibacillosis, salmonellosis and cholera. Zhang et al. (1996) tested the effectiveness of qincola on fowls. Dry garlic powder, golden buckwheat rhizome, Sophora root, liquorice, and Polygala root are some of the medicinal plants used in making a feed additive called qincola. It was observed that adding 1% qincola in the diet increased their food consumption and helped in gaining weight. Feeding qincola proved effective against pullorum disease and also increased the resistance against disease in young birds and chances of survival rate. The aroma, taste and juiciness of broiler meat were great with no bad smell. And the quality of the meat was good in the supplemented group. Bharathi et al. (2018) conducted an

experiment and concluded that the quail birds that were offered feed supplemented with turmeric oil or garlic or its mixture without any antibiotic with no significant loss in productivity. Garlic, turmeric oil and their combination could be useful and an effective replacement of antibiotics in quail farming.

Garlic, when combined with vancomycin, boosts up the immunity by increasing its antimicrobial properties (Jonkers et al., 1999). Alteration in the chemical structure of the bacterial membrane and their absorptivity to allicin could be the reason for garlic antimicrobial property (Miron et al., 2000)

2.1.2 Garlic as an antiviral agent

Mostly Commercially prepared antibiotics are ineffective against viral diseases. Viral diseases of poultry are untreatable with antibiotics. There is barely any research conducted on antiviral characteristics of garlic. Laboratory research on garlic showed that it is effective against many viruses such as influenza A and B, rhinovirus, cytomegalovirus, human immunodeficiency viruses, rotavirus, herpes simplex 1 and 2 and viral pneumonia (Rehman et al., 2015).

2.1.3 Garlic as an anti-protozoal agent

Supplementation of garlic in poultry feed shows antiprotozoal results. However, the exact mechanism of action has yet to be found. Previous studies reported that garlic has a significant effect against many protozoal diseases such as *Entamoeba, Trypanosomes, Leishmania,* and *Leptomonas* (Reuter et al., 2014). In China, *Trichomonas vaginalis* and *Entamoeba histolytica* causing diseases are treating by a commercially available product known as Dasuansu made up of garlic having diallyl trisulphide component (Lang et al., 1981). Moreover, another researcher performed an experiment to check the efficacy of dietary garlic in *Cryptosporidium bailleyi* infected birds. Increased shedding of oocyst with diarrheal conditions, 30% weight loss, 60% reduced weight of bursa of fabricius and 62-44% decreased lymphocytic count was observed in infected birds. Moreover, phagocytic activity of macrophages was also reduced. By giving garlic in the feed (5% and 10%) to 2 of the 3 groups for consecutive 9 days, incredible results were seen as there was no shedding of oocyst with fully cured diarrhoea and a total body

weight gain (BWG) with the increased weight of bursa of Fabricius. Ali et al. (2019) conducted a research to investigate the anticoccidial effect of ginger and garlic in chickens. They induced coccidiosis in broiler birds and observed a statistically positive effect on growth performance of birds in ginger and garlic treated groups. Moreover, supplementation of garlic and ginger improves gut morphology and shedding of oocysts in coccidia infected birds as compared from the control group supplemented with amprolium.

2.1.4 Garlic as an antifungal agent

Antifungal characteristics of garlic have been observed by some researchers. Schmidt and Marquardt was the scientist who reported the first-ever antifungal activity of garlic in epidermophyte cultures (Lemar et al., 2002). Garlic decrease the oxygen uptake due to presence of oxygen scavenging molecules inhibit protein, lipids and the nucleic acid formation and decrease the growth of the organism and alter the membranous structure (Rehman et al., 2015). The efficiency of thiabendazole with garlic was studied against a fungus called *Aspergillus fumigatus* by injecting it in pigeons. Less mortality with mild clinical symptoms were developed and pathological changes were observed in birds getting the treatment. Garlic is better than thiabendazole so it is preferred in the feed of poultry and act as an antifungal and antimicrobial agent (Nafady et al., 1990). Allicin is the affective component in garlic that shows antifungal activity (Hughes et al., 1991). Other components like diallyl trisulphide and ajoene also have significant effects against cryptococcal meningitis, Candida and Aspergillus respectively (Rehman et al., 2015).

2.1.5 Garlic as an antioxidant agent

Garlic has been used extensively to cure the diseases due to its antioxidant activity. Herbs and phytobiotics have phenolic compounds that play a role in antioxidant property. Administering garlic has shown an antioxidant inflence that is the reason for decreasing the value of thiobarbituric acid reactive substances (TBARS) prevent lipid oxidation (Ao et al., 2011). They studied the impact of dietary fermented garlic supplementation on meat quality of broiler and found that TBARS value decreased with the increased level of garlic powder in the diet from 0 to 4 g/kg. Moreover, Kim et al.

(2009) found that 20 or 40 g/kg garlic bulb and husk decreased TBARS value in broiler meat. While, Onibi et al. (2009) observed that dietary addition of garlic in the broilers feed improved the oxidative stability of stored or refrigerated meat. Garlic having flavonoids and sulphur containing compounds acts as a strong antioxidant (Gorinstein et al., 2005). Apart from it, Leonarduzzi et al. (2002) described that low-density lipids (LDL) particles have principal quantities of cholesterol oxidation products and deficiency in LDL cholesterol shows antioxidant effects of garlic administration. Allicin is a chief compound present in garlic and it is effective against lowering blood cholesterol level, triglycerides and diseases (Rahmatnejad and Roshanfekr, 2009).

2.1.6 Garlic as immunomodulatory agent

Garlic not only kills microorganisms but also acts as an immune stimulatory agent and enhance the body's natural defence against different pathogens. Garlic elixir showed immunomodulatory results and lower the age-related retrogression of immune response. Dietary addition of garlic in the broilers feed raises the weight of spleen, thymus and bursa of fabricius (Hanieh et al., 2010). Garlic is a great immune-stimulant as it stimulates the activity of T-Lymphocytes and macrophages and advances Interleukin-1 level. A rapid increase in spleen cells and liberated cytokines is observed by giving garlic extracts. Phagocytic activity of peritoneal macrophages is increased by garlic extracts (Tadi et al., 1990). Garlic components such as diallyl trisulfide and protein fraction have been reported to inflate the T lymphocytes activation and promote the ratio of helper to the suppressor T cell in acquired immunodeficiency syndrome (AIDS) (Rehman et al., 2015). Moreover, garlic inflates the antibody manufacturing against *Leptospira Pomona, Pasteurella multocida* and *Salmonella enteritidi* bacteria which proves its positive effect on the B lymphocytes (Rehman et al., 2015). Dietary supplementation of alliums enhances the humoral immune response against *Brucella abortus* in broiler birds (Hanieh et al., 2010). Nidaullah et al. (2010) reported the immunostimulatory influence of ginger rhizome and garlic bulb extract on many protozoal diseases like coccidiosis, Newcastle disease (ND), infectious bronchitis and infectious bursal disease (IBD).

2.1.7 Detoxification activity

Previous literature reported that garlic works antagonistically against lead toxicity. Consequently using garlic in feed leads to the elimination of lead from poultry that has been previously faced natural or experimental lead pollution. Groups of birds such as 10 chickens in each group were assorted and offered lead separately (lead acetate equivalent to 5 mg lead/kg) in one group, in other group garlic and lead were offered together and garlic was also offered in a group. It was observed that lead was found in lesser quantity in muscles and liver tissues of those poultry birds that were given lead as well as garlic, or after treating bird with lead, garlic was supplemented. Better results were obtained when garlic was given right after the treatment rather than giving garlic and lead at the same time. Garlic has chelating agents that help in increasing elimination of lead. Garlic supplementation in the feed of animals decreases the amount of lead in meat animals that living in a lead polluted environment (Hanafy et al., 1994).

2.1.8 Chemical composition of garlic powder

Proximate analysis of garlic powder shows that it contains moisture 4.55%, crude protein 15.33%, crude fibre 2.10%, crude fat 0.72%, ash 4.08% and carbohydrate 73.22% (Otunola et al., 2010).

2.2 Previous Research on Utilization of Garlic as a Feed Additive for Quails

Premavalli and Omprakash, (2020) evaluated the influence of the addition of garlic powder in a basal feed as herbal additives on the performance of quails. In this trial 300-day old quail chicks were assorted into 4 supplementary groups (each group further sub-divided into three replicates containing twenty-five chicks per replicate). Garlic powder was given with basal diet at the rate of 0, 0.5, 1.0 and 1.5% level and offered for 6 weeks in order to check the growth performance. The results were non-significant in initial body weights up to the fourth week between control and garlic powder supplemented groups. However, in case of mean live body weight (LBW) from fourth to six-week result were significantly higher in quail fed with garlic powder supplemented diets than the control group. Results of FCR was significantly ($P< 0.05$) recorded for garlic powder supplemented diets T2 – T4 (2.88-2.85) than the T1 control

group (2.97). Livability percentage were insignificant. In conclusion, the obtained results indicate that dietary supplementation with dried garlic (up to 1.5%) can exert a beneficial effect on the performance of Japanese quail.

Ali et al. (2014) revealed that dietary inclusion of kalonji, garlic and turmeric effect on performance, carcass traits and haemato-biochemical profile of broiler birds. Birds were casually distributed into 4 dietary treatment groups. Group A assigned as a control group contains only basal diet, birds in group B were offered feed having an addition of garlic with the inclusion level of 0.5 g/kg of the feed. Birds in group C and D were offered feed with kalonji and turmeric at the inclusion rate of 0.5 g/kg of feed, respectively. Chicks of group C gained highest weight gain (1476.60 g) during six weeks as compared to birds of group D (1341 g), B (1339.98 g) and A (1332.50 g) respectively. Chicks of group B showed highest feed consumption (3110 g) in comparison to others. Moreover, FCR was found better in group C than others. In group C, the value of antibody titer against ND was found maximum and the highest titer against IBD was observed in C group. Serum cholesterol value (134 mg/dL) was recorded in group A was highest in comparison of other treatment groups. In the case of BWG, results were observed insignificant. However, a statistically positive effect on FI and FCR was revealed. In carcass characteristics, dressing weight and edible offals weight, the result was non-significant although the significant effect was revealed by statistical analysis on intestinal weight, antibody titre against ND and IBD, abdominal fat and serum cholesterol level.

Zekić et al. (2014) observed the affect of 2% dietary garlic powder addition on the parameters of growth performance, the quality of breast meat and costs effectivness of broiler birds. For this study, 600 day old chicks (DOC) (Hubbard) of broilers were raised up to 42 days and divided into 2 groups of 75 chickens in 4 repetitions. Birds in garlic supplemented group had significantly higher body weight (2019.0 g) during six weeks followed by birds of the control group (1949.5 g). Economic efficiency results revealed that the price of broiler birds is growing in each group, 2.02 $/kg was the price of the control group followed by the experimental group price (2.12 $/kg). Price of chicken meat is higher as compared to the control group but this increase in cost is negligible in order to get healthier and nutritive products without any side effects for human consumption.

Sasidhar et al. (2016) described the influence of using distinct inclusion levels of garlic powder on carcass traits as well as on the organoleptic properties of cooked meat of Japanese quail. Birds were fed with the powder of garlic at the inclusion level of 0, 5, 10 and 15 g/kg in the primary diet of Japanese quail up to four weeks. In the case of carcass and sensory characteristics, results were non-significant in the birds that were fed with garlic supplementation. However, overall acceptability and flavour towards garlic revealed a highly significant difference at concentration level of 1.5% garlic powder supplementation in comparison of the control group.

Raya et al. (2014) performed two experiments simultaneously to check the influence of supplementation of garlic powder and thyme on productivity, carcass traits and serum biochemistry of Japanese quail. In each experiment, three hundred quail birds of two week age were arranged into five treatment groups, each with three replications. In experiment 1 and 2 birds were fed with dietary supplemented garlic powder at the inclusion of (0.0, 1.0, 2.0, 3.0 and 4.0%) or dried thyme (0.0, 0.5, 1.0, 1.5 and 2.0%) respectively. During two to six weeks of age growth performance of Japanese quail were assessed as feed intake (FI), LBW, BWG, FCR and economic efficiency of production. After slaughtering, carcass traits and some blood plasma parameters of birds were also determined. In experiment 1, LBW and FCR were positively significant in those groups that were fed with garlic. Moreover, FI and carcass traits were not significantly different than the control group. Feeding group containing garlic up to 2% significantly affected the efficiency of production in comparison from the control group. Statistical analysis revealed that garlic supplemented group led to a significant decline in blood plasma levels of glucose, triglycerides, total cholesterol and low-density lipoprotein-cholesterol (LDL-C), and activity of aspartate aminotransferase (AST) while high-density lipoprotein-cholesterol (HDL-C) level was significantly increased; but the activity of alanine aminotransferase was not affected, compared from the control. Feeding group containing garlic 2.0% and 3.0% showed significantly higher levels of plasma total protein and albumin as compared to the control group. In experiment 2, groups supplemented with thyme showed higher value of final LBW, FCR and in the economic efficiency of production (up to 1.5% of dietary thyme), but FI and carcass traits were not affected compared with their control group. Thyme supplemented diet group has shown a significant reduction in Blood plasma levels of glucose, triglycerides, total cholesterol, LDL-C and activity of AST, while levels of total protein,

albumin and HDL-C were increased but the activity of alanine aminotransferase was not affected as compared to control group. As a conclusion, it has been determined that addition of dried garlic up to inclusion level of 2% and dried thyme (up to 1.5%) has a beneficial effect on the performance of Japanese quail under the conditions of the present study.

Lukanov et al. (2015) observed the influence of dietary garlic powder addition in the feed as a feed additive on the performance parameters, carcass traits and the meat quality in chickens. 120 male broiler DOC were randomly allocated to 4 groups. Group 1, 2, 3 and 4 were supplemented with garlic powder with the inclusion of 0, 2 g/kg, 4 g/kg and 8 g/kg respectively. Birds were reared up to 56^{th} day of age. Performance characteristics of birds were determined and 56^{th}-day post-slaughter measurement was analyzed that includes, pH, water holding capacity and colour (L*, a*, b*) of broiler meat. Statistical analysis revealed an increase in live weight of birds in groups that were supplemented with garlic powder. Moreover, similar results were obtained in case of FCR. Non-significant effect of dietary garlic addition on the proportion of edible offal and meat cuts was observed. However, significant results have been shown of garlic supplementation on abdominal fat percentage. Garlic powder addition in feed up to the inclusion level of 0.8% had no harmful effect on meat quality. However, tenderness of *Musculus pectoralis superficialis* was observed increased.

Fayed et al. (2011) studied the garlic powder supplementation effect on the performance of growth, carcass traits, meat offals and meat quality of the broilers. For this study, 360 DOC were arranged into 3 experimental groups and each group contained 4 replicates with thirty chicks in each repetition. Birds were reared up to the sixth week of age. Group A assigned as a control group contains only basal diet, birds in group B and C were offered feed with dietary raw garlic powder at the concentration of 0.5 and 1.0 kg/ton, respectively. LBW was significantly higher in the B group and the same group showed the better FCR while FI was the same. In the case of average dressing percentages, results were significantly different but findings were non-significant for heart, liver and gizzard weight among treatment groups. The concentration of cholesterol in thigh meat and breast muscles significantly decreased in birds fed with dietary garlic. Result of microbiological examination revealed that the garlic

supplemented groups has a slight decline in coliforms. They concluded that garlic addition in basal diet might be helpful in efficient broilers production.

Jamel et al. (2013) experimented to evaluated the dietary effect of garlic powder, black cumin seed and plant premix (garlic powder and black cumin seed) in feed on growth performance and intestinal wall structure of broilers. In this experiment, 480 Hubbard broiler DOC were raised up to forty-two days in 4 treatment groups each group further assorted into three replicates. Group 1 contains only basal diet without any feed supplementation and assigned as a control group. Birds in group 2 were offered with a basal diet supplemented with garlic powder at the rate of 0.5%. Birds in group 3 were given basal feed supplemented with 0.5% black seed and in 4^{th} group, birds were offered basal diet with the addition of 0.5% plant premix (garlic powder and black seed). Growth performance parameters were determined weekly and intestinal characteristics were evaluated after slaughtering of birds. Statistical analysis revealed that the group supplemented with garlic powder, black cumin seed and plant premix has shown significant result in case of LBW, BWG and FI in comparison of control group except for FCR. In term of intestinal characteristics, results were significantly higher in garlic powder and plant premix supplemented group against other treatment groups. In terms of goblet cells, results were non- significant among all experimental group. Based on theie trail, it can be concluded that broiler feed should be supplemented with 5g/kg garlic powder and plant premix.

Bharathi et al. (2018) designed an experiment to evaluate the dietary influence of garlic powder, turmeric oil and their mixture on performance of Japanese quail. In this experiment, 150 Japanese quail chicks were arranged into 5 feeding groups and each group contains three more subgroups. BWG, FI, feed efficiency and livability were used as benchmark in response to feeding. It can be concluded that the quail birds that were offered feed supplemented with turmeric oil or garlic or its mixture without any antibiotic with no significant loss in productivity. Garlic, turmeric oil and their combination could be useful and an effective replacement of antibiotics in quail farming.

Onibi et al. (2009) studied to evaluate the efficacy of dietary inclusion of garlic powder on the quality of meat and performance of the broilers. For this study three hundred

DOC of starbro casually assorted into treatment groups having six replicates and 10 birds/replicate. This study lasted for seven weeks. The crude protein of basal starter and finisher phase diets were 228.60 and 204.5 g/kg. The control group-containing compound feed without any supplementation. Basal diets of groups 2 and 3 had addition of garlic powder at the inclusion level of 0.05 and 0.5% respectively while in group 4 and 5 birds were fed with a diet supplemented with boiled garlic powder at 0.05 and 0.5% level respectively. Post slaughter measurements were carried out at the end of the experiment for that purpose 4 female birds from each replication were slaughtered to acquire the carcass, muscle traits, sensory evaluation of the meat and oxidative stability.of refrigerated.meat at 4°C for 6 days. Results of growth performance parameters were non-significant. Birds that were fed with dietary garlic have shown relatively higher BWG in comparison of a control group and weight gain increased with the increased level of garlic supplementation. There were non-significant results were observed in carcass characteristics but values of abdominal fat were lowered in the experimental group. Garlic supplemented group showed significant results (high) in garlic aroma and high palatability scores with the highest concentration of garlic feeding. Meat oxidation analysis measured as malondialdehyde concentration that declined with the high level of garlic supplementation. Statistical analysis revealed that birds that were fed with garlic supplementation at the rate of (5000 mg/kg diet) have shown better weight gain. In a comparison of raw garlic, boiled garlic produced no useful effect. It was also reported that the garlic supplementation in diet enhanced meat quality by improving meat palatability score and protect the meat from oxidation during refrigerated storage.

Aminzade et al. (2012) conducted a biological experiment to check the effect of distinct concentration levels of *Mentha piperita* plant (MPP) on quality of meat traits in quail. A total of one hundred and eighty quail birds were carried out in a completely randomized design using 3 concentration levels of MPP (0, 1.50 and 3.0 %). Each treatment group contained 4 replicates (15 quails/ replicate). On completion of the biological trial, after sacrificing and evisceration of 2 birds from each replicate of treatment. Birds carcass were preserved in a refrigerator (2-4°C) for 24 hours. Parameters including in meat quality were brightness, yellowness, and redness of colours, the capacity of water holding, pH, intra-muscular fats were accessed on samples of breast meat. The result findings revealed that redness, yellowness, and thiobarbituric acid-reacting substances

influenced by diets supplemented with MPP. While, no significant differences was observed for the remaining quality of meat characteristics like water holding capacity, pH, brightness, and intramuscular fat.

El-Shenway et al. (2016) observed the influence of essential oils and blend of organic acids on the performance of quail birds. A total of four hundred, mix sexed DOC of quails were casually assorted into 4 dietary groups and 100 chicks per group. The first treatment group (control) fed only basal diet without any dietary supplementation while, 2^{nd}, 3^{rd}, and 4^{th} were fed the basal diet supplemented with 0.25, 0.5, or 0.75 g of essential oils and blend of organic acids respectively. This trial lasted for six weeks. During this trial, it was observed that using a blend of essential oil, and volatile fatty acids at 0.25 or 0.5 g/kg in the diet increased final weight of chicks like 4.1 and 9.9% respectively, in comparison of the control. While at a higher dose (0.75 g/kg diet) had no significant impact on LBW of chicks. Moreover, there was a significant increased in LBW about 4.3 and 10.6% when compared to the control. While at higher supplementation level had shown a non-significant impact on LBW of quail birds. It was observed that using a blend of essential oils and volatile fatty acids deduced the total FI of quail birds and no significant influence on FCR and protein efficiency ratio when compared from the control. While it was noticed that using essential oils and blend of volatile fatty acids specifically at the inclusion of 0.5 g/kg in the diet increased percentage of neutrophil, phagocytic activity and production of antibodies against ND vaccine and had no detrimental impacts on kidney or hepatic cells function when compared from the control. Besides, the use of essential oils and volatile fatty acids in Japanese quail feed causes significantly decreased in total bacterial count and *E.coli* in cecal content, while counts of lactobacillus had been increased in cecal content when compared from the control.

Swain et al. (2017) conducted an experimental trial to examine the effects of dietary addition of ginger and garlic on the growth performance and blood chemical profile of birds. Supplementation of natural additives as a substitute for antibiotics as a growth promoter includes garlic and ginger. Japanese quail birds are stalwart which can bear even bad management conditions. One week old, three hundred Japanese quails were selected and divided casually into 4 groups having seventy-five birds in each group. This research lasted for five weeks. Weekly body weight changes were noticed during

this trial. On 4th week, group T2 had shown the highest LBW significantly higher than groups T0, T1, and T3. On completion of this trial, blood samples were collected and estimate the serum biochemical parameters like albumin, glucose, protein, cholesterol and triglycerides. It was noticed that the dietary addition of garlic and ginger powder causes a significantly reduction in cholesterol and triglycerides of birds. In group T1, the lowest level of serum cholesterol and triglycerides were noticed. Hence, it can be inferences that the addition of ginger and garlic in the diet not only enhance the bodyweight but also reduced the cholesterol and triglycerides of quail.

El-sayed et al. (2017) planned a study to explore the impacts of dietary addition of antibiotics, oregano essential oil and garlic powder as feed additives in the ration of the quails on production and growth performance. A total of five hundred and forty mix sexed DOC of Japanese quails were casually divided into 9 experimental groups. Each group containing sixty birds (three replicates of twenty quails in each). Quail chicks in 1st group were given a basal diet without any additives and treated as a control. Chicks of 2nd and 3rd treatment groups were fed primary diet supplemented with oxytetracycline at the inclusion of 0.5 and 1g/kg in diet respectively. While, chicks of 4th, 5th, and 6th groups were fed a basal diet supplemented with oregano essential oil at the inclusion of 0.5, 1 and 1.5g/kg diet respectively. Birds of 7th, 8th, and 9th groups were fed a basal diet supplemented with garlic powder at the inclusion of 0.1, 0.2, and 0.3 g/kg in diet respectively. The current findings revealed that highly significant differences were noticed in average LBW, BWG, growth rate, FI, FCR, carcass traits, the mortality rate, cost of production and total microbes in the small intestine. The highest significant advancement in LBW, BWG, growth rate, FI, FCR, carcass characteristics, and the reduced level of total microbial populations in intestine and mortality rate were studied in chicks group that were fed with dietary addition of oregano essential oil at the inclusion of 1.5 and 1.0 g/kg, respectively compared from other treatments and control group, followed by those that were fed diet supplemented with 0.2 g/kg powdered garlic. Although, from an economic point of view, it could be reiterated that feeding basal diet supplemented with garlic powder with the inclusion rate of 0.2 g/kg diet had shown the lower cost of feeding than feeding a basal diet with dietary addition of oregano essential oil with the inclusion rate of 1.5 and 1 g/kg diet. It was crystal clear that chicks of the control group had shown the lowest performance and higher mortality rate. So, it could be recommended to use oregano essential oil with the inclusion rate of

1.5 and 1 g/kg diet and garlic powder at the inclusion of 0.2 g/kg in the diet as a substitute to antibiotic growth promoters to enhance the production performance and economics of quail feeding.

El-Katcha et al. (2011) performed an experiment to explore the impact of feeding dietary addition of distinct inclusion levels of garlic powder (0, 5, 10, 20, 25, and 30 g/kg) on LBW, BWG, FCR, immune system, serum biochemistry and carcass characteristics of quails. On completion of this trial, it was noticed that no significant difference in BWG. İn case of FCR results was also insignificant among all treatment groups. İn groups where quail chicks were offered garlic powder as a feed additive showed increased FI except quail birds of group 6. Increased in lymphocytes and monocytes were observed in all garlic powder receiving groups in comparison with the group having 0% of garlic. While, non-significant differences observed between quail birds supplemented with garlic powder with distinct inclusion levels in serum alkaline phosphatase levels, red blood cells, White blood cells. Results were also observed non-significant in terms of carcass characteristics, edible offals and weight of immune organs. Serum cholesterol level and triglycerides level were decreased significantly in all garlic powder supplemented groups in comparison of control. However, reduction in fat percentage of body with the dietary supplementation of garlic powder in all treated groups was observed.

Abdullah et al. (2010) conducted an experiment to evaluate the impact of garlic powder as a feed additive on the growth performance of broiler birds. A total of 400, DOC chicks were purchased from a local hatchery and fed basal diet supplemented with distinct concentrations (0, 0.25, 0.50 and 1%) of garlic powder. Each treatment group having five pens. Throughout this experiment, ad-libitum water and feed supplied to the birds. Parameters include in production were body weight, FCR and FI. Garlic powder had shown non-significant effects on final body weight and feed utilization rate. However, a significant effect of garlic powder at 0.5 and 1.0% on FI was observed. Small intestine histo-pathological measurements were shown significant effect by garlic powder supplementation. In the duodenum, villus length was shown highest in birds fed diets supplemented with 1% garlic powder. In the jejunum, villus length was highest in birds fed basal diet supplemented with 0.25 and 1% garlic powder. Garlic powder supplementation had shown non-significant impacts on carcass characteristics.

Physiochemical properties of meat were not influenced by the dietary treatment except for juiciness percentage and pH, which were the lowest at 1.0% and 0.25%, respectively. They concluded that garlic powder at the inclusion of 0.5% might be useful on gut morphological parameters and production performance.

CHAPTER III

MATERIALS AND METHODS

3.1 Material

The current study was performed on animals in the quail unit of Niğde Ömer Halisdemir University, Ayhan Şahenk Agricultural Research Application and Research Center. Laboratory studies were carried out in Niğde Ömer Halisdemir University (NOHU), Faculty of Agricultural Sciences and Technologies, Department of Animal Production and Technologies.

3.1.1 Housing and management

This study was conducted in a controlled quail growing room in the size of 3 x 5.5 m in the quail unit within the body of (NOHU), Ayhan Şahenk Agricultural Research Application and Research Center. Cleaning, fumigation and washing of the experimental quail unit were done before chick's arrival. Disinfection of feeders, drinkers, and utensils was done with a commercial sanitizer. Birds were reared at 5-storey octagonal housing, which was 120 x 92 x 45 cm in size and each floor was 92 x 45 x 25 cm in size, equipped with multi-deck cages designed especially for the quails having automatic (nipple drinker) and thermostat main machine (Figure 3.1). The house was well ventilated. Quail chick feeders were placed in each cage for the first two weeks in case of quail chicks not being able to reach the water. Clean and fresh drinking water having low total digestible solvents (TDS) was provided to the birds round the clock.

(a) (b) (c)

Figure 3.1. Quail chicks cage (a), drinker (b) and thermostat machine (c)

3.1.2 Animal material

A total of 240 Japanese quail (Coturnix coturnix japonica) birds were procured from the hatchery in the quail unit of (NOHU), Ayhan Şahenk Agricultural Research Application and Research Center. The birds were equally distributed into 4 treatment groups and each treatment group having 4 replicates of 15 birds according to complete randomized design. Individual live weights of quail birds were determined with an electronic scale with an accuracy of ± 0.01 g and each group was placed with mixed-sex in the compartments of quail cages (Figure 3.2). The average weight of birds was tried to keep the same.

(a) (b)

Figure 3.2. Hatching of day old quail chicks (a) and quail chicks placed in cage after hatching (b)

3.1.3 Feed material

In this study, commercial broiler chick starter feed which was taken from a commercial enterprise and provided to all the birds according to the recommendation of NRC (1994) having CP 23% and ME 3100 kcal/kg supplemented with or without garlic powder (Figure 3.3). Commercial broiler chick starter feed was given to quails for 5 weeks but 4 different mixed feed groups were made by adding 0, 0.5, 1 and 2% garlic powder to the feed. Birds in group A served as a control group and fed the basal diet. Group B was offered with basal diet addition with garlic powder 0.5%, group C was offered basal diet supplemented with garlic powder 1%, and group D was offered basal diet with garlic powder 2%. Experimental diets were given to four replicates of each group of quail birds from day 1-35. Freshwater (24 hours) was provided by using a nipple drinking system.

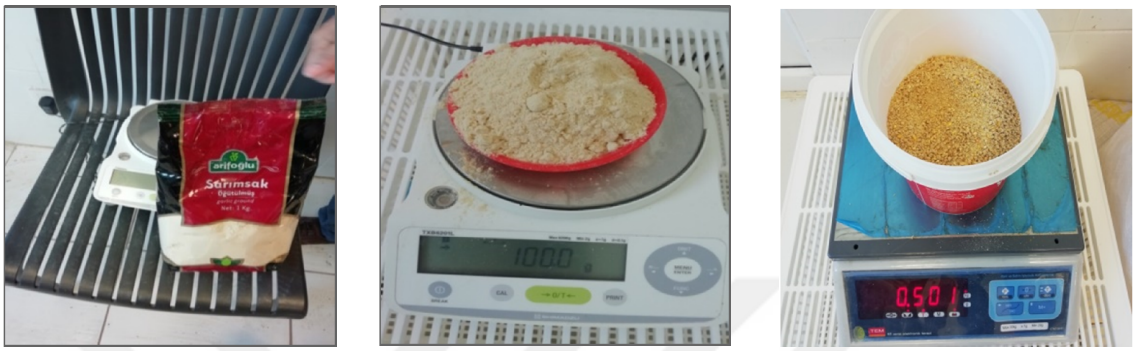
Table 3.1. Composition of the basal experimental diet

Raw materials	Percentage	Calculated nutrients (%)	
Corn	43.308	ME (kcal / kg)	3100
Soy bean	38.058	Crude Protein	22.92
Wheat bran	12.00	Dry Matter	89.326
Vegetable oil	3.5	Raw oil	6.775
$CaCO_3$	0.819	Ash	5.518
DCP	0.777	Crude fiber	5.369
Salt	0.300	Lysine	1.44
Lysine	0.523	Methionine	0.683
Methionine	0.385	Methionine + Cystine	1.083
Threonine	0.130	Calcium	0.900
Vitamin mix *	0.100	Phosphorus	0.439
Mineral mix **	0.100		
Total	100.00		

2.5 kg vitamin mixture 12.000.000 IU Vit. D3, 30.000 mg Vit. E, 5000 mg Vit. K3, 3.000 mg Vit. B1, 6.000 mg Vit. B2, 5,000 mg Vit. B6, 30 mg Vit. B12, 10.000 mg Calcium-D-pentothenate, 750 mg Folic acid, 75 mg D-Biotin, 375.000 mg Choline Chloride. 1 kg of mineral mix contains 80,000 mg iron, 60,000 mg zinc, 8,000 mg copper, 500 mg iodine, 200 mg cobalt, 150 mg selenium.

Table 3.2. Experimental design

Diets	Treatments	Garlic inclusion level	
A	Control	---	Treatments = 4 Replicates per treatment = 4 Birds per replicate = 15 Total = 4×4×15 = 240
B	Diet B with garlic powder	0.5%	
C	Diet C with garlic powder	1%	
D	Diet D with garlic powder	2%	



(a) (b) (c)

Figure 3.3. Commercial garlic powder (a) and weighing of garlic powder before mixing in basal feed (b, c)

3.2 Methods

240 quail chicks used in the study were weighed with an electronic scale with an accuracy of ± 0.01 g at the beginning of the trial and the mean of LBW in each group was tried to be similar. The study consisted of 4 groups containing 0, 0.5, 1 and 2% garlic powder, 4 replicates with 15 chicks in each group. The temperature was adjusted to 32-33°C in the first week with the thermostat heater and temperature was decreased by 2-3°C every week and fixed at 24-25°C. The room temperature was adjusted to a suitable level for the quail with the air conditioner and temperature was measured with the thermometer. The quail trial was continued for 35 days. Feed and water were provided ad-libitum, natural and artificial lighting was applied for 24 hours.

3.2.1 Extraction of garlic powder

For extraction of garlic powder, 10 g of garlic powder dissolved in 100 mL of 80% ethanol then stirred by ultrasonic water bath for 30 minutes. After that garlic powder was dissolved by keeping it in the shaking machine for 24 hours at a temperature of

40°C and 500 resolution per minute (RPM) agitation speed. The dissolved mixture was then filtered with coarse filter paper and then ethanol was evaporated at 50°C in a rotary evaporator (IKA, HB-10 digital, Germany) to obtain garlic powder extract (Figure 3.4) (Uçak, 2019). The extract was stored at -80°C in order to determine the total phenolic substance and antioxidant content.

(a) (b)

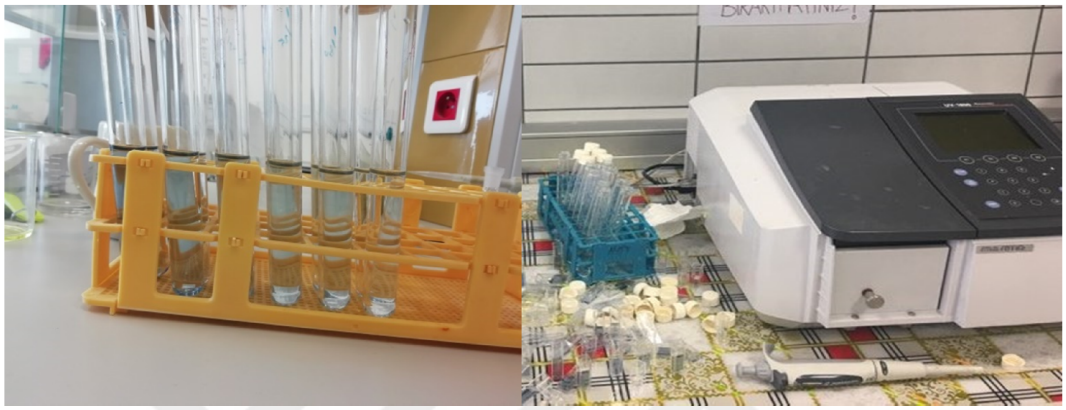
Figure 3.4. The process of filtering the garlic powder extract by filter paper (a) and evaporating the ethanol from garlic powder extracts (b)

3.2.2 Determination of the total phenolic content of garlic powder

The basis of the determination of total phenolic substance is based on the redox reaction in which phenolic compounds reduce the Folin-Ciocalteu reagent in the basic medium and turn into an oxidized form. In the preparation of the standard graphic, the gallic acid standard, a phenolic compound is used. Different concentrations of gallic acid with ethanol (1-0.5-0.25-0.125-0.0625-0.03125 mg/mL) are prepared and their absorbance is read. Absorbance graph is drawn against concentration. According to the graph, the total amount of phenolic substance of ethanolic sample extracts is found (Slinkard and Singleton, 1992).

Folin Ciocalteu reagent was used to investigate the total amount of phenolic substance in the extract from garlic powder. For this purpose, 900 µl of distilled water, 5ml of 0.2 N Folin-Ciocalteu reagent and 4ml of saturated sodium carbonate (Na_2CO_3) solution (7.5 g/L) were added to 100 µl of the solution diluted from the garlic powder extract.

Subsequently, samples that were kept at room temperature in the dark for two hours were read against the curve in the spectrophotometer at 765nm (Figure 3.5). Total phenolic compound concentration was determined as miligram gallic acid equivalent (mg gallic acid/1g) using an equation obtained from the standard gallic acid graph. The results determined with the help of the previously determined gallic acid ribbon were evaluated as mg gallic acid/g (Spanos and Wrolstad, 1990).



(a) (b)

Figure 3.5. Analysis of total phenolic content in garlic powder extract

3.2.3 Determination of the antioxidant activity of garlic powder

Trolox Equivalent Antioxidant Capacity (TEAC) analysis is an analysis based on inhibition of the absorbance of the 2,2'-azinobis 3-ethyl-bezothiazoline 6 sulfonate (ABTS) radical cation by antioxidants (Okan et al., 2013). To determine the antioxidant activity in garlic powder, ABTS solution was prepared first. For this, a 7 mM ABTS solution containing 2.45 mM potassium persulfate ($K_2S_2O_8$) was prepared and a radical solution (ABTS + •) was obtained by storing at room temperature for 12-16 hours in the dark. In order to find the antioxidant activity of garlic powder extract as trolox response, a series of concentrations of extract and trolox have been prepared. 10 µl of the sample was added on 1 mL ABTS + and a decrease in absorbance was observed in spectrometry for 6 minutes. The slope was calculated from the graphs where per cent inhibition was drawn against the concentrations. The antioxidant activity of the antioxidant substance as a 1 mM trolox response was determined as a result of the proportion of the slope of garlic powder to the slope of trolox concentrations (Re et al.,

1999). While determining the antioxidant activity, three parallels were made for each concentration level and the measurements in the spectrometer were determined at 30°C with micro cuvettes.

Example: slope / slope of trolox) x dilution factor = TEAC value µM trolox

TEAC: Trolox Equivalent Antioxidant Capacity

3.3 Parameters Studied

The following parameters were recorded in this biological trial.

3.3.1 Growth performance

Growth performance of birds was measured weekly. Parameters regarding the overall performance of growth in the birds included the following.

3.3.2 Determination of live weight gain of quail

At the first day of study, the initial (primary) weight of day old quail chicks from the incubation was measured individually with the aid of a digital weighing balance. They placed in the compartments, paying attention to the fact that the live weights in each group were similar. During the research, the live weight of the quails was determined by weighing individually with an electronic scale with an accuracy of ± 0.01 g based on the day that the research started (Figure 3.6). To determine the weekly LWG of quails, it was measured by subtraction of initial mean body weight from the mean final body weight.

Calculation of bodyweight gain was done with the aid of the following formula:

Body weight gain (g) = Final weight (g) – Initial weight (g)

Figure 3.6. Determination of final body weight of quail bird

3.3.3 Determination of quail feed intake

During the research, the feed was weighed daily and the amount of feed given was recorded. The feed fell in the cage cells were collected and put into the mangers back. During the trial, the feed was given as ad-libutum. For each replicate the amount of FI was determined weekly. FI was calculated by subtracting the amount of feed remaining in the feeder from the total amount of feed given to each repetition of each group. In order to determine the weekly individual feed consumption amount, divide the amount of feed consumed in each repetition by the total number of quail in that repetition.

Feed intake (FI) was calculated with the help of following formula:

Feed Intake (g) = Feed offered (g) – Feed refused (g)

3.3.4 Feed conversion ratio

Moreover, FCR was estimated as the amount of feed consumed in grams divided by body weight gain in grams. All these measurements were taken under serious observation. The weekly feed conversion ratio was calculated with the help of following formula:

$$\text{FCR} = \frac{\text{Feed Consumsed (g)}}{\text{Body Weight Gain (g)}} \quad (3.1)$$

3.3.5 Determination of carcass characteristics

On completion of the trial, live weight of birds was taken and the average live weight value (female and male separately) of each group was determined. Two female and 2 male quail, which represent the female and male live weight average of each group were taken from each repetition and a wing number was attached and the number of the group belonged to which repetition. Quails fasted for 12 hours before slaughter. Quails with wing numbers were then taken to the slaughter house and routine slaughtering was performed. The quails that were cut and bleed were transferred to the boiling boiler and then subjected to plucking. The quail feathers were cut and the hot carcass weight determined after the internal organs were removed. After measuring the hot carcass weight the abdominal fat and internal organs weight such as heart, liver and gizzard were also taken. The carcasses were kept at 4°C for 24 hours in order to investigate the cold carcass weight. After the cold carcass weight was determined, the weights of the carcass main parts (neck, back, thighs, breast and wings) were weighed with a scale accuracy of ± 0.01 g to determine the ratios of the carcass main parts in the carcass. The proportion of each carcass cut was calculated by calculating the carcass main parts whose weight was determined by the carcass weight.

Carcass characteristics were collected with the help of following formulas

Carcass yield:

$$\text{Carcass yield \%} = \frac{\text{Dressed weight (g)}}{\text{Live Weight (g)}} \times 100 \quad (3.2)$$

Thigh Meat Yield %

$$\text{Thigh meat yield \%} = \frac{\text{Thigh meat yield (g)}}{\text{Live Weight (g)}} \times 100 \quad (3.3)$$

Breast Meat Yield %

$$\text{Breast meat yield \%} = \frac{\text{Breast meat yield (g)}}{\text{Live Weight (g)}} \times 100 \quad (3.4)$$

Neck weight %

$$\text{Neck weight \%} = \frac{\text{Neck weight (g)}}{\text{Live Weight (g)}} \times 100 \quad (3.5)$$

Back weight %

$$\text{Back weight \%} = \frac{\text{Back weight (g)}}{\text{Live Weight (g)}} \times 100 \quad (3.6)$$

Wing weight %

$$\text{Wing weight \%} = \frac{\text{Wing weight (g)}}{\text{Live Weight (g)}} \times 100 \quad (3.7)$$

Liver Weight %

$$\text{Liver weight \%} = \frac{\text{Liver Weight (g)}}{\text{Live Weight (g)}} \times 100 \quad (3.8)$$

Gizzard Weight %

$$\text{Gizzard weight \%} = \frac{\text{Gizard (g)}}{\text{Live Weight (g)}} \times 100 \quad (3.9)$$

Heart Weight %

$$\text{Heart weight \%} = \frac{\text{Heart (g)}}{\text{Live Weight (g)}} \times 100 \quad (3.10)$$

3.3.6 Determination of shelf life in breast meat samples

At the end of the research, samples were stored at 4˚C for 0, 3, 5 and 7 days and different effects on meat quality have been investigated. Samples of breast meat were taken from each group of quails, which were cut and meat quality were determined.

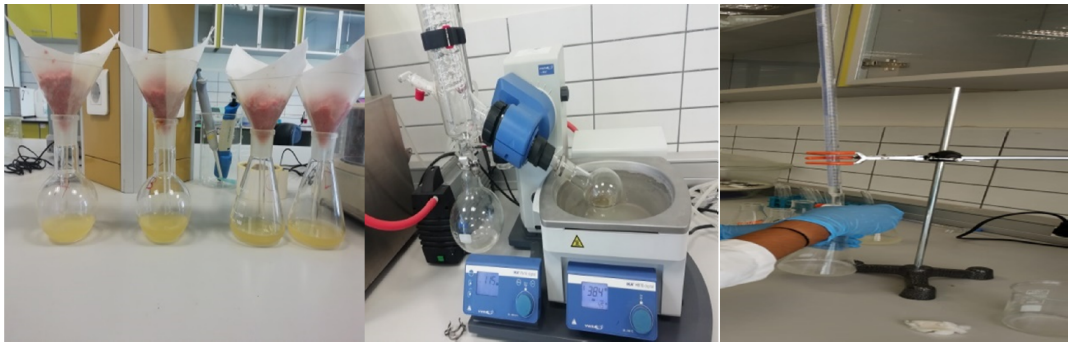
3.3.6.1 Oxidation analysis

3.3.6.1.1 Peroxide value analysis

Meat samples taken from quails were kept at 4˚C for 0, 3, 5 and 7 days and peroxide value analysis was performed according to the AOAC 965.33 method (AOAC, 1995) to determine the oxidation state in the meat. For this purpose, the breast meat was blended and after it was homogenized, it was extracted and fat was obtained (figure 3.8). 1 ml of the oil obtained as a result of extraction was taken into 250 ml flasks and 30 ml of chloroform-acetic acid solution (3 parts of chloroform and 2 parts of acetic acid) were added. Then, 1 ml of saturated potassium iodide (KI) solution was added to it and it was left in the dark for five minutes after mixing. Then, 30 ml of pure water and 4 drops of the starch solution were added, and titration was performed with sodium thiosulfate ($N_2S_2O_3$) solution. Titration was continued until the light colour and the amount of sodium thiosulfate spent in titration was recorded (V2). Similar processes were performed in the blank with the same reagents and the sodium thiosulfate volume (V1) spent in it was determined (Figure 3.7). The normality of sodium thiosulfate is taken as 0.01. By making use of these values, the number of peroxide in the fat of the quail was calculated with the formula below.

$$\text{Peroxide analysis} = \frac{(V1-V2)\times N\times 100}{m\ (g)} \tag{3.11}$$

V1 = Amount of sodium thiosulfate spent on the sample
V2 = Sodium thiosulfate amount spent for the blank
N = Normality of sodium thiosulfate, N
m = the amount of sample taken.



(a) (b) (c)

Figure 3.7. Fat extraction and titration process in breast meat samples for peroxide analysis

3.3.6.1.2 Thiobarbituric acid number

Thiobarbituric acid number analysis (TBA) was performed to determine the lipid oxidation level of 3 breast meat samples taken from each group at 4˚C after 0, 3, 5 and 7 days storage period. For this purpose, after obtaining oil through extraction from breast meat samples, 0.100 g of oil sample was taken and transferred to 25 ml flask and completed to 25 ml by adding Butylated hydroxytoluene (BHT) solution. The mixture was then mixed with the help of an ultra-thorax homogenizer and made homogeneous. The homogeneous mixture was then poured into the beaker and transferred to the tubes by taking 5 ml and 5 ml of thiobarbituric acid was added into the tube and mixed again with the mixer. The mixtures in the obtained tube were kept in a boiling water bath at 95 °C for 2 hours. In the end, samples were read in a spectrophotometer at a wavelength of 530 nm (Figure 3.8) The amount of TBA in meat was calculated using the formula below. In the analysis, BHT was used as perchloric acid extraction solution to prevent oxidation during the analysis.

TBA = 50 x (Absorbance of oil sample - Blank absorbance) / sample weight (mg)

(a) (b) (c)

Figure 3.8. Samples for TBA analysis (a), (b) and reading in spectrophotometer (c)

3.3.6.1.3 Microbiological analysis (total psychrophilic bacteria counts)

Total psychrophilic counts were performed at 0, 3, 5 and 7 days at 4 °C of the breast meat samples taken from quails. For this, 10g of breast meat samples were mixed with 90 ml of ringer solution and homogenized for 1 minute. Serial dilutions were prepared by diluting with 1ml of homogenized sample with 9ml ringer. Plate count agar (PCA) medium was used in total psychrophilic live count analysis. To prepare medium, powder PCA medium was dissolved in 22.5 g/L in distilled water. This medium was then sterilized in an autoclave with all materials to be used at 121 °C for 25 minutes. After this process, the medium was poured into 12.5 ml Petri dishes. The total number of psychrophilic bacteria was determined by the cast plate method (Figure 3.9). Petri dishes were incubated at 7 ºC for 7 days. The number of microbial bacteria is reported as log CFU / g.

(a) (b) (c)

Figure 3.9. Microbiological analysis of breast meat samples preperation of media (a), serial dilutions (b) and petri plates (c)

3.3.7 Determination of pH in meat

On completion of the trial, 3 samples of breast meat were taken from each group and the pH level of the breast meat at 0, 3, 5 and 7 days was measured. Testo 205 brand meat and food pH meter were used to determine the pH level on day 1. For this purpose, measurements were made from 3 different parts of the breast meat and calculated by taking the average of these values. In order to determine the pH value at the end of 0, 3, 5 and 7 days of storage at 4°C in the refrigerator, the breast meat was passed through the blender and mixed with pure water after taking 5 g sample and homogenized. The homogeneous mixture obtained was filtered and the pH level in the breast meat was measured through a pH meter with probe (Hunt et al., 1991).

3.3.8 Colour measurement

After the experiment, a Konica Minolta Chromometer model CR-300 colorimeter instrument was used to measure the colour of quail breast and thigh muscle is taken from each group. Measurements were made from two different parts of the thigh and breast with the help of a colorimeter (Figure 3.10). L* measures (relative lightness), a* measures (relative redness) and b* measures (relative yellowness) values of meat were measured with the help of a chromometer (Hunt et al., 1991). Before starting the measurement, calibration was made with the black and white plate.

Figure 3.10. Colour measurment of breast and thigh meat

3.3.9 Sensory evaluation

Sensory evaluation of quail's thigh and breast meat was conducted on day 1 by 8 member panel. The panellists included staff members and students of Niğde Omer Halisdemir University. Each sample was wrapped separately in aluminium foil and roasted at (175^{o}C) for 75 minutes (Eltazi et al., 2014) (Figure 3.11) . Breast meat were cut into uniform size and served to panellists in covered serving dishes coded with 4 digit random numbers.

The sensory attributes such as colour, aroma, juiciness and tenderness were evaluated using a 9 point hedonic scale (Table 3.1). The averages of the scores given by the panellists were taken and the total sensory quality was evaluated by summing the average scores of each characteristic.

Table 3.3. Sensory evaluation form

Sample Code	Smell	Colour	Texture	Appearance

Using a 9 points scale, the grades' range of sensory attributes were: (9) extremely desirable, (8) desirable, (7) desirable moderately, (6) slightly desirable, (5) neither desirable nor undesirable , (4) slightly undesirable, (3) moderately undesirable, (2) undesirable, (1) extremely undesirable

(a) (b)

Figure 3.11. Quail thigh meat for sensory evaluation (a) and quail breat and thigh meat wrapped in aluminium foil before roasting (b)

3.4 Statistical Analysis

SPSS 18 program was used to evaluate all the data statistically that was obtained at the end of the experiment. Duncan multiple range test was applied to find differences between the treatment means (Bek and Efe, 1989). The statistical significance level of $P < 0.05$ was used.

CHAPTER IV

RESULTS AND DISCUSSION

4.1 Total Phenolic Content and Antioxidant Activity of Garlic Powder

Phenolic compounds have been recognized for their nutritional and functional advantages such as antioxidant and antimicrobial effects. In this study, 80% ethanol and 20% water were used to get the garlic powder extract to investigate the total phenolic content (TPC) and antioxidant activity. The antioxidant activity value of garlic powder was found 83.80 µmol trolox/g while the total phenolic substance content ranges from 97.80 mg gallic acid equivalent (GAE)/g. Jang et al. (2017) obtained the garlic powder extract through distil water, ethanol and chloroform. They found TPC as 43.01 mg (GAE)/g and antioxidant activity as 83.49 µmol trolox/g from ethanol extracted aliquot. Bhandari et al (2014) examined TPC varies from 70 to 121 mg GAE/100 g dry weight and antioxidant activity 27.5%. However, TPC determined in this study were relatively higher than those published by Chen et al. (2013). They found garlic phenolic contents among different cultivars ranged from 21.27 to 33.96 mg GAE/g. The difference of TPC and antioxidant activity among this study and previous literature might be due to the contrast in the genotype of the different cultivars of garlic, agricultural practices and growing seasons. The phenolic content varies also depend on the extraction method.

4.2 Effects of Garlic Powder on Performance

4.2.1 Live body weight

The mean weight of each bird was tried to keep similar at the beginning of this study. The body weight in the groups was ranged between 9.63 g to 9.80 g. The weekly LBW of quails supplemented with different levels of garlic powder (0, 0.5, 1 and 2%) are presented in Table 4.1. The results exhibited that live weight was not observed significantly different among different feeding groups during the 1st and 2nd weeks ($P>0.05$). While significant difference ($P<0.05$) was found in 3rd, 4th and 5th weeks. However, higher LBW was observed in group C (272.63 ± 2.13) and D (267.17 ± 2.77) as compared to group A (260.60 ± 2.97) and B (262.77 ± 2.99) in 5th week of this

experiment. Similar results were observed by Raya et al. (2014) who found that quail fed with garlic powder supplementation shows better final live weight as compared to the control group (P<0.05). Brzoska et al. (2015) and Lukanov et al. (2015) also observed similar findings related to this study, which documented that dietary addition of garlic powder causes enhancment in the final LBW of broilers. Besides, Parthasarathi et al. (2017) conducted an experimental trial to determine the influence of dietary addition of ginger and garlic on the growth performance of quail birds. They concluded that the dietary addition of ginger and garlic enhanced the body weight of quail. Another researcher, Zekić et al. (2014) observed the influence of 2% of garlic powder supplementation on growth performance of broiler birds and they concluded that birds in garlic supplemented group had significantly higher body weight (2019.0 g) during six weeks followed by birds of the control group (1949.5 g). Contrary to the finding of our study, Issa and Omer (2012) and Fadlalla et al. (2010) found that LBW was not influenced by the dietary addition of garlic powder in the broilers. Moreover, non-significant results of garlic supplementation were observed on broiler growth performance reported by Choi et al. (2010).

Table 4.1. Effect of garlic powder supplementation in different levels on weekly live body weight (LBW)

Weeks		Groups				SEM	P value
		A	B	C	D		
DOC		9.6 ± 0.08	9.6 ± 0.09	9.7 ± 0.10	9.8 ± 0.10	0.048	0.698
1		40.71 ± 0.45	41.48 ± 0.49	40.24 ± 0.48	40.58 ± 0.40	0.230	0.276
2	M	104.11 ± 1.50	105.3 ± 1.21	103.88 ± 1.50	104.56 ± 1.07	0.658	0.923
	F	104.53 ± 1.31	105.74 ± 2.12	103.47 ± 2.97	105.64 ± 1.46	1.045	0.857
	Mean	104.35 ± 0.98	105.29 ± 1.08	103.63 ± 1.85	105.23 ± 0.93	0.630	0.764
3	M	172.17 ± 2.01^{c}	174.72 ± 1.86^{c}	185.32 ± 1.12^{a}	179.47 ± 1.24^{b}	0.923	0.00
	F	177.56 ± 1.87^{c}	182.73 ± 2.97^{c}	188.82 ± 1.64^{a}	188.18 ± 1.65^{b}	0.076	0.020
	Mean	174.96 ± 1.40^{b}	177.52 ± 1.65^{b}	187.01 ± 1.00^{a}	183.75 ± 1.17^{a}	1.732	0.007
4	M	229.45 ± 2.40^{b}	229.90 ± 2.72^{b}	238.29 ± 2.01^{a}	235.04 ± 1.58^{ab}	1.187	0.020
	F	172.17 ± 2.01	174.72 ± 1.86	185.32 ± 1.12	179. 47 ± 1.24	0.923	0.409
	Mean	232.84 ± 1.95^{b}	232.69 ± 2.27^{b}	239.50 ± 1.23^{a}	238.72 ± 1.74^{a}	0.940	0.009
5	M	260.60 ± 2.97^{b}	262.77 ± 2.99^{b}	272.63 ± 2.13^{a}	267.17 ± 2.77^{ab}	1.438	0.019
	F	284.91 ± 3.12	287.35 ± 4.84	291.60 ± 3.81	291.95 ± 4.05	1.875	0.453
	Mean	$272.96 \pm 2.67b^{c}$	270.96 ± 2.95^{c}	281.63 ± 2.27^{a}	279.15 ± 2.89^{ab}	1.379	0.018

The means with different superscripts in the same rows are significantly different from each other (P<0.05). SEM: Standard Mean Error, P: Significance, M: Male, F: Female, A: Control, B: 0.5% Garlic powder, C: 1% Garlic powder, D: 2% Garlic powder

The reason behind the significant improvement in final mean body weight in this study could be possible due to the allicin compound present in garlic, which plays role in inhibition of harmful bacteria and fungi aflatoxins (Sivam et al., 2001). Moreover, it

might be possible due to the positive effects of allicin on gut morphology that enhanced nutrient rate of absorption through enterocytes.

4.2.2 Body weight gain

Impact of distinct levels of garlic supplementation on BWG (g) in quail is presented in Table 4.2. Statistically, the difference was found in weight gain between groups in 3rd, 4th and 5th weeks of the study. While, BWG was non-significant between groups during 1st and 2nd weeks. However, highest BWG was recorded in group C followed by group D, B and A.

Table 4.2. Effect of garlic powder supplementation in different levels on weekly body weight gain (BWG)

Weeks	Groups				SEM	P value
	A	B	C	D		
1	31.11 ± 0.71	31.88 ± 0.89	30.56 ± 0.58	30.82 ± 0.31	0.322	0.549
2	63.64 ± 1.28	63.78 ± 1.04	63.41 ± 2.03	64.65 ± 0.13	0.599	0.915
3	70.60 ± 0.85^{c}	72.23 ± 1.20^{c}	83.25 ± 2.28^{a}	78.71 ± 0.63^{b}	1.452	0.000
4	56.62 ± 1.41^{b}	55.16 ± 0.81^{b}	59.32 ± 1.05^{a}	59.93 ± 1.01^{a}	0.701	0.029
5	37.83 ± 2.52^{b}	38.27 ± 1.64^{b}	44.36 ± 0.45^{a}	43.39 ± 1.48^{a}	1.071	0.035

The means with different superscripts in the same rows are significantly different from each other (P<0.05). SEM: Standard Mean Error, P: Significance, M: Male, F: Female, A: Control, B: 0.5% Garlic powder, C: 1% Garlic powder, D: 2% Garlic powder

Week wise effect of garlic supplementation on BWG in quail is presented in table 4.3. The results demonstarted that statistically difference (P<0.05) was found in BWG between groups in 1-5 weeks and 3-5 weeks. While, non- significant difference (P>0.05) was observed in 0-2 weeks. The significantly (P<0.05) higher total weight gain was observed in groups C (280.91 ± 1.32 g) and D (277.51 ± 1.49 g) as compared to groups B (261.33 ± 2.66 g) and A (259.83 ± 2.41 g). The significant results of BWG of quail who fed with garlic powder might be due to the presence of allicin active ingredient in garlic that enhances the performance of intestinal microflora, which lead towards digestion improvement and utilization of energy.

These results are in accordance with the observations of Khalil et al. (2007) who observed that quail fed with dietary garlic showed significantly better BWG when compared from the control. Moreover, Oladele et al. (2012) found that garlic supplementation improved BWG of broiler chickens. Elagib et al. (2013) also evaluated

the influence of dietary addition of garlic on performance. They observed that birds fed with garlic significantly improved BWG. In addition, Ziton (2009) who revealed that the dietary supplementation of garlic powder in broiler diet at 2, 3 and 4% concentration significantly enhanced the BWG of birds when compared from the control. In contrast to the current study, non-significant results of garlic supplementation were found on broiler growth performance reported by (Choi et al., 2010). Moreover, Issa and Omer (2012) also found that BWG did not influenc by the dietary addition of garlic powder in chickens.

Table 4.3. Effect of garlic powder supplementation in different levels on body weight gain (BWG)

Groups	Weeks		
	0-2	**3-5**	**0-5**
A	94.76 ± 1.89	165.06 ± 3.77^{b}	259.83 ± 2.41^{b}
B	95.66 ± 1.90	165.67 ± 0.98^{b}	261.33 ± 2.66^{b}
C	93.97 ± 2.58	186.94 ± 2.24^{a}	280.91 ± 1.32^{a}
D	95.47 ±0.26	182.04 ± 1.25^{a}	277.51 ± 1.49^{a}
SEM	0.853	2.718	2.597
P value	0.916	0.000	0.000

The means with different superscripts in the same column are significantly different from each other (P<0.05). SEM: Standard Mean Error, P: Significance, M: Male, F: Female, A: Control, B: 0.5% Garlic powder, C: 1% Garlic powder, D: 2% Garlic powder

4.2.3 Feed intake

Effect of garlic supplementation on FI (g) is illustrated in table 4.4. FI was found non-significantly different among all the groups. In the 5th week of the experiment, lowest feed consumption was observed in group B (212.40 ± 4.39 g) as compared to groups A (234.12 ± 5.06 g), C (235.44 ± 6.10 g) and D (234.23 ± 1.70 g).

Table 4.4. Effect of garlic powder supplementation in different levels on weekly feed intake (FI)

Groups	Weeks				
	1	**2**	**3**	**4**	**5**
A	46.10 ± 1.91	109.66 ± 2.57	157.47 ± 1.99	188.58 ± 4.46	234.12 ± 5.06
B	46.57 ± 1.39	110.56 ± 1.37	156.51 ± 2.32	181.41 ± 4.42	212.40 ± 4.39
C	44.34 ± 1.56	113.92 ± 2.47	163.79 ± 2.07	184.53 ± 1.85	235.44 ± 6.10
D	45.05 ± 1.73	110.41 ± 1.72	158.65 ± 2.12	181.71 ± 0.67	234.23 ± 1.70
SEM	0.777	1.029	1.198	1.650	2.540
P-value	0.777	0.508	0.128	0.419	0.195

SEM: Standard Mean Error, P: Significance, A: Control, B: 0.5% Garlic powder, C: 1% Garlic powder, D: 2% Garlic powder

Impact of dietary addition of garlic in distinct concentartion and weeks on FI in quails is presented in table 4.5. The FI was found non-significant among all the feeding groups. However, group C (742.04 ± 11.72) consumed more feed as compared to group A (735.94 ± 12.0 g), B (716.48 ± 12.32 g) and D (730.07 ± 5.73 g) in 0-5 week. Similar findings were observed by Issa and Omer (2012) who observed no significant differences in FI between the control and other experimental groups of the broiler birds. The results of Khalil et al. (2007) and Raya et al. (2014) are also coinciding with our findings reported that quail fed with dietary garlic showed significant final live weight, BWG and FCR but FI was not affected (P>0.05) in comparison of the control group.

Table 4.5. Effect of garlic powder supplementation in different levels on feed intake (FI)

Groups	Weeks		
	0-2	3-5	0-5
A	155.77 ± 4.07	580.17 ± 8.87	735.94 ± 12.0
B	157.14 ± 2.49	559.33 ± 10.43	716.48 ± 12.32
C	158.26 ± 3.15	583.77 ± 9.74	742.04 ± 11.72
D	155.47 ± 2.44	574.60 ± 3.99	730.07 ± 5.73
SEM	1.421	4.553	5.411
P value	0.913	0.252	0.417

SEM: Standard Mean Error, P: Significance, A: Control, B: 0.5% Garlic powder, C: 1% Garlic powder, D: 2% Garlic powder

Opposite to our results, Racesi et al. (2010) found that dietary garlic powder addition in feed upto 1-3% concentration level had significantly better FI as compared from the control.

4.2.4 Feed conversion ratio

Impact of distinct concentration levels of dietary addition of garlic powder as feed additives on weekly FCR in quail is presented in table 4.6. The results exhibited that the FCR was not significantly different (P > 0.05) between the groups in all the weeks except 3rd week (P<0.05). In the 3rd week of this study, FCR was observed non-significantly different among group C (1.97 ± 0.06) and D (2.01 ± 0.01) while these groups were found significantly different against group A (2.23 ± 0.04) and B (2.16 ± 0.01).

Table 4.6. Effect of garlic powder supplementation in different levels on weekly feed conversion ratio (FCR)

WEEK	Groups				SEM	P value
	A	B	C	D		
1	1.48 ± 0.04	1.46 ± 0.03	1.45 ± 0.03	1.46 ± 0.05	0.019	0.958
2	1.72 ± 0.01	1.73 ± 0.01	1.80 ± 0.05	1.70 ± 0.02	0.017	0.253
3	2.23 ± 0.04^{a}	2.16 ± 0.01^{a}	1.97 ± 0.06^{b}	2.01 ± 0.01^{b}	0.033	0.003
4	3.34 ± 0.14	3.29 ± 0.08	3.11 ± 0.08	3.03 ± 0.06	0.054	0.156
5	6.3 ± 0.56	5.81 ± 0.28	5.41 ± 0.16	5.41 ± 0.16	0.177	0.254

The means with different superscripts in the same rows are significantly different from each other (P<0.05). SEM: Standard Mean Error, P: Significance, A: Control, B: 0.5% Garlic powder, C: 1% Garlic powder, D: 2% Garlic powder

Impact of dietary addition of garlic in different concentartion levels and periods on FCR in quails is presented in table 4.7. Feed utilization rate was observed non-significantly different in all groups during 0-2 weeks but significantly different during 3-5 weeks and 0-5 weeks. Group C and D showed a statistically improved FCR as compared to group A and B during 3-5 weeks and 0-5 weeks. The significant result of FCR might be due to the antimicrobial characteristics of garlic which enhance nutrient absorption in the gut and finally leading towards the improvement in FCR. Similar results were observed by Khalil et al. (2007) and Raya et al. (2014) who found that quail fed with garlic powder supplementation exhibited better FCR in comparison to control group. Moreover, results of this study are consistent with the findings of Karangiya et al. (2016), Tollba and Hassan (2003) and Lukanov et al. (2015) who found significantly better feed utilization rate due to addition of garlic powder in broilers diet at different levels (P<0.05). Opposite to the current findings, Amouzmehr et al. (2012) and Issa and Omer (2012) found that the FCR was not influenced by garlic powder supplementation in broiler chicken.

Table 4.7. Effect of garlic powder supplementation in different levels on feed conversion ratio (FCR)

Groups	Weeks		
	0-2	3-5	0-5
A	1.64 ± 0.011	3.52 ± 0.138^{a}	2.83 ± 0.072^{a}
B	1.64 ± 0.015	3.37 ± 0.046^{ab}	2.74 ± 0.021^{ab}
C	1.68 ± 0.025	3.12 ± 0.076^{b}	2.64 ± 0.044^{b}
D	1.63 ± 0.023	3.15 ± 0.012^{b}	2.63 ± 0.014^{b}
SEM	0.0104	0.0559	0.0293
P value	0.242	0.016	0.023

The means with different superscripts in the same column are significantly different from each other (P<0.05). SEM: Standard Mean Error, P: Significance, A: Control, B: 0.5% Garlic powder, C: 1% Garlic powder, D: 2% Garlic powder

4.3 Effects of Garlic Powder Supplementation on Carcass Characteristics and Relative Organ Weight

At the completion of the five-week experiment, the quails were weighed and the average weight of female and male of each group were determined and subjected to slaughter by selecting 2 females and 2 males close to the average live weight from each subgroup and the results regarding the carcass values are presented below.

4.3.1 Carcass characteristics

Quails were slaughtered on the 35th day at the end of this study. Table (4.8) exhibits the impact of feeding various concentartion levels of garlic powder on the carcass traits of the quails. Statistically significant differences were noticed between the groups in case of male hot carcass weight ($P<0.05$). The highest hot carcass male average values were obtained from group C (207.32 ± 1.58 g) and D (208.16 ± 1.70 g) as compared to group A (200.17 ± 1.73 g) and B (205.11 ± 2.30 g). However, In the case of general hot carcass mean values, results were observed non-significantly different ($P>0.05$). The addition of garlic powder in the quail diet did not significantly ($P>0.05$) improve the cold carcass weight as compared to the control diet. Moreover, no significant differences were observed between the groups in terms of carcass yield values ($P>0.05$) while the carcass yield of group D (76.09 ± 0.57) was found higher than the group A (75.59 ± 0.47 g), B (75.03 ± 0.74 g) and C (75.90 ± 0.65 g). The current study findings were in accordance with observations of Dieumou et al. (2009) and Fadlalla et al. (2010), who reported the non-significant influence of garlic powder supplementation on broiler dressing percentage values (but numerically higher). Moreover, present results also agree with Javandel et al. (2008) who found that there were no significant results in carcass efficiency of birds fed with different concentrations of garlic powder. Another study reported by Khalil et al. (2007) who found that carcass characteristic of quail was not affected by feeding garlic containing diets. Similar findings were also observed by Abdullah et al. (2010), Amzouzmehr et al. (2012), Onibi et al. (2009) and Issa and Omar (2012) who found the insignificant effect of dietary garlic powder addition on carcass dressing percentage. In opposite to our results, Raeesi et al. (2010) reported that dietary addition of garlic in feed at 1% level had higher carcass yield in comparison to other experimental groups. Moreover, Samresh et al. (2003) revealed that a significant

difference between the feeding groups in term of average dressing percentage. Also, Ali et al. (2014) conducted a trial to investigate the dietary inclusion of garlic kalonji and turmeric effect on productive performance and carcass traits and of broiler birds and their results were non-significant in case of carcass characteristics, dressing weight and edible offals weight. While, in this current study general mean value of hot and cold carcass weight were statistically non-significant. The results regarding hot and cold dressing percentage are in compliance with the observation of Fadlalla et al. (2010) who observed a non-significant effect of garlic supplementation on hot and cold dressing percentage. In contrast to current findings, Eltazi et al. (2014) conculded that the cold and hot dressing percentages were significantly increased and highest in birds fed on a diet with 3% dietary garlic powder when compared from the control ($P<0.05$).

Table 4.8. Effect of garlic powder supplementation in different levels on carcass characteristics

Groups		Live weight (g)	Hot Carcass weight (g)	Cold Carcass weight (g)	Carcass yield (%)
A	Mean	275.93 ± 4.08	208.38 ± 2.36	210.33 ± 2.66	75.59±0.47
B	Mean	281.98 ± 4.12	211.16 ± 2.82	210.28 ± 2.69	75.03±0.74
C	Mean	281.83 ± 4.01	213.67 ± 2.32	211.26 ± 2.32	75.90±0.65
D	Mean	280.51 ± 3.20	213.14 ± 2.05	210.66 ± 1.94	76.09±0.57
SEM		1.917	1.202	1.187	0.306
P value		0.660	0.393	0.991	0.657
A	M	260.66 ± 1.68^{b}	200.17 ± 1.73^{b}	211.65 ± 2.35	76.79 ± 0.36
B	M	267.86 ± 2.14^{a}	205.11 ± 2.30^{b}	204.00 ± 1.55	76.57 ± 0.57
C	M	267.73 ± 1.85^{a}	207.32 ± 1.58^{a}	205.63 ± 1.60	77.45 ± 0.63
D	M	270.13 ± 1.70^{a}	208.16 ± 1.70^{a}	205.91 ± 1.48	77.06 ± 0.65
SEM		1.089	1.041	0.900	0.276
P value		0.007	0.022	0.326	0.724
A	F	291.20 ± 1.42	216.60 ± 1.29	219.01 ± 1.84	74.39 ± 0.66
B	F	297.61 ± 3.51	218.07 ± 4.21	217.45 ± 4.12	73.27 ± 1.16
C	F	295.93 ± 2.97	220.02 ± 3.02	216.88 ± 3.40	74.36 ± 0.88
D	F	292.01 ± 3.48	218.84 ± 2.67	216.10 ± 2.60	74.97 ± 0.84
SEM		1.457	1.398	1.466	0.436
P value		0.360	0.855	0.920	0.629

The means with different superscripts in the same column are significantly different from each other ($P<0.05$). SEM: Standard Mean Error, P: Significance, M: Male, F: Female, A: Control, B: 0.5% Garlic powder, C: 1% Garlic powder, D: 2% Garlic powder

4.3.2 Carcass organs ratios

Organs proportion of quail as a ratio of cold carcass weight is presented in table 4.9. The results demonstrated that there was no significant difference between the groups in

terms of organ proportions such as thigh, breast and back percentages (P>0.05). Whereas, in case of wing percentage significant results were observed among the groups (P<0.05). Group A showed the highest values of wing percentage as compared to other dietary groups. However, general mean values of thigh percentage were observed highest in group C (34.95 ± 0.25) as compared to group A (33.46 ± 0.66), B (34.65 ± 0.29), and D (34.18 ± 0.24). Findings of this trial illustrated that all carcass cuts (thigh, breast, neck and back) were the same in quail birds of all experimental groups. These results are in agreement with the earlier studies where dietary addition of garlic at 500 and 5000 mg/kg diet exhibited no impacts on carcass traits (dressing, thigh, breast, drumstick and back) (Onibi et al., 2009). Moreover, Amouzmehr et al. (2012) observed that the use of two herb extracts (garlic and thyme) had no significant impacts on carcass organ proportions such as thigh and breast.

Table 4.9. Effect of garlic powder supplementation in different levels on the commercial cut of quail carcass (%)

Groups		Thigh (%)	Breast (%)	Back (%)	Wings (%)	Neck (%)
A	Mean	33.46 ± 0.66	34.42 ± 0.56	14.13 ± 0.28	9.91 ± 0.16^{a}	7.66 ± 0.66
B	Mean	34.65 ± 0.29	34.99 ± 0.47	14.15 ± 0.33	8.99 ± 0.15^{b}	6.13 ± 0.28
C	Mean	34.95 ± 0.25	34.45 ± 0.34	13.87 ± 0.28	9.77 ± 0.18^{a}	6.62 ± 0.22
D	Mean	34.18 ± 0.24	34.81 ± 0.33	13.97 ± 0.27	9.65 ± 0.11^{a}	7.08 ± 0.20
SEM		0.214	0.217	0.143	0.088	0.208
P value		0.066	0.759	0.891	0.001	0.055
A	M	33.96 ± 0.44	34.28 ± 0.82	14.15 ± 0.32	10.01 ± 0.17^{a}	7.24 ± 0.32
B	M	34.86 ± 0.36	35.41 ± 0.40	14.04 ± 0.28	9.12 ± 0.11^{b}	6.05 ± 0.46
C	M	34.80 ± 0.47	34.17 ± 0.58	14.24 ± 0.49	9.70 ± 0.28^{ab}	6.81 ± 0.35
D	M	34.13 ± 0.39	35.30 ± 0.39	13.56 ± 0.23	9.70 ± 0.19^{ab}	7.02 ± 0.33
SEM		0.212	0.293	0.171	0.111	0.194
P value		0.338	0.299	0.529	0.028	0.147
A	F	32.95 ± 1.27	34.56 ± 0.82	14.10 ± 0.49	9.80 ± 0.28^{a}	8.08 ± 1.32
B	F	34.40 ± 0.48	34.50 ± 0.90	14.27 ± 0.65	8.86 ± 0.29^{b}	6.20 ± 0.33
C	F	35.10 ± 0.21	34.74 ± 0.39	13.49 ± 0.22	9.85 ± 0.25^{a}	6.43 ± 0.28
D	F	34.23 ± 0.32	34.25 ± 0.49	14.45 ± 0.47	9.59 ± 0.13^{a}	7.14 ± 0.25
SEM		0.383	0.326	0.235	0.140	0.380
P value		0.229	0.969	0.519	0.039	0.144

The means with different superscripts in the same column are significantly different from each other (P<0.05), SEM: Standard Mean Error, P: Significance, M: Male, F: Female, A: Control, B: 0.5% Garlic powder, C: 1% Garlic powder, D: 2% Garlic powder

Similar observations have been also exhibited by Hernandez et al. (2014) who found that utilization of a combination of plant herbs had no significant impact on carcass traits. Another researcher Sarikaya et al. (2018) determined the effect of pollen bee (same as garlic) as natural feed supplementation on quail's LBW, BWG, FCR and

carcass characteristics. They also observed non-significant difference among the groups in case of carcass cuts such as breast, thigh back and neck. Similar results were also studied by Mahmood et al. (2009) who found that dietary garlic up to 0.5% level did not significantly affect dressing percentage and relative weight of giblets. Opposite to the current findings, Eltazi et al. (2014) observed significant result in the ratio of carcass commercial cuts such as breast, thigh and drumstick, between the dietary treatment groups. They revealed that 3% of garlic powder supplementation significantly increased the breast percentage but had no positive effect on thigh percentage. Jamroz and Kamel (2002) also observed that chicken birds fed with herbal juice had higher breast weight in comparison to the control group.

4.3.3 Edible internal organ and abdominal fat proportion

The edible internal organs and abdominal fat ratios of the mixed feed groups are given in Table 4.10. It was found that the heart, liver, gizzard and abdominal fat ratios did not differ significantly ($P<0.05$) in terms of both the general mean values of the groups and separate male and female groups. Although there was no significant difference observed but group A had a higher abdominal fat ratio (1.87%) than the other groups while, group C had the lowest value (1.57%). Results of this trial exhibited that the selected edible organs and abdominal fat showed a non-significant impact of garlic supplementation. These findings are in accordancewith the previous researches. Onibi et al. (2009) observed non-significant difference in term of edible organ characteristics and abdominal fat in the response of garlic supplemented diet. In the current study, the lowest abdominal fat ratio measured in the diet containing 1% garlic powder that might be due to the action of garlic which has been described to reduce fat deposition effects. These results are in consent with the Kirkpinar et al. (2014) who revealed that there was no significant difference between dietary supplemented groups of essential oil on carcass traits. Moreover, Raeesi et al. (2010) studied that dietary addition of garlic at rate of 1 and 3% showed no significant impacts on relative weights of carcass, fat pad, or digestive organs between different treatments except small intestine. Findings of Fayed et al. (2011) were also in accordance with the result of our study. They reported non-significant result in term of heart, liver and gizzard weight in comparison of the control group. Raya et al. (2014) also found that there was no significant difference among garlic supplemented group in comparison of the control group in terms of edible

internal organ rate (heart, liver, and gizzard). In addition, Lukanov et al. (2015) checked the influence of garlic powder supplementation on growth performance, carcass traits and the quality of meat in the broilers and there was no significant impacts of garlic supplementation observed on the proportion of edible offal and meat cuts.

Table 4.10. Effect of garlic powder supplementation in different levels on giblet proportion and abdominal fat (%)

Groups		Heart (%)	Liver (%)	Gizzard (%)	Abdominal Fat (%)
A	Mean	1.27 ± 0.04	3.34 ± 0.21	2.68 ± 0.08	1.87 ± 0.18
B	Mean	1.28 ± 0.04	3.35 ± 0.22	2.68 ± 0.09	1.65 ± 0.12
C	Mean	1.17 ± 0.05	3.32 ± 0.30	2.72 ± 0.07	1.57 ± 0.17
D	Mean	1.27 ± 0.03	3.31 ± 0.16	2.69 ± 0.07	1.81 ± 0.14
SEM		0.023	0.112	0.041	0.080
P value		0.597	0.932	0.584	0.229
A	M	1.26 ± 0.07	3.05 ± 0.26	2.60 ± 0.10	1.88 ± 0.25
B	M	1.24 ± 0.04	3.09 ± 0.25	2.55 ± 0.12	1.57 ± 0.22
C	M	1.08 ± 0.09	2.74 ± 0.23	2.74 ± 0.14	1.33 ± 0.29
D	M	1.23 ± 0.04	3.06 ± 0.14	2.67 ± 0.10	1.52 ± 0.15
SEM		0.034	0.113	0.057	0.118
P value		0.229	0.699	0.685	0.440
A	F	1.28 ± 0.07	3.63 ± 0.30	2.75 ± 0.14	1.85 ± 0.29
B	F	1.32 ± 0.07	3.63 ± 0.34	2.82 ± 0.14	1.73 ± 0.10
C	F	1.27 ± 0.05	3.89 ± 0.48	2.71 ± .87	1.81 ± 0.13
D	F	1.31 ± 0.04	3.60 ± 0.27	2.71 ± 0.11	2.10 ± 0.20
SEM		0.030	0.177	0.058	0.101
P value		0.932	0.937	0.902	0.544

SEM: Standard Mean Error, P: Significance, M: Male, F: Female, A: Control, B: 0.5% Garlic powder, C: 1% Garlic powder, D: 2% Garlic powder

However, results of Eltazi et al. (2014) were in disagreement with our findings. They reported that feeding garlic powder at different concentrations significantly ($P<0.05$) influenced the development of edible organs (liver, gizzard and abdominal fat) of the broilers except for the heart percentage.

4.4 Effects of Storage on Breast Meat Lipid Peroxidation, Microbiological Load and pH

4.4.1 Breast meat peroxide value

Changes in peroxide values in breast meat were observed at 0, 3, 5 and 7 days after storage at 4 °C in the refrigerator and the results are given in Table 4.11. The initial

peroxide value of breast meat was 4 meq/kg and raised in all samples during the storage time. It was noticed that the peroxide value of the breast meat decreased with increased garlic powder level on the days 1, 3, 5 and 7. The group A had the highest peroxide value on all days as compared to other dietary groups. It was found that group D had the lowest breast meat peroxide value as compared to other groups. As a matter of fact, peroxide value was obtained as 6.33 ± 0.33, 5.66 ± 0.33, 3.99 ± 0.57and 2.66 ± 0.33 in groups A, B, C and D respectively after 7 days of storage. To our knowledge, this is the first ever study suggesting an oxidative protective impact of garlic powder on quail meat and the usefulness of peroxide value as a fast and sensitive simple protocol to detect alterations in poultry meat oxidative stability.

Table 4.11. Breast meat peroxide value (meq/kg)

Groups	Days			
	0	3	5	7
A	4.00 ± 0.00^{Ca}	5.33 ± 0.33^{Ba}	5.66 ± 0.33^{Aba}	6.33 ± 0.33^{Aa}
B	3.66 ± 0.33^{Ca}	4.33 ± 0.33^{Bbc}	5.06 ± 0.16^{Aba}	5.66 ± 0.33^{Aa}
C	2.32 ± 0.33^{b}	2.99 ± 0.00^{c}	3.66 ± 0.33^{b}	3.99 ± 0.57^{c}
D	1.00 ± 0.00^{Cc}	1.66 ± 0.33^{BCd}	2.00 ± 0.00^{ABc}	2.66 ± 0.33^{Ab}
SEM	0.371	0.434	0.433	0.465
P value	0.00	0.00	0.00	0.01

Means with different superscripts (capital letters) in the same line significantly different from each other ($P < 0.05$). Means with different superscripts (lowercase) letters in the same column differ significantly ($P<0.05$), SEM: Standard Mean Error, P: Significance, A: Control, B: 0.5% garlic powder, C: 1% garlic powder, D: 2% garlic powder

These results are in agreement with the previous studies where Satılmış (2019) used liquorice root powder as an antioxidant source. The peroxide value was significantly different and observed lower in the additive groups than the control group. Similar findings were observed by Naimati (2020) who used quinoa seed extract as an antioxidant source in the quail feed. She observed that peroxide value decreased as the level of additives increased at the end of each storage period. Scaricity of knowledge is present about postmortem oxidation analysis (PV) of quail meat. Because of this, we have compared our results with other phytobyotic compounds such as liquorice powder and quinoa seed extract.

4.4.2 Breast meat thiobarbituric acid value

TBA value in breast meat was observed at 0, 3, 5 and 7 days after storage at 4°C. The results are given in Table 4.12. At 0 day, TBARS value of breast meat sample of control group was 0.182 mg MDA/kg and increased in all samples during the storage. The control group showed the highest TBA value on all days. It was found that group D (2% garlic level) had the lowest breast meat TBA value as compared to other groups ($P<0.05$). It was noticed that the TBA value of the breast meat decreased with increasing garlic powder level on all days. The results obtained revealed that the antioxidant capacity of the garlic powder used in the research was effective in preventing oxidation in the breast meat obtained from quail. The results we obtained regarding the breast meat TBA value were similar to the findings of (Ao et al., 2011). They studied the impact of dietary fermented garlic supplementation on meat quality of broiler and found that TBARS value decreased with the increased level of garlic powder in the diet from 0 to 4 g/kg. Moreover, current findings are in agreement with the observations of Kim et al. (2009) who found that 20 or 40 g/kg garlic bulb and garlic husk decreased TBARS value in chicken meat. While, Onibi et al. (2009) observed that dietary addition of garlic in diet of the broielers improved the oxidative stability of stored or refrigerated meat. Previous literature has shown that garlic can prolong the shelf life of refrigerated meat that might be due to the presence of flavonoid and sulfur-containing compounds that plays a role in the prevention of lipid oxidation.

Table 4.12. Breast meat thiobarbituric acid (TBA) value (mg MDA/kg)

Groups	Days			
	0	3	5	7
A	0.182 ± 0.08^{Ca}	0.270 ± 0.03^{Ba}	0.363 ± 0.00^{Aa}	0.411 ± 0.00^{Aa}
B	0.167 ± 0.002^{Cab}	0.217 ± 0.01^{Bab}	0.328 ± 0.00^{Ab}	0.356 ± 0.00^{Ab}
C	0.160 ± 0.00^{Db}	0.195 ± 0.00^{Cb}	0.313 ± 0.00^{Bc}	0.345 ± 0.00^{Ab}
D	0.137 ± 0.00^{Dc}	0.172 ± 0.00^{Bc}	0.303 ± 0.00^{Bc}	0.339 ± 0.00^{Ab}
SEM	0.00	0.00	0.00	0.00
P value	0.001	0.014	0.00	0.00

Means with different superscripts (capital letters) in the same line significantly different from each other ($P < 0.05$). Means with different superscripts (lowercase) letters in the same column differ significantly ($P<0.05$), SEM: Standard Mean Error, P: Significance, A: Control, B: 0.5% garlic powder, C: 1% garlic powder, D: 2% garlic powder

4.4.3 Breast meat microbiological analysis

The total number of psychrophilic bacteria were noticed at the end of storage in quails fed at different levels of garlic powder at 0, 3 5 and 7 days at 4°C is given in table 4.13. The continuous increases in the number of psychrophilic bacterial in all samples were observed with increasing storage time up to day 7. It was noticed that the total number of psychrophilic bacteria in the breast meat showed a statistically significant result among the groups ($P<0.05$) at 3, 5 and 7 days. However, there was no bacterial growth observed at 0 day. The total number of psychrophilic bacteria increased in each group with the increase in storage time and decreased with the increase in garlic powder inclusion level. After seven days of storage, group A (2.65 ± 0.00) had significantly higher ($P<0.05$) number of psychrophilic bacteria as compared to group B (2.51 ± 0.06), C (2.43 ± 0.05) and D (2.40 ± 0.03). The microbial load of meat is one of the important factors that affect the storage quality of meat. If there is an antimicrobial substance in the meat, it may be possible to preserve the meat for a certain period without spoiling. As a matter of fact, it has been demonstrated that the number of bacteria in the meat can be reduced by using herbal sources containing antimicrobial properties as additives (Gümüş et al., 2017). The current findings are in consent with the previous studies. Scaricity of knowledge is present about postmortem microbial analyses of quail meat. Because of this, we have compared our results with other phytobyotic compounds such as ginger, liquorice powder and thyme. Selim et al. (2013) studied the effect of ginger root extract, extract of beetroot and tomato puree as natural antioxidant sources in broiler diets. They reported a significant effect of ginger root extract and tomato puree as a natural antioxidant additive on decreasing count of total bacteria and Staphylococcus aureus in refrigerated and frozen broiler meat. Similar findings were obtained by Satılmış (2019) who reported that the total number of psychrophilic bacteria increased due to the increase in the storage time of the thigh meat and decreased with the additive of liquorice powder on the days of analysis ($P < 0.05$). Gümüş et al. (2017) investigated the effect of different levels of thyme essential oil on quail feed on microbiological properties of breast meat and observed a decrease in bacterial count. The results obtained revealed that the antimicrobial property of the garlic powder used in the research was effective in preventing microbial growth in the quail breast meat samples. Alteration in the chemical composition of bacterial

membranes and their absorptivity to allicin could be the reason for garlic antimicrobial property (Miron et al., 2000).

Table 4.13. Breast meat total psychrophilic bacteria count (log cfu g-1)

Groups	Days			
	0	3	5	7
A	0	2.10 ± 0.023^{Ca}	2.34 ± 0.014^{Ba}	2.65 ± 0.00^{Aa}
B	0	1.18 ± 0.029^{Cb}	2.15 ± 0.04^{Bb}	2.51 ± 0.06^{Ab}
C	0	0.80 ± 0.102^{Cbc}	2.08 ± 0.01^{Bbc}	2.43 ± 0.05^{Ab}
D	0	0.50 ± 0.198^{Bc}	2.05 ± 0.00^{Ac}	2.40 ± 0.03^{Ab}
SEM	0	0.232	0.044	0.040
P value	0	0.002	0.004	0.046

Means with different superscripts (capital letters) in the same rows significantly different from each other ($P < 0.05$). Means with different superscripts (lowercase) letters in the same column differ significantly ($P<0.05$), SEM: Standard Mean Error, P: Significance, A: Control, B: 0.5% garlic powder, C: 1% garlic powder, D: 2% garlic powder

4.4.4 pH values of breast meat

Three breast meat samples were taken on completion of the trial and pH value were measured at 0, 3, 5, and 7 days at 4^{o}C. The effect of storage on breast meat pH is given in table 4.14. The pH value in breast meat found increased with storage period and pH value was highest at day 7. The groups (B, C, D) supplemented with garlic powder had lower pH values than the control group (A) in all days. The lowest pH value was observed in group D (5.74 ± 0.00) followed by C (5.88 ± 0.00), B (5.88 ± 0.00) and A (6.13 ± 0.00) after 7 days of storage. Similar findings were reported by Naimati (2020), who used quinoa seed extract as an antioxidant source in the quail feed. She observed that breast meat pH value was significantly lowest in the quinoa seed extract supplemented groups as compared to the control group during storage at 4^{o}C in all days. A decline in quail's breast meat pH could be possible due to the existance of polyphenols and flavonoids in garlic powder (Xiong et al., 1993). However, contrary to our study, Aksu et al. (2014) observed that the pH value they determined in the cold carcass was higher in groups receiving thyme oil supplementation.

Table 4.14. The effect of storage on breast meat pH values

Groups	Days			
	0	3	5	7
A	5.94 ± 0.015^{Ba}	6.01 ± 0.00^{Ba}	6.14 ± 0.05^{Aa}	6.13 ± 0.00^{Aa}
B	5.90 ± 0.009^{a}	5.90 ± 0.02^{Bb}	5.78 ± 0.08^{b}	5.88 ± 0.01^{b}
C	5.78 ± 0.030^{Cb}	5.81 ± 0.01^{BCc}	5.86 ± 0.00^{ABb}	5.88 ± 0.00^{Ab}
D	5.61 ± 0.005^{Cc}	5.71 ± 0.0^{Bd}	5.72 ± 0.00^{Bb}	5.74 ± 0.00^{Ac}
SEM	0.039	0.034	0.052	0.042
P value	0.000	0.000	0.002	0.000

Means with different superscripts (capital letters) in the same rows significantly different from each other ($P < 0.05$). Means with different superscripts (lowercase) letters in the same column differ significantly ($P<0.05$), SEM: Standard Mean Error, P: Significance, A: Control, B: 0.5% garlic powder, C: 1% garlic powder, D: 2% garlic powder

4.5 Effect of Garlic Powder on Breast and Thigh Meat Colour and pH

At the end of the study, quail thigh and breast meat pH and colour such as L* (brightness), a* (redness) and b* (yellowness) were determined in the cold carcass (Table 4.15). No significant difference was observed between the treatment groups in terms of L* (brightness), a* (redness) values of thigh meat and skin in the cold carcass ($P>0.05$). While, there was a significant difference observed among the dietary treatments in the case of b* (yellowness) values of thigh meat ($P<0.05$). It was observed that the lowest b* (yellowness) value in thigh meat was in group B.

Table 4.15. Effect of garlic powder supplementation on thigh meat and skin colour in cold carcass

Groups	Thigh meat			Thigh skin		
	L*	a*	b*	L*	a*	b*
A	55.85±0.44	2.18±0.13	6.79 ± 0.40^{a}	60.60±1.16	1.57±0.19	6.35±0.73
B	56.09±0.45	2.51±0.31	5.57 ± 0.39^{b}	59.79±0.45	1.63±0.12	5.51±0.33
C	56.25±0.53	2.24±0.13	7.46 ± 0.33^{a}	60.26±0.77	1.76±0.27	6.19±0.51
D	55.49±0.38	2.76±0.28	7.09 ± 0.38^{a}	58.79±0.95	2.01±0.20	6.40±0.46
SEM	0.223	0.122	0.207	0.431	0.097	0.261
P value	0.680	0.322	0.05	0.493	0.392	0.591

Means with different superscripts in the same column differ significantly ($P<0.05$), SEM: Standard Mean Error, P: Significance, A: Control, B: 0.5% garlic powder, C: 1% garlic powder, D: 2% garlic powder

The results of skin colour L* (brightness), a* (redness) and b* (yellowness) values of the breast meat and skin of quail are given in Table 4.16. It was observed that there was no statistically significant difference between the groups in terms of L*, a* and b* values in breast meat ($P>0.05$). Whereas, there was no statistically significant difference

observed in breast skin between the groups in case of a* (redness) values. However, significant difference was observed between experimental groups in case of breast skin L* (lightness) and b* (yellowness) (P<0.05). Although, there was a statistically significant difference was observed in breast meat pH between the experimental groups. Similar results were found by Ao et al. (2011) who studied the effect of dietary fermented garlic supplementation on meat quality of broiler. They found that mean values of L*, a* and b* were not statistically different among treatment group in broiler breast meat. However, they observed a decline in pH value with the increased garlic level in diet from 0 to 4g/kg. Moreover, these results are in line with the findings of Hong et al. (2012) who found no statistical difference in breast or thigh meat L, a, or b values in the oregano, anise essential oil and peel powder supplemented group. In contrast to present findings, Choi et al. (2010) studied the effects of dietary garlic and α-tocopherol on thigh meat colour of broiler birds. They found a significant effect of 3% garlic powder with the addition of α-tocopherol on L* (lightness), a* (redness), and b* (yellowness) values of thigh meat. However, In terms of pH the results were significantly different ($p < 0.05$) and related to findings of our study. The pH values decreased with the increased level of garlic powder and the combination of garlic powder and α-tocopherol. Moreover, Kirkpinar et al. (2014) also observed difference in L* and a* values of breast meat when birds fed with 150 mg oregano and garlic essential oil and 300 mg mixed in combination. In this present study, decrease in the pH value of quail breast meat observed and these findings are in line with the findings of Kim et al. (2009) that exhibited a linear decline in pH with higher levels of the feeding garlic bulb and husk in comparison of the control group.

Table 4.16. Effect of garlic powder supplementation on breast meat and skin colour and pH

Groups	breast meat			breast skin			pH
	L*	a*	b*	L*	a*	b*	
A	62.31±0.67	4.01±0.38	10.74±0.34	68.06±0.42^{a}	3.75±0.30	9.79±0.46^{b}	5.86±0.03^{a}
B	60.35±0.80	3.67±0.37	10.21±0.30	68.69±0.66^{a}	3.83±0.54	12.46±1.20^{a}	5.77±0.05^{ab}
C	62.11±1.10	3.65±0.31	10.68±0.22	68.59±0.55^{a}	3.34±0.23	9.86±0.25^{b}	5.73±0.02^{b}
D	60.60±0.77	3.75±0.29	10.55±0.29	65.51±0.83^{b}	3.80±3.33	9.60±0.48^{b}	5.74±0.02^{b}
SEM	0.422	0.169	0.146	0.350	0.187	0.395	0.019
P value	0.237	0.873	0.576	0.002	0.801	0.020	0.048

Means with different superscripts (lowercase) letters in the same column differ significantly (P<0.05), SEM: Standard Mean Error, P: Significance, A: Control, B: 0.5% garlic powder, C: 1% Garlic powder, D: 2% Garlic powder

4.6 Sensory Evaluation

In this current trial, the impacts of dietary addition of garlic powder were investigated at different inclusion levels on quail breast and thigh meat sensory characteristics. At day 1, sensory characteristics of quails' thigh and breast meat were investigated. Table (4.17) exhibits the impacts of dietary addition of garlic on the subjective scores for breast and thigh of quail meat. The Values of the colour, juiciness, tenderness and flavour of thigh meat were significantly higher in the treatment groups as compared to control group ($P<0.05$). Sensory values of thigh meat of control group were lower than the experimental groups. Tenderness values of breast meat were found non-significant ($P>0.05$) between the experimental groups. While, significant differences ($P<0.05$) were found in colour, juiciness and flavour of breast meat between the control group and other garlic supplemented groups. Numerically values of colour, juiciness and flavour were lower in group A as compared to group B, C and D. Similar research finding were reported by Eugeiuszr and Edyta (2007) who observed that 5mg/kg dietary addition of garlic enhanced the sensory characteristics of chicken meat as compared to control group. Moreover, similar research findings were observed by Schleicher et al. (1996) who concluded that the meat of birds fed on garlic diet gained the highest sensory score. These research outputs are also in consent with the Bobko et al. (2019) who reported a statistically significant effect of different plant supplementation on the sensory quality of chicken meat. However, Onibi et al. (2009) found no significant difference in sensory characteristics of cooked broiler meat except palatability of meat samples that increased with the increased level of garlic supplementation. In another study, Kim et al. (2009) found no significant difference in meat juiciness but sensory panellists reported higher hardness and flavour scores in garlic supplemented samples. While, Sasidhar et al. (2016) described the influence of using distinct inclusion levels of garlic powder on carcass traits as well as on the organoleptic properties of cooked meat of Japanese quail. They found that flavour and overall acceptability exhibited a huge significant difference ($P<0.01$) at 1.5% level of garlic powder supplementation in comparison of the control group. These findings suggest that supplementation of garlic powder in quail diet can enhance sensory quality because sensory panellists recorded better sensory score in the thigh and breast meat from quail that were fed on dietary garlic.

Table 4.17. Sensory characteristics of cooked meat of Japanese quail as influenced by dietary garlic powder

Parameters	A	B	C	D	SEM	P value
Colour						
Thigh	6.68±0.32^{c}	7.31±0.19^{b}	8.43±0.15^{a}	7.81±0.13^{b}	0.133	0.000
Breast	6.75±0.41^{b}	7.12±0.39^{b}	8.37±0.18^{a}	7.50±0.18^{ab}	0.184	0.007
Juiciness						
Thigh	6.87±0.35^{c}	7.43±0.24^{bc}	8.50±0.12^{a}	8.00±0.18^{ab}	0.140	0.000
Breast	6.25±0.25^{b}	6.75±0.52^{ab}	7.87±0.35^{a}	6.50±0.50^{b}	0.229	0.053
Tenderness						
Thigh	6.93±0.30^{c}	7.43±0.20^{bc}	8.18±0.18^{a}	8.06±0.17^{ab}	0.126	0.001
Breast	6.75±0.45	6.75±0.49	7.87±0.29	7.50±0.26	0.204	0.124
Flavour						
Thigh	6.81±0.27^{b}	7.50±0.27^{a}	8.06±0.14^{a}	7.50±0.15^{a}	0.121	0.003
Breast	6.12±0.29^{b}	6.37±0.53^{b}	8.50±0.26^{a}	6.80±0.35^{b}	0.243	0.000

The means with different superscripts in the same rows are significantly different from each other ($P<0.05$), SEM: Standard Mean Error, P: Significance, A = Control, B: 0.5% Garlic powder, C: 1% Garlic powder, D: 2% Garlic powder

CHAPTER V

CONCLUSION

In 2006, European Union restricted the use of antibiotic growth promoter in animal feed due to their undesirable effects on living cells such as mutagenicity, carcinogenicity, teratogenicity, toxicity and hypersensitivity issues. Consequently a series of research has been started to discover the alternative to synthetic feed additives that do not threaten human health and do not leave residues. This study was performed to reveal the quality alterations in the storage time of the meat as well as the effect of the use of garlic powder with high antioxidant activity and phenolic content in quail mixed feed as a natural feed additive.

In this study, Commercial broiler chick starter feed was given to quails for 5 weeks but 4 different mixed feed groups were made by adding 0, 0.5, 1 and 2% garlic powder to the feed. At the end of the trial, it was observed that garlic powder has a significantly positive influence on LBW, BWG and FCR except for FI.

The impact of garlic powder on the parameters of the carcass characteristics such as carcass yield, thigh, breast, neck and back ratio, abdominal fat, heart and liver ratio from internal organs was found non-significant ($P>0.05$). However, differences were noticed between the groups in terms of male hot carcass weights and wing ratio ($P<0.05$).

The pH, lipid oxidation and a microbiological load of meat were determined at +4 ° C at 0, 3, 5 and 7 days at the end of the storage period. It has been demonstrated that the groups with garlic powder supplementation had significantly ($P<0.05$) lower breast meat pH value than the control group in all days (0, 3, 5 and 7) and pH value decreased with the increase in the amount of garlic powder. The breast meat thiobarbituric acid value and the primary oxidation product, peroxide value was found to be lower than the control in the additive groups on all days of analysis ($P<0.05$). These results showed that the antioxidant effective phenolic substances of garlic powder are effective in preventing or delaying the oxidation of meat and can be used as a natural antioxidant in feed.

Microbial load (total number of psychrophilic bacteria), which is one of the crucial factors affecting the quality of the meat, has increased with the increase in storage time, but it has been revealed in the analyzes made at the end of each storage period that the total number of psychrophilic bacteria in the control group is higher than the additive groups ($P<0.05$).

There were no significant difference observed between breast meat and skin colour L*, a* and b* values in the cold carcass. However, it was observed that the b* value in thigh meat and thigh skin colours decreased with increasing additives. There was no significant difference was observed among the treatment groups in terms of L* (brightness), a* (redness) values of thigh meat and skin in the cold carcass ($P>0.05$). While, there was a significant difference between the treatment groups was observed in the case of b* (yellowness) values of thigh meat ($P<0.05$).

Sensory characteristics of quails' thigh and breast meat were investigated at day 1. Values of the colour, juiciness, tenderness and flavour of thigh meat were significantly higher in the treatment groups as compared from the control ($P<0.05$). Sensory values of thigh meat of control group were lower than the experimental groups. While, significant differences ($P<0.05$) were observed in colour, flavour and juiciness of breast meat between the control group and other garlic supplemented groups.

It is concluded that 1% garlic had better effects on all the studied parameters than other concentrations. Moreover, it is not necessary to add garlic in high amount as feed additive in animal diet. It may cause depression in feed intake and pose negative effects on growth performance parameters. Outcomes of this study will help poultry producers to reduce production cost by using garlic instead of expensive chemical feed additives. Furthermore, garlic powder had a significant impact on the performance of quail and the shelf life of the meat and it can be used in poultry feed as a natural antioxidant to avert or delay the lipid oxidation of meat. Animal diet can play an important role to inhibit the free radical production in organisms and their derived products at their localized sites. The addition of garlic in the diet of animals is a simple and efficient approach to incorporate natural anti-oxidant compounds into lipidic layers of membrane. In this way, they can inhibit lipid oxidation more effectively and prevent oxidative losses of animal products compared to postmortem addition.

REFERENCES

Abdullah, A.Y., Mahmoud, K.Z., Nusairat, B.M. and Qudsieh, R.I., "Small intestinal histology, production parameters, and meat quality as influenced by dietary supplementation of garlic (Allium sativum) in broiler chicks", ***Italian Journal of Animal Science*** 9 (4), 80, 2010.

Ahmad, S., "Effect of Selection for higher 4 week body weight in 4 closebred stocks and three age groups of Japanese quail in 4th generation", M.Phil Thesis, ***University of Veterinary & Animal Sciences*****,** Pakistan, 2014.

Aksu, T., Aksu, M. I., Önel, S. E., Yakan, A., Kaya, D.A. and Baylan, M., "Effect of thyme oil (Thymbra spicata L. var. spicata) on meat quality in Japanese quails". ***European Poultry Science*** 78, 2014.

Alcicek, A., Bozkurt, M. and Çabuk, M., "The effect of an essential oil combination derived from selected herbs growing wild in Turkey on broiler performance", ***South African Journal of Animal Science*** 33 (2), 89-94, 2003.

Ali, M., Chand, N., Khan, R.U., Naz, S. and Gul, S., "Anticoccidial effect of garlic (Allium sativum) and ginger (Zingiber officinale) against experimentally induced coccidiosis in broiler chickens", ***Journal of Applied Animal Research*** 47 (1), 79-84, 2019.

Ali, S., Mukhtar, M., Manzoor, S., Hssain, Z., Ali, A., Tabassum, R., Imran, M., Amer, M.Y. and Bhatti, N., "Effect of garlic, black seed and turmeric on the growth of broiler chicken", ***Pakistan Journal of Nutrition*** 13 (4), 204, 2014.

Aminzade, B., B. Karami, and E. Lotfi., "Meat quality characteristics in Japanese quails fed with Mentha piperita plant", ***Animal Biology & Animal Husbandry*** 4 (1), 2012.

Amouzmehr, A., Dastar, B., Nejad, .J D., Sung, K., Lohakare, J. and Forghani, F., "Effects of garlic and thyme extracts on the growth performance and carcass characteristics of broiler chicks", ***Journal of Animal Science and Technology*** 54 (3), 185-190, 2012.

Ankri, S. and Mirelman. D., "Antimicrobial properties of allicin from garlic", ***Microbes and infection*** 1 (2), 125-129, 1999.

Ao, X., Yoo, J. S., Zhou, T. X., Wang, J. P., Meng, Q. W., Yan, L., Cho, J. H. and Kim, I. H., "Effects of fermented garlic powder supplementation on growth performance, blood profiles and breast meat quality in broilers", ***Livestock Science*** 141 (1), 85-89, 2011.

AOAC, "Official methods of analyses", (15th Edn**)** ***Association of official analytical Chemists, Washington, DC***., USA 1995.

Bampidis, V. A., Christodoulou ,V., Christaki, E., Florou-Paneri, P. and Spais, A. B., "Effect of dietary garlic bulb and garlic husk supplementation on performance and carcass characteristics of growing lambs", ***Animal Feed Science and Technology*** 121, 273-283, 2005.

Bek, Y. ve Efe, E., "Araştırma ve Deneme Metodları I", ***Çukurova Üniversitesi Ziraat Fakültesi Yay***. No: 71, Adana, 1988.

Bhandari, S. R., Yoon, M. K. and Kwak, J.H., "Contents of phytochemical constituents and antioxidant activity of 19 garlic (Allium sativum L.) parental lines and cultivars", ***Horticulture Environment, and Biotechnology*** 55(2),138-147, 2014.

Bharathi, I. D., Shamsudeen, P., Kannan, D. and Thirunavukarasu, P., "Dietary supplementation of turmeric oil (curcuma longa) and garlic powder (allium sativum) on growth performance of meat type Japanese Quail (Coturnix japonica)", ***International Journal of Science, Environment and Technology*** 7 (3), 992–996, 2018.

Block, E., “The chemistry of garlic and onions”, ***Scientific american*** 252(3), 114-121, 1985.

Bobko, M., Haščík, P., Bobková, A., Kňazovická, V., Tóth, T. and Angelovičová, M., “Influence of different plant supplements applied in chicken nutrition on quality of their meat”, ***Journal of Microbiology, Biotechnology and Food Sciences*** 1020-1031, 2019.

Borek, C., “Antioxidant health effects of aged garlic extract”, ***The Journal of nutrition*** 131 (3), 1010S-1015S, 2001.

Botsoglou, N.A., Christaki, E., Fletouris, D.J., Florou–Paneri, P. and Spais, A.B., “The effect of dietary oregano oil on lipid oxidation in raw and cooked chicken during refrigerated storage”, ***Meat Science*** 62, 259-265, 2002.

Brzoska, F., Sliwinski, B., Michalik-Rutkowska, O. and Sliwa, J., “The effect of garlic (*Allium sativum)* on growth performance, mortality rate, meat and blood parameters in broilers”, ***Annals of Animal Science*** 15 (4), 961-975, 2015.

Capitani, C. D., Hatano, M. K., Marques, M. F. and Castro I. A., “Effects of optimized mixtures containing phenolic compounds on the oxidative stability of sausages”, ***Food Science and Technology International*** 19, 69–77, 2015.

Chang, K. J. and Cheong, S. H., "Volatile organosulfur and nutrient compounds from garlic by cultivating areas and processing methods", ***Federation of American Societies for Experimental Biology*** 1108-2, 2008.

Chen, S., Shen, X., Cheng, S., Li, P., Du, J., Chang, Y. and Meng, H., “Evaluation of garlic cultivars for polyphenolic content and antioxidant properties”, ***PLoS One*** 8 (11), 79730, 2013.

Chi, M. S., Koh, E. T. and Steward, T. J., “Effects of garlic on lipid metabolism in rats fed cholesterol or lard”, ***Journal of Nutrition*** 112, 241-248, 1982.

Choi, I. H., Park, W. Y. and Kim, Y. J., “Effects of dietary garlic powder and α-tocopherol supplementation on performance, serum cholesterol levels, and meat quality of chicken”, ***Poultry Science*** 89, 1724-1731, 2010.

Chowdhury, S. D. and T. K. Smith., "Effects of dietary garlic on cholesterol metabolism in laying hens", ***Poultry science*** 81 (12), 1856-1862, 2002.

Cofrades, S., Serrano, A., Ayo, J., Carballo, J. and Jime´nez-Colmenero, F., “Characteristics of meat batters with added native and preheateddefatted walnut”, ***Food Chemistry*** 107,1506-1514, 2008.

Decker, E. A. and Park, Y., “Healthier meat products as functional foods”, ***Meat Science*** 86 (1), 49-55, 2010.

Dieumou , F. E. A., Teguia, J. R., Kuiate, J. D., Tamokou, N. B., Fonge, A. and Dongmo M. C., “Effects of ginger and garlic essential oils on growth performance and gut microbial population of broiler chickens”, ***Livestock Research for Rural Development*** 21 (8), 2009.

Elagib, H. A. A., El-Amin, W. I. A., Elamin K. M. and Malik, H. E. E., “Effect of dietary garlic (*Allium sativum*) supplementation as feed additive on broiler performance and blood profile”, ***Journal of Animal Science Advances*** 3 (2), 58-64, 2013.

Elgayyar, M., Draughon, F., Golden, D. and Mount, J., “Antimicrobial activity of essential oils from plants against selected pathogenic and saprophytic microorganisms”, ***Journal of Food Protection*** 64, 1019-1024, 2001.

El-Katcha, M. I., Shewita, R. S., Ahmed, H. A. and Amar, H. S., “Effect of dietary supplementation of different levels of garlic powder on performance and immune response of Japanese quail”, ***Alexandria Journal of Veterinary Sciences*** 33 (1), 121-138, 2011.

Elkayam, A., Mirelman, D., Peleg, E., Wilchek, M., Miron, T., Rabinkov, A., Oron-Herman, M. and Rosenthal, T., "The effects of allicin on weight in fructose-induced hyperinsulinemic, hyperlipidemic, hypertensive rats", ***American journal of hypertension*** 16 (12), 1053-1056, 2003.

El-Sayed, Z. S., El-Garhy, O. H. M., Abdella, M. M., and El-Sayaad, G. A., "Effect of adding antibiotic, oregano oil and garlic powder on growth performance, carcass traits and ıntestinal pathogenic microrganisms of quails", ***Egyptian Journal of Animal Production*** 54 (1), 55-66, 2017

El-Shenway, A. M. and Gehan I. E. A., "Effect of Some Organic Acids and Essential Oils as Feed Additives on Growth Performance, Immune Response and Carcass Quality of Japanese Quail", ***Alexandria Journal for Veterinary Sciences*** 51 (1), 2016.

Eltazi, S. M. A., Mohamed, K. A. and Mukhtar, M. A., "Effect of using garlic powder as natural feed additives on performance and carcass quality of broiler chicks", ***Assiut. Veterinary Medical Journal*** 60 (141), 45-53, 2014.

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

Fadlalla, I. M. T., Mohammed, B. H. and Bakhiet, A. O., "Effect of feeding garlic on the performance and immunity of broilers", ***Asian J Poult Sci*** 4 (4), 182-189, 2010.

Fayed, R. H., Abeer, H., Razek, A. and Jehan, M., "Effect of dietary garlic supplementation on performance, carcass traits, and meat quality in broiler chickens", ***Parameters*** 100, 1000-1004, 2011.

Fenelli, S. L., Castro, G. D., Toranzo, E. G. and Castro, J. A., "Mechanism of the preventive properties of some garlic compounds in the carbon tetrachloride promoted oxidative stress", ***Diallyl sulfide: Research Communications in Molecular Pathology and Pharmacology*** 110 (2), 163-169, 1998.

Gorinstein, S., Drzewiecki, J., Leontowicz, H., Leontowicz, M., Najman, K., Jastrzebski, Z., Zachwieja, Z., Barton, H., Shtabsky, B., Katrich, E. and Trakhtenberg, S., "Comparison of the bioactive compounds and antioxidant potentials of fresh and cooked Polish, Ukrainian, and Israeli garlic", ***Journal of Agricultural and food Chemistry*** 53 (7), 2726-2732, 2005.

Gümüş, R., Urçar Gelen, S., Ceylan, Z. G. ve İmik, H., "Bıldırcın Rasyonuna Katılan Kekik Uçucu Yağının Göğüs Etinin Bazı Mikrobiyolojik ve Fizikokimyasal Özelliklerine Etkisi", ***F.Ü. Sağ. Bil.Vet. Derg.*** 31 (3), 153 -158, 2017.

Hanafy, M. S., Shalaby, S. M., El-Fouly, M. A., Abd, M. E. A. and Soliman, F. A., "Effect of garlic on lead contents in chicken tissues", ***DTW. Deutsche Tierarztliche Wochenschrift*** 101 (4), 157-158, 1994.

Hanieh, H., Narabara, K., Piao, M., Gerile, C., Abe, A. and Kondo, Y., "Modulatory effects of two levels of dietary Alliums on immune response and certain immunological variables, following immunization, in White Leghorn chickens", ***Animal Science Journal*** 81 (6), 673-680, 2010.

Hann, G., "History, folk medicine, and legendary uses of garlic. In: Koch HP, Lawson LD (eds) Garlic: the science and therapeutic application of Allium sativum L. and related species", ***Williams and Wilkins, Baltimore***, 37-107, 1996.

Hernandez, F., Madrid, J., Garcia, V., Orengo, J. and Megias, M. D., "Influence of two plant extracts on broilers performance, digestibility, and digestive organ size", ***Poultry science*** 83 (2), 169-174, 2004.

Hong, J. C., Steıner, T., Aufy, A. and Lıen, T.F., "Effects of supplemental essential oil on growth performance, lipid metabolites and immunity, intestinal characteristics, microbiota and carcase traits in broilers", ***Livestock Science*** 144, 253–262, 2012.

Horie, T., Awazu, S., Itakura, Y. and Fuwa, T., “Identified diallyl polysulfides from an aged garlic extract which protects the membranes from lipid peroxidation”, ***Planta Medica*** 58 (05), 468-469, 1992.

Hughes, B. G. and Lawson, L. D., “Antimicrobial effects of Allium sativum L.(garlic), Allium ampeloprasum L.(elephant garlic), and Allium cepa L.(onion), garlic compounds and commercial garlic supplement products”, ***Phytotherapy Research*** 5 (4), 154-158, 1991.

Hunt, M. C., Acton, J. C., Benedict, R. C., Calkins, C. R., Cornforth, D. P., Jeremiah, L. E., Olson, D. P., Salm, C. P., Savell, J. W. and Shivas, S. D., “Guidelines For Meat Color Evaluation”, ***American Meat Science Association and National Live Stock And Meat Board***, Chicago, 1991.

Hygreeva, D., Pandey, M.C. and Radhakrishna K., “Potential applications of plant based derivatives as fat replacers, antioxidants and antimicrobials in fresh and processed meat products”, ***Meat Science*** 98, 47-57, 2014.

Issa, K. and Omar, J., "Effect of garlic powder on performance and lipid profile of broilers", ***Open Journal of Animal Sciences***, 2, 62-68, 2012

Jamel, M.S., Mohamed, A.B. and Al-Baddy, M.A., “Effect of adding garlic powder (Allium sativum) and black seed (Nigella sativa) in feed on broiler growth performance and intestinal wall structure”, ***Journal of Natural Sciences Research*** 3 (1), 35-41, 2013.

Jamroz, D. and Kamel, C., “Plant extracts enhance broiler performance in non ruminant nutrition: antimicrobial agent and plant extracts on immunity, health and performance”, ***Journal of Animal Sciences*** 80, 41, 2002.

Jang, H. J., Lee, H. J., Yoon, D. K., Ji, D. S., Kim, J. H. and Lee, C. H., “Antioxidant and antimicrobial activities of fresh garlic and aged garlic by-products extracted with different solvents”, ***Food science and biotechnology*** 27 (1), 219-225, 2017.

Jatoi, A. S., Sahota, A. W., Akram, M., Javed, K., Jaspal, M. H., Mehmood, S., Hussain, J., Ishaq, H. M. and Bughio, E., "Egg quality characteristics as influenced by different body sizes in four close-bred flocks of Japanese quails (*coturnix coturnix japonica*)", ***Journal of Animal and Plant Science*** 25 (4), 921-926, 2015.

Javandel, F., Navidshad, B., Seifdavati, J., Pourrahimi, G. H. and Baniyaghoub, S., "The favorite dosage of garlic meal as a feed additive in broiler chickens ratios", ***Pakistan journal of biological sciences: PJBS*** 11 (13), 1746-1749, 2008.

Jonkers, D., Sluimer, J. and Stobberingh, E., "Effect of garlic on vancomycin-resistant enterococci", ***Antimicrobial Agents and Chemotherapy*** 43 (12), 3045-3045, 1999.

Karangiya, V. K., Savsani, H. H., Patil, S. S., Garg, D. D., Murthy, K. S., Ribadiya, N. K. and Vekariya, S. J., "Effect of dietary supplementation of garlic, ginger and their combination on feed intake, growth performance and economics in commercial broilers", ***Veterinary World*** 9 (3), 245-250, 2016.

Khalil, H. A., Faten, A. M., Attia, H. S., A. Elhalim and Mady, M. E., "Efficacy of dietary garlic under hot weather in Japanese quail", ***Egyptian Poultry Science*** 27 (III), 645-661, 2007.

Kim, Y. J., Jin, S. K. and Yang, H. S., "Effect of dietary garlic bulb and husk on the physicochemical properties of chicken meat", ***Poultry Science*** 88, 398–405, 2009.

Kinsella, J. E. B. Lokesh and Stone. R. A.., "Dietary n-3 polyunsaturated fatty acids and amelioration of cardiovascular discase: possible mechanisms", ***American Journal of Clinical Nutrition*** 52, 1-28, 1990.

Kirkpinar, F., Unlu, H. B., Serdaroğlu, M. and Turp, G. Y., "Effects of dietary oregano and garlic essential oils on carcass characteristics, meat composition, colour, pH and sensory quality of broiler meat", ***British Poultry Science*** 55 (1), 157-166, 2014.

Lang, Y. J. and Zhang, K.Y., "Studies on the effective components of garlic (Allium sativum L.)", ***Chin Herb Med.*** 4, 4-6, 1981.

Lemar, K. M., Turner, M. P. and Lloyd, D., "Garlic (Allium sativum) as an anti-Candida agent: a comparison of the efficacy of fresh garlic and freeze-dried extracts", ***Journal of Applied Microbiology*** 93 (3), 398-405, 2002.

Leonarduzzi, G., Sottero, B. and Poli, G., "Oxidized products of cholesterol: dietary and metabolic origin, and proatherosclerotic effects", ***The Journal of nutritional biochemistry*** 13 (12), 700-710, 2002.

Lukanov, H., Genchev, A. and Ribarski, S., "Effect of feed supplementation with garlic powder on meat productivity and meat quality traits of Classic Ross 308 male hybrid chickens", ***Trakia Journal of Science*** 13 (1), 66-76, 2015.

Mahmood, S., M. M. Ul-Hassan, M. Alam and F. Ahmad., "Comparative efficacy of *Nigella sativa* and *Allium sativum* as growth promoters in broilers", ***International Journal of Agriculture and Biology*** 11 (6), 775–778, 2009.

Marilynn, L., "Effect of garlic on blood lipids in particles with coronary heart disease", ***American Journal of Clinical Nutrition*** 34, 2100-2103, 2001.

Miles, R. D., Butcher, G. D., Henry, P. R. and Littell, R. C., "Effect of antibiotic growth promoters on broiler performance, intestinal growth parameters and qualitative morphology", ***Poultry Science*** 85, 476–485, 2006.

Miron, T., Rabinkov, A., Mirelman, D., Wilchek, M. and Weiner, L., "The mode of action of allicin: its ready permeability through phospholipid membranes may contribute to its biological activity", ***Biochimica et Biophysica Acta (BBA)-Biomembranes*** 1463 (1), 20-30, 2000.

Nafady, A., Abd-El-Motelib, T. Y., Salem, B. and El-Zanaty, K., "Aspergillosis in pigeon and role of thiabendazole or garlic juice for prevention of infection", ***Assiut Veterinary Medical Journal*** 22 (44), 192-197, 1990.

Naimati, S. "Kinoa Tohomu (*Chenopodium quinoa* Willd.) Ekstraktının Japon Bıldırcınlarında Performans, Karkas Özellikleri Ve Et Kalitesi Üzerine Etkileri", Yuksek Lisans Tezi, ***N.Ö.H.U. Fen Bilimleri Enstitüsü***, Niğde, s. 44-47. 2019.

Nettleton, J. A., "Omega-3 fatty acids: comparison of plant and seafood sources in human nutrition", ***Journal of American Diet Association*** 91, 331-337, 1991.

Nidaullah, H., Durrani, F. R., Ahmad, S., Jan, I. U. and Gul, S., "Aqueous extract from different medicinal plants as anticoccidial, growth promotive and immunostimulant in broilers", ***Journal of agricultural and biological science*** 5 (1), 53-59, 2010.

Okan, O. T., Varlıbaş, H., Öz, M. ve Denizli, İ., "Antioksidan Analiz Yöntemleri ve Doğu Karadeniz Bölgesinde Antioksidan Kaynağı Olarak Kullanılabilecek Odun Dışı Bazı Bitkisel Ürünler" ***Kastamonu Üni, Orman Fakültesi Dergisi*** 13 (1), 48-59, 2013.

Oladele, O. A., Emikpe, B. O. and Bakare, H., "Effects of dietary garlic (*Allium sativum* Linn.) supplementation on body weight and gut morphometry of commercial broilers", ***International Journal of Morphology*** 30 (1), 238-240, 2012.

Onibi, G. E., Oluwatoyin, E., Adebisi, A., N. Fajemisin, and Ayodeji, V., Adetunji. "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, 2009.

Otunola, G. A., Oloyede, O. B., Oladiji, A. T. and Afolayan, A. J., "Comparative analysis of the chemical composition of three spices–Allium sativum L. Zingiber officinale Rosc. and Capsicum frutescens L. commonly consumed in Nigeria", ***African Journal of Biotechnology*** 9 (41), 6927-6931, 2010.

Pawel, M. and Pisulewski., "Nutritional potential for improving meat quality in poultry", ***Animal Science Papers and Reports*** 23, 303-315, 2005.

Premavalli, K. and Omprakash, A. V., "Effect of various levels of garlic (Allium sativum L.) powder in feed on growth performance of Japanese quail (Coturnix japonica)", ***Journal of Entomology and Zoology Studies*** 8 (2), 1515-1517, 2020.

Racesi, M., Hoseini-Aliabad, S.A., Roofchaee, A., Shahneh, A. and Pirali, S., "Effect periodically use of garlic (Allium sativum) powder on performance and carcass characteristics in broiler chicken", ***World Academy of Science, Engineering and Technology*** 68, 1213-1219, 2010.

Rahman, K., "Garlic and aging: new insights into an old remedy", ***Ageing research reviews*** 2 (1), 39-56, 2003.

Rahmatnejad, E., Roshanfekr, H., Ashayerizadeh, O., Mamooee, M. and Ashayerizadeh, A., "Evaluation the effect of several non-antibiotic additives on growth performance of broiler chickens", ***Journal of Animal and Veterinary Advances*** 8, 1670-1673, 2009.

Ray, S., Das, S. K., Mishra, S. K., Swain, R. K., Maity, A., Swain, P. S. and Das, A., "Performance of Japanese quail on organically complexed minerals by replacing inorganic sources", ***Indian Journal of Animal Sciences*** 84 (1), 60-67, 2014.

Raya, A. H., Sherif, K. H., El Rabie M. H. and Bedair, H. F., "Effect of dietary supplementation with dried garlic and thyme on growth performance of Japanese quail", ***Journal of Animal and Poultry Production*** 5 (2),73- 85, 2014.

Re, R., Pellegrini, N., Proteggente, A., Pannala, A., Yang, M. and Rice-Evans, C., "Antioxidant activity applying an improved ABTS radical cation decolourization assay", ***Free Radical Biology and Medicine*** 26, 1231-1237, 1999.

Rehman, Z. U. and Munir, M. T., "Effect of garlic on the health and performance of broilers." ***Veterinaria*** 3 (1), 32-39, 2015.

Reuter, H. D., "Therapeutic effects and applications of garlic and its preparations. *Garlic*", ***Indian Journal of Pharmaceutical Sciences*** 76 (3), 256-261, 2014.

Rivlin, R.S., "Historical perspective on the use of garlic", ***The Journal of nutrition*** 131 (3), 951S-954S, 2001.

Samresh, D., A. Srivastava, V. Singh and A. Sharma, "An overview of Ocimum chemistry and pharmacological profile", ***Hamdard Medicus*** 46, 43, 2003.

Sarıkaya, Y., Tufan, T. ve Bolacalı, M., "Bıldırcın Rasyonlarına Polen İlavesinin Besi Performansı ve Karkas Parametreleri Üzerine Etkisi", ***Harran Üniversitesi Veteriner Fakültesi Dergisi*** 7 (1), 26-31, 2018.

Sasidhar, T., Mani, K., Rajendran, K., Vasanthakumar, T., Prabhakaran, U. and Sukandhiya, K., "Influence of different L
levels of dietary garlic on carcass characteristics and organoleptic properties of cooked meat of Japanese Quails", ***International Journal of Science, Environment and Technology*** 5 (3), 1177-1180, 2016.

Satılmış, A. S. "Etlik piliç karma yemlerinde meyan kökü kullanımının performans, karkas özellikleri ve et kalitesi üzerine etkileri", Yüksek Lisans Tezi, ***N.Ö.H.U. Fen Bilimleri Enstitüsü***, Niğde, s. 41-45. 2019.

Schleicher, A., Fritz, Z. and Kinal, S., "Effect of the use of herbal-garlic additives in mixtures on the production and post-mortem performance of slaughter chickens", ***Scientific Journals of the Agricultural University in Wrocław. Animal Science*** 41, 181-189, 1996.

Selim, N. A., Nada, S. A., Abdel-Salam, A. F. and Youssef, S. F., "Evaluation of some natural antioxidant sources in broiler diets: 2-effect on chemical and microbiological quality of chilled and frozen broiler meat", ***International Journal of Poultry Science*** 12 (10), 572, 2013.

Shaidi,, F., Janitha, P. K. and Wanasundura, P. D., "Phenolic antioxidants", ***Critical Reviews in Food Science and Nutrition*** 32, 67-103, 1992.

Sivam, G. P., "Protection against helicobacter pylori and other bacterial infections by garlic", ***Journal of Nutrition*** 131, 1106S-1108S, 2001.

Slinkard, K.and Singleton, V. L., "Total phenol analyses, automation and comparison with manual methods", ***American Journal of Enology and Viticulture (AJEV)*** 28, 49-55, 1992.

Spanos, G. A. and Wrolstad, R. E., "Influence of processing and storage on the phenolic composition of Thompson seedless grape juice", ***Journal of Agriculture and Food Chemistry*** 38, 1565-1571, 1990.

Sumiyoshi, H., "New pharmacological activities of garlic and its constituents", ***Nihon yakurigaku zasshi. Folia pharmacologica Japonica*** 110, 93P-97P, 1997.

Swain, P., L. M. Mohapatra, K. Sethy, P. R. Sahoo, S. M. Nayak, P. Patro, K. Behera, and C. R. Pradhan., "Effect of ginger and garlic supplement on growth and haemato-biochemical profile of japanese quail (Coturnix Coturnix Japonica)", ***Exploratory Animal and Medical Research*** 7, 77-83, 2017.

Tadi, P. P., Teel, R. W. and Lau, B. H. S., "Anticandidal and anticarcinogenic potentials of garlic", ***International Clinical Nutrition Review*** 10 (4), 423-429, 1990.

Tollba, A. A. and Hassan, M. S., "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)", ***Poultry Science*** 23, 327-340, 2003.

Uçak, I., "Physicochemical and antimicrobial effects of gelatin-based edible films incorporated with garlic peel extract on the rainbow trout fillets". ***Progress in Nutrition*** 21 (1), 232-240, 2019.

Udeh, F. U., Onah, C. C., Oyeagu, C. E., Onodugo, M. O., Okonkwo, C. O. and Ozoke, R. U., "Effect of dietary garlic powder on the haematology and cholesterol level of

Japanese Quail", ***International Journal of Scientific & Engineering Research*** 9(9), 2229-5518, 2018.

Unal, R., Fleming, H. P., McFeeters, R. F., Thompson, R. L., Breidt Jr, F. and Giesbrecht, F. G., "Novel quantitative assays for estimating the antimicrobial activity of fresh garlic juice", ***Journal of food protection*** 64 (2), 189-194, 2001.

Xiong, Y. L., Decker, E. A., Robe, G. H. and Moody, W. G., "Gelation of crude myofibrillar protein isolated from beef heart under antioxidative conditions", ***Journal of Food Science*** 58 (6), 1241-1244, 1993.

Zekić, V., Puvača, N., Milić, D., Beuković, M., Glamočić, D., Vukelić, N., Lukač, D. and Zekić, S., "Effect of garlic powder in broiler chicken nutrition: emphasis on production economic efficiency costs and chicken meat quality", ***Custos e @gronegócio*** 10 (2), 86-98, 2014.

Zhang, Y., L. Z. Ming, L. N. Feng, H. Y. Jin and Y. B. Ling., "Preliminary report on the effect of Qincola in the reatment of pullorum disease", ***Chinese Journal of Veterinary Medicine*** 22 (9), 25, 1996.

Ziton, A. A., "Response of broiler chicks to diet containing garlic as natural feed additive". Doctoral dissertation, M. Sc. Thesis, ***College of Agricultural Studies and Technology***, 2009.

CURRICULUM VITAE

I am Hassan Jalal, I was born on the 10th of October 1994 in Pakistan. I completed my high school degree from the Superior College Faisalabad, in 2012. I have done my bachelors from University of Veterinary & Animal Sciences, Lahore Pakistan. I had involved in different research projects during my studies. I have a total of 5 numbers of publications and had various projects done. As a Student of Veterinary and Animal sciences I have gained much knowledge about Livestock production, Poultry nutrition, dairy herd health, rumen physiology, animal feed resources, formulation and conservation, dairy cattle nutrition, calf nutrition, and it's Management. I have also been awarded ERASMUS scholarship which I availed in Poland. During my externship at Poznan University of Life Sciences Poland (Erasmus 2019/2020), I worked on a different project. I was responsible for lab experiments (Batch culture technique and Hohenheim gas system) to evaluate the in-vitro digestibility of *Galega Orientalis* and *Medicago sativa* silages. I've analyzed total Gas production, methane production, ammonia production, fatty acid and volatile fatty acid profiles, as well as protozoa, count in rumen fluid after fermentation in vitro using batch culture experiment and Hohenheim gas production system.

My Mphil research is related to Poultry nutrition in which I worked on "Evaluation of dietary supplementation of garlic powder (*Allium sativum*) on the growth performance, carcass traits and meat quality of Japanese quails (Coturnix coturnix japonica)" under the supervision of Prof. Dr. Sibel CANOĞULLARI DOĞAN.