EFFECT OF CINNAMON AND GARLIC ON GROWTH PERFORMANCE AND CARCASS CHARACTERISTICS OF BROILER

FARHANA YESMIN SUMI

DEPARTMENT OF ANIMAL NUTRITION, GENETICS AND BREEDING

SHER-E-BANGLA AGRICULTURAL UNIVERSITY

DHAKA-1207

JUNE-2022

EFFECT OF CINNAMON AND GARLIC ON GROWTH PERFORMANCE AND CARCASS CHARACTERISTICS OF BROILER

BY

FARHANA YESMIN SUMI

REGISTRATION No.: 20-11127

A Thesis

Submitted to the Department of Animal Nutrition, Genetics and Breeding
Sher-e-Bangla Agricultural University, Dhaka-1207
For the Partial Fulfillment of the Requirements
For the Degree of

MASTER OF SCIENCE (MS)
IN
ANIMAL NUTRITION
SEMESTER: JANUARY- JUNE, 2022

APPROVED BY

Associate Prof. Dr. Mofassara Akter Supervisor Department of Animal Nutrition, Genetics and Breeding Sher-e-Bangla Agricultural University, Dhaka-1207	**Prof. Dr. Md. Saiful Islam** Co-Supervisor Department of Animal Production and Management Sher-e-Bangla Agricultural University, Dhaka-1207

Associate Prof. Dr. AL-Nur Md. Iftekhar Rahman
Chairman
Department of Animal Nutrition, Genetics and Breeding
Sher-e-Bangla Agricultural University, Dhaka-1207
Dhaka-1207

Associate Prof. Dr. Mofassara Akter
Department of Animal Nutrition,
Genetics and Breeding
Sher-e-Bangla Agricultural University,
Dhaka-1207

mn‡hvMx Aa¨vcK W. †gvdvQ‡Qiv Av³vi
এনিম্যাল নিউট্রিশন, জেনেটিক্স এন্ড ব্রিডিং বিভাগ
এনিম্যাল সাইন্স এন্ড ভেটেরিনারি মেডিসিন অনুষদ
শেরেবাংলা কৃষি বিশ্ববিদ্যালয়, ঢাকা-১২০৭

CERTIFICATE

This is to certify that the thesis entitled **"Effect of Feeding Cinnamon and Garlic as an Alternative of Antibiotics on Growth Performance of Broiler"** submitted to the Department of Animal Nutrition, Genetics and Breeding, Faculty of Animal Science & Veterinary Medicine, Sher-e-Bangla Agricultural University, Dhaka-1207, as partial fulfillment for the requirements of the degree of Master of Science (MS) in Animal Nutrition, embodies the result of a piece of bona fide research work carried out by FarhanaYesmin Sumi, Registration No.: 20-11127 under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that any help or source of information, received during the course of this investigation has been duly acknowledged by her.

Date:
Place: Dhaka, Bangladesh

Associate Prof. Dr. Mofassara Akter
Supervisor
Department of Animal Nutrition, Genetics & Breeding
Sher-e-Bangla Agricultural University,
Dhaka-1207

ACKNOWLEDGEMENT

All praises are due to “Almighty Allah” who enables me to complete this thesis work. The author with a sense of respect expresses his heart felt gratitude, profound appreciation and ever endebtedness to my **Supervisor Associate Prof. Dr. Mofassara Akter**, Department of Animal Nutrition, Genetics and Breeding, Sher-e-Bangla Agricultural University, Dhaka-1207 for his untiring and painstaking guidance, invaluable suggestions, continuous supervision, timely instructions, inspirations and constructive criticism throughout the tenure of research work.

Heartfelt gratitude and profound respect are due to his **Co-supervisor Prof. Dr. Md. Saiful Islam**, Department of Animal Production and Management, Sher-e- Bangla Agricultural University, Dhaka-1207 for his co-operation, constructive criticism, and valuable suggestions for the modification and improvement of the research work.

The author expresses his last but not least grateful acknowledgement and indebtedness to his beloved father **Md. Dulal Shikder** and mother **Mosa. Rasheda Begum** their never-ending prayer, encouragement, sacrifice and dedicated efforts to educate me at this level.

The author expresses his deep and boundless gratefulness and profound respect to his beloved Brother **Abdullah Al Fahad** for their love, blessings, prayers, sacrifices and moral support.

Finally, the author is also boundless gratitude to **all the staff** of the Department of Animal Nutrition, Genetics and Breeding especially **Md. Kholilur Rahman** for their co-operation.

The Author

Email: farhanayesminsumi58@gmail.com

Phone Number: +01761461988

LIST OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ACRONYMS AND ABBREVIATION

ABBREVIATION	FULL WORD
ADG	Average daily gain
AGPs	Antibiotic growth promoter
ANOVA	Analysis of variance
Avg	Average
BCR	Benefit cost ratio
BDT	Bangladeshi taka
BWG	Body weight gain
Cm^2	Square centimeter
CP	Crude protein
CRD	Completely randomized design
DLS	Department of livestock services
DOC	Day old chick
DP	Dressing percentage
e.g.	For example
et al	And others/Associates
EU	European union
FAO	Food and agricultural organization
FC	Feed consumption
FCR	Feed conversion ratio
FDA	Food and drug administration
FI	Feed intake
g	Gram
GIT	Gastro intestinal tract
HDL	High density lipoprotein
i.e.	That is
IU	International unit
Kcal	Kilo calorie
Kg	Kilogram

LIST OF ACRONYMS AND ABBREVIATION

ABBREVIATION	FULL WORD
L	Liter
LDL	Low density lipoprotein
M.S.	Master of Science
ME	Metabolizable energy
ml	Milliliter
mm	Millimeter
MT	Metric ton
NAGP	Non antibiotic growth promoter
ND	Newcastle disease
No	Number
NS	Non-Significance
RH	Relative humidity
SAU	Sher-e-Bangla Agricultural University
SE	Statistical error
SPSS	Statistical package for social science
TG	Triglyceride
TM	Trade mark
Viz.	Such as
Vs.	Versus
WBWG	Weekly body weight gain
WHO	World health organization
Wks.	Weeks

LIST OF SYMBOLS

SYMBOLS	FULL MEANING
^{0}C	Degree Celsius
^{0}F	Degree Fahrenheit
@	At the rate of
:	Ratio
<	Less than
>	Greater than
*	5% level of significance
&	And
/	Per
±	Plus-minus
%	Percentage

Effect of Feeding Cinnamon and Garlic on Growth Performance and Carcass Characteristics of Broiler

ABSTRACT

The aim of the study is to evaluate the effect of feeding cinnamon and garlic on growth performance and carcass characteristics of broiler. The experiment was conducted by applying different levels of cinnamon and garlic with commercial broiler feed. A total of 180 one day-old of Lohmann Meat (Indian River) broiler chicks were purchased from Kazi farms hatchery, Gazipur, Dhaka. In the experiment broilers were randomly allocated into four treatments and a control group. Each dietary treatment consisted of 3 replications having 12 broilers in each of the replication. The dietary treatment consisted for 4 weeks and the treatment of various groups consisted as control (T_0) and the other four treatments were T_1 (basal feed + antibiotics), T_2 (basal feed + 0.2% cinnamon), T_3 (basal feed + 0.2% garlic) and T_4 (basal feed+ 0.2% cinnamon + 0.2 garlic). During the experimental periods of 4 weeks feed intake, body weight gain, feed conversion ratio (FCR), dressing percentage were calculated. Birds fed 0.2% cinnamon and 0.2% garlic (T_4) gained superior body weights ($1958.33^{a}\pm21.05$) compared to any other group T_0 ($1912.33^{ab}\pm16.49$), T_3 ($1896.33^{ab}\pm17.40$), T_2 ($1886^{ab}\pm21.65$) and group T_1 ($1866^{b}\pm29.01$). The average body weight gains on T_4 group at the 1st, 2nd, 3rd and 4th weeks were significantly higher ($P<0.05$) than other treatment groups. The groups fed diets containing 0.2% cinnamon and 0.2% garlic feed (T_4) had lower (best) FCR (1.30 ± 0.01) compared to group T_3 basal feed with 0.2% garlic (1.32 ± 0.02), group T_2 basal feed with 0.2% cinnamon (1.33 ± 0.01), group T_1 basal feed with antibiotic (1.33 ± 0.02) and group T_0 basal feed (1.34 ± 0.01). However, evaluation of dressing percentage on slaughtered representative birds revealed that group T_4 (57.60 ± 0.73) had significantly higher dressing percentage than group T_1 (57.56 ± 0.62), group T_0 (57.27 ± 1.27), group T_2 (56.92 ± 0.64) and lower in group T_3 (55.77 ± 0.44). It is concluded that the use of 0.2% cinnamon and 0.2% garlic in broiler diet separately or combined resulted in improved growth performance and carcass yields in broiler chicken.

Key words: Cinnamon, Garlic, Growth performance, Carcass, Broiler

CHAPTER I

INTRODUCTION

Poultry sector is one of the most important and promising industrial sector for the economic development of Bangladesh. With the advancement of time, it has transformed from backyard rearing to commercial organized, scientific and vibrant industry. Most of the poultry farmers are interested in broiler production due to its quick returns, shorter marketing age, less space requirement, and higher weight gains. With the commercialization, the use of several chemicals, antibiotics, growth promoters at sub-therapeutic levels over extended periods is also increased, which have adverse effects in poultry health and its residues in meat can make danger for human health.

Antibiotics have been supplemented in animal feed at sub-therapeutic doses to improve growth and feed conversion efficiency and to prevent infections for more than 60 years (Castanon, 2007). The continued and non-judicious use of antibiotics has led to the selection and dissemination of antibiotic-resistant strains of poultry pathogens such as Salmonella, Campylobacter and *E. coli*. The rapid spread of drug-resistant pathogens as well as emergence of antibiotic-related environmental pollutants is of global concern. Hence, the identification and development of new and effective alternatives to antibiotics that do not hinder productivity is imperative. For this, it is essential to understand not only the molecular basis of development of resistance to antibiotics but also the mechanisms of action of antibiotics alternatives (Suresh *et al*., 2017). The sub-therapeutic levels of antibiotics in growth promotion and disease prevention can increase the risk of bacteria acquiring resistance to specific antibiotics. World Health Organization (WHO, 1997) has recommended antibiotics should be phased out from the poultry diet and replaced by alternatives which do have any adverse effect on the consumers health (Bywater, 2005). Considering this, European Union (EU) already banned antibiotic growth promoters since 2006 (Castanon, 2007).

Medicinal plants (Specially herbs) have been used as food for medicinal purposes for centuries and some of them have played a significant role in maintaining human health and improving the quality of human life for thousands of years. It is not

surprising, therefore, that several herbal agents have been empirically used in poultry birds and other animals. Many herbs have a long history of their use even prehistory, in preventing or treating human and animal illnesses. However, even a single medicinal plant or herb consists of many bioactive chemical compounds and may act as a diuretic (Vohra and Khan, 1981), as an anthelmentic (Al-Khalil, 1995. In addition, nutritional substances necessary for growth and development of chicks, the feed is regularly supplemented with pharmacological products, either for preventive purposes, as preventive against certain diseases (coccidiostatics) or as growth stimulators (antibiotic), primarily in case of young chicks. During the past 50 years, the growth rate of broiler has been improved greatly. Thus, during the last decade many studies had investigated the use of new and promising feed additives including probiotics, prebiotics, enzymes, and plant extracts in animal feeding (Sarica *et al*., 2005). Spices are very common to be useful additives in broiler diets (Zhang *et al.,* 2009). The supplementation of spices and herbs could have many benefits to broiler's health and performance such as having anti-oxidative potential, antimicrobial activity (Dorman and Deans, 2000) and enhancing digestion by stimulating endogenous enzymes (Brugalli, 2003).

Cinnamon (*Cinnamomum cassia*) is a spice obtained from several trees from the genus (Cinnamomum) that is used in both sweet and savoury foods. It is a disinfectant, antifungal and antimicrobial compound. Cinnamon is known as an appetite and digestion stimulant and its antimicrobial properties are mainly related to its cinnamaldehyde, trans-cinnamaldehyde and euginol content (Toghyania *et al*., 2011). Recent studies have also shown that cinnamon powder, cinnamaldehyde alone or in combination with other essential oils had a wide array of beneficial effects in poultry. Some of those effects include increased feed intake, improved performance, feed efficiency and health status, increased breast meat yield (Al-Kassie, 2009).

Garlic (*Allium sativum*) is known as herbal medicine for the prevention and treatment of a variety of diseases ranging from infections to heart diseases (Ologhobo *et al*., 2008). Allicin–the main bioactive component of garlic may account for some effects of garlic (Toghyania *et al*., 2011). The inhibitory properties of garlic on growth of microorganism including bacteria, yeast, viruses and fungi has been documented (Kivanc and Kunduhoglu, 1997). Garlic is considered as a plant with antibiotic, anticancer, antioxidant, immunomodulatory, anti-inflammatory, hypoglycemic and

cardiovascular-protecting effects. Moreover it boost the immune system, improves body weight gain, heightens the digestibility of feed ingredients, decreases bad cholesterol and also increase the meat quality (Mansoub, 2011). Moreover, garlic has been found to lower serum and liver cholesterol (Qureshi *et al*., 1983a) and abdominal fat percentage (Ashayerizadeh *et al*., 2009). Numerous reports have been published and described the beneficial effects of garlic on growth efficiency of broilers (Kumar *et al*., 2010). Ramakrishna *et al*. (2003) suggested that garlic supplementation enhances the activity of pancreatic enzymes and provides an environment for better absorption of nutrients.

The use of cinnamon and garlic as a spice for human consumption is very common but considering the bioactive component their use in broiler diet is a new idea in Bangladesh. The effect of feeding cinnamon, garlic and their combination on broiler performance as well as its cost effectiveness under Bangladeshi condition is scanty. Moreover, to get the safe poultry products the poultry feed industry need adequate information on this aspect to augment commercial broiler production in Bangladesh. There are few studies have been carried out to investigate the effect of cinnamon and garlic on broiler performance but the results have not been consisted. These studies indicated the positive effects on growth performance, FCR, immune response and digestibility in broiler. But, the references are still limited in our country. If we implement this study successfully we hope every people in our country will able to meet the requirement of broiler meat by increasing its production. We hypothesized that cinnamon and garlic can assure as an alternative of antibiotics on broiler production in Bangladesh. Therefore, the purpose of this study is to investigate the effect of cinnamon and garlic on growth performance and carcass characteristics of broiler. Considering the above importance the present study was undertaken with the following objectives

i. To determine the growth performance and carcass characteristics of broiler meat by addition of cinnamon and garlic in broiler feed
ii. To know the suitable doses of cinnamon and garlic in broiler feed
iii. To study the feasibility of cinnamon and garlic as alternative feed additives against antibiotic for broiler

CHAPTER II
REVIEW OF LITERATURE

The antibiotic has been used as growth promoters in poultry production since the 1950s. The positive effects of antibiotic as a growth promoter in broilers were first described by Moore *et al*., (1946). Antibiotic growth promoters have undoubtedly improved animal growth, feed consumption, and stabilization of animal health status. But due to some adverse effects antibiotics have been under scrutiny for many years and already banned in many countries. From January 2006, European Union fully banned the use of antibiotic in animal and poultry feed (Castanon, 2007). In Bangladesh some antibiotic has already been banned. In this situation, scientists, feed manufacturers and the animal growers have been actively searching for safe alternatives.

Today considering the safety aspect of the products prebiotic, probiotic, enzymes, medicinal plants, several herbs, spice etc. are being used as alternative safe feed additives in poultry diet as well as human health. This summarization of published information assesses the effects of using different medicinal plants with special emphasis on cinnamon and garlic.

2.1 Alternatives to the use of antibiotics

The use of antibiotic growth promoters (AGPs) as sub-therapeutic level in animals and poultry caused consequent appearance of resistance to that particular antibiotic among several pathogenic bacteria (Rerksuppaphol *et al.,* 2003 and Zhao *et al.,* 2003). Cervantes (2004) stated that scientific evidence of antibiotic resistance in food animals is associated with resistance infections in humans. Harmful effects of antibiotic use and the ban of antibiotics in EU have prompted researchers to think about alternatives to antibiotics (Diarra and Malouin, 2014). The aim of these alternatives is to maintain a low mortality rate, a good level of animal yield while preserving environment and consumer health. Much research has been carried out to look for natural agents with similar beneficial effects of growth promoters. There are a number of non-therapeutic alternatives that can substitute antibiotics use. Among these, the most popular are probiotics, prebiotics, enzymes, organic acids, immunostimulants, bacteriocins, phytogenic feed additives, phytocides, nanoparticles

and essential oils. The possible adverse effect of using antibiotics to human health was first reported by Swann (1969). It was mentioned that the probable hazard to human health was from feeding sub-therapeutic levels of antibiotics to food producing animals. Antibiotic resistance genes may be transferred from animal pathogens or commensals to human pathogens (Van den Bogaard and Stobberingh, 1999; 2000). Several reports (WHO, 1998, MAFF, 1998) described the link between antibiotic use in animals and the development of resistance in human pathogens. Gold and Moellering (1996) stated that the majority of human antibiotic resistance problems have connection with use of antibiotics in animals.

2.2 Antibiotic impact on chicken growth, digestive tract and immune systems

The poultry industry uses antibiotics to improve meat production through increased feed conversion, growth rate promotion and disease prevention. Antibiotics can be used successfully at sub-therapeutic doses in poultry production to promote growth (Barcelo, 2007, Chattopadhyay, 2014, Engberg *et al.*, 2000, Harms *et al*., 1986, Khodambashi Emami, 2012, Rosen, 1996) and protect the health of birds by modifying the immune status of broiler chickens (Lee *et al*., 2012). A change in the intestinal microbiota of chickens can influence their immunity and their health. However, changes in the intestinal micro biota of chickens can be influenced by several factors. These factors include housing conditions, exposure to pathogens, diet composition and the presence of antibiotics in feed (Lee *et al*., 2012).

2.3 Herbs and herbal products

Herbs and herbal products may be used as the safer alternatives to antibiotics. They have no residual effect like antibiotic, minimum health hazard, lower production cost and very low chance of toxicity so can securely be used to produce safe food. Therefore, herbs and organic acid have received an increased attention as an alternative to antibiotics (Craig, 1999, Ricke, 2003). In India several biological trials of certain herbs and herbal products show encouraging results of improvement of weight gain, feed efficiency, lowered mortality, increased immunity and increased livability in poultry birds (Kumar, 1991; Hassan *et al*., 2004). Huang *et al*. (1992) concluded that the Chinese medicinal herbs have a stimulating effect on growth of broilers. Herbal natural feed additives such as oregano, garlic and cinnamon as

alternatives to an antibiotic growth promoter in broiler production (Demir *et al*., 2005).

2.4 Cinnamon

(*Cinnamomum zeylanicum*) commonly known as "dalchini" is one of the oldest medicinal plants and widely used as condiment in India. It is a valued spice which is being used all over the world. *C. zeylanicum* is indigenous to Sri Lanka and South India (Jakhetia *et al.,* 2010). Various parts of the cinnamon are widely used Ayurvedic and ethnomedicine. Cinnamon is mainly used in the aroma and essence industries due to its fragrance, which can be incorporated into various foodstuffs, perfumes and medicinal product (Huang *et al*., 2007).

The dietary supplementation of cinnamon in poultry feed as a natural feed additive has beneficial impacts on nutrient digestibility, hypocholesterolaemic, blood biochemical profile, gene expression, immunity, and particularly on gut health to alleviate the impact of disease and heat stress by maintaining water and electrolytic balance and feed intake. It is clearly demonstrated that cinnamon can be used as an alternative to antibiotics in the poultry industry offering greater animal health, food safety, and economic aspects of poultry production. In recent years, cinnamon (one of the most widely used spices) has attracted attention from researchers as a natural product with numerous health benefits for poultry. The principal chemical constituents of cinnamon are cinnamaldehyde, transcinnamaldehyde (Cin) and euginol, which are present in the essential oil and contribute to the fragrance and various biological activities (Chang *et al.,* 2013). One of the major constituents of essential oil extracted from *C. zeylanicum* named (E)-cinnamaldehyde has an anti-tyrosinase activity (Marongiu *et al.,* 2007), while cinnamaldehyde is the principle compound responsible for this activity (Chou *et al.,* 2013). Cinnamon bark contains procyanidins and catechins (Nonaka *et al*., 1983). Cinnamon consists of a variety of resinous compounds, including cinnamaldehyde, Cinnamate, Cinnamic acid and numerous essential oils (Senanayake *et al*., 1978). The presence of a wide range of essential oils such as transcinnamaldehyde, cinnamyl acetate, euginol, Lborneol, Caryophyllene oxide, b-caryophyllene, Lbornyl acetate, E-nerolidol, a-thujene, has been reported (Chang *et al*., 2008).

2.5 Utilization of cinnamon in poultry feed

Cinnamon is one of the PFAs that have been approved for inclusion in poultry feed by the US Food and Drug Administration (FDA). Since 2000, bioactive compounds including EOs, cinnamaldehyde, phenolic compounds and others have been included in poultry feed to improve immunity, metabolism, health, growth performance, carcass traits and meat quality. The bioactive compounds of cinnamon have potent anti-inflammatory, anti-microbial and antioxidant properties with free radical scavenging actions and strong inhibitory effects. Cinnamon bioactive compounds can disrupt the growth of pathogenic microbes and stimulate the growth of commensal bacteria in the intestinal tract of poultry birds.

2.6 Impact of cinnamon on the digestibility of nutrients

Improved utilization of feed improves the feed conversion ratio (FCR), body weight gain (BWG) and overall health performance of broiler chicken. The stabilization of the gut microbiota ecosystem and the stimulation of digestive enzymes secretion are the two well-accepted mechanisms that play a leading role in improving feed utilization and inhibiting the growth-depressing ailments related to metabolism and digestion. The potential impacts of CNO on the secretion of digestive enzymes from the intestinal mucosa and pancreas. These positive impacts had been confirmed to improve the digestibility of nutrients. Additionally, the bioactive compounds of cinnamon affect lipid metabolism by transporting the fatty acids in the digestive tract of broilers. The CNO has positive effects on the secretion of digestive enzymes and improves the digestibility of nutrients in the gut. Cinnamaldehyde is considered a digestion stimulating agent which enhances the digestive system of broiler chicken. For example, cinnamaldehyde increased the activity of pancreatic and intestinal enzymes by provoking the secretion of salivary glands, which ultimately improved the digestion of broiler chickens.

2.7 Effect of cinnamon on body weight and growth rate of chicken

Lee *et al*. (2003) found that the feeding of cinnamaldehyde did not affect growth performance, micronutrient digestibility or plasma lipids in female broiler chickens. Lee *et al*. (2004) reported that the addition of cinnamon to the diet of broilers improved their growth performance. Mull and Liebert (2007) found no significant effects of 2 commercial PFA containing 5.0% carvacol, 3.0% cinnamaldehyde and

2.0% capsicum oleoresin, or the alkaloids sanguinarin and chelerythrin on the growth performance in broiler chickens. Chang *et al*. (2008); Park (2008) reported that cinnamon extract supplementation had significantly higher daily gain and lower feed to gain ratio. Al-Kassie (2009) found positive effect of ground thyme and cinnamon on the live weight gain and improvement of the health of broiler chickens, in addition to the other performance traits, feed conversion ratio and feed intake. Al-Kassie (2009) reported that chicks fed with 200 ppm EO derived from thyme and cinnamon had significantly (P0.05) on cholesterol, triglyceride, low density lipoproteins (LDL), abdominal fat, gizzard and heart weights and on breast protein percentage.

Koochaksaraie *et al.* (2011) reported that addition of cinnamon at 500 to 2000 mg/kg diet had no effect on growth of the broiler chicken. Toghyani *et al*. (2011) reported that dietary inclusion of cinnamon @ 2 g/kg diet improved body weight significantly and suggested that it could be as alternative to antibiotic growth promoters in broilers.

Ebrahimi *et al*. (2013) found that the body weight of the broilers was significantly higher in the group supplemented with cinnamon diet. Sang Oh *et al*. (2013) reported that growth performance and meat quality improved significantly when diets were supplemented with 3.0, 5.0 and 7.0 percent of cinnamon powder compared to the control birds. Sampath and Atapattu (2013) found that supplementation of cinnamon powder had no effect on final live body weight of the broiler chickens. Najafi and Taherpour (2014) found that the inclusion of ginger (*Zingiber officinale*) and cinnamon (Cinnamomum) in addition to the broiler diet enhanced the growth and could also improve the health statue. Safa-Eltazi (2014) reported that dietary inclusion of cinnamon at 5.0% had significantly ($p>0.05$) higher body weight gain, feed intake and best feed conversion ratio. Singh *et al*. (2014) reported that the dietary inclusion of cinnamon might improve the growth performance of broilers. Shirzadegan (2014) observed that supplementing different concentrations of cinnamon powder in the diet (especially at a level of 0.50%) increased the final body weight of broiler chickens.

2.8 Effect of cinnamon on feed intake and feed conversion efficiency of chicken

Hernandez *et al*. (2004) reported no difference in the feed intake or FCR in broilers fed 200 mg/kg of diet with essential oils extracted from oregano, cinnamon and pepper or 5000 mg/kg of diet with a labiates extract from sage, thyme and rosemary.

Jamroz *et al*. (2005) showed that the supplementation of feed mixtures with plant extract consisting of capsaicin, cinnamaldehyde and carvacrol improved feed conversion by 4.1% with a maize diet and 2.0% with a wheat and barley diet, whereas the BW was not affected. Garcia *et al*. (2007) reported that the dietary supplementation with a blend of oregano, cinnamon and pepper essential oil (200 ppm) improved the FCR (0-42 days). Al-Kassie (2009) study showed that the supplementation of 200 ppm oil extract derived from thyme and cinnamon in broiler diets significantly improved the live weight gain and feed conversion ratio during a growing period of 6 weeks. Toghyani *et al*. (2011) found no difference in feed intake and FCR of broilers after the dietary incorporation of cinnamon powder. Sampath and Atapattu (2013) found that supplementation of dietary cinnamon powder tends (P=0.09) to increase the feed intake and feed conversion ratio (FCR) but had no effects on final live weight, weight gain, visceral organ weight, and gizzard, cloaca and total fat contents or serum cholesterol level.

2.9 Effect on carcass traits and organ weight of chicken

Lee *et al*. (2003) reported no significant differences in the internal organs of the broiler chickens when incorporated with cinnamaldehyde (100 ppm.) Hernandez *et al*. (2004) concluded that the Labiatae extract and the blend of carvacrol, cinnamaldehyde and capsaicin improved the digestibility of the feeds but no effects were noted on organ weight. Garcia *et al*. (2007) observed that a blend of oregano, cinnamon and pepper oil (200 ppm) had no influence on carcass weight of broilers. However, breast weight (% of carcass) appeared to increase after the incorporation of a plant extract based on a blend of clove and cinnamon oil (100 ppm). Byung-Sung (2008) reported that the sensory evaluation of the taste and savour in fried and boiled chicken meat were better from broiler chicken fed with diets containing cinnamon powder. Al-Kassie (2009) found that different levels of oil extract derived from thyme and cinnamon had significant effects on dressing percentage, abdominal fat, and internal organs percentage (liver, heart and gizzard). Ciftci *et al.* (2009) reported that supplementation of cinnamon oil (500, 1000 ppm) in diet decreased the cholesterol levels of serum and chicken meat. But they also suggested that dietary cinnamon supplementation would improve the nutritional quality of chicken meat as cinnamon oil plays an important role as an endogenous antioxidant and could be applicable as a protective agent against tissue damage. Stefan *et al.* (2009) did not observe any effect

of cinnamon on the concentration of MDA in the liver and kidney tissues. Koochaksaraie *et al*. (2011) revealed that supplementation of cinnamon powder at the dose of 250 to 2000 mg/kg broiler diets did not have any influence on the carcass parameters. Toghyani *et al.* (2011) observed no impact of diets on carcass parameters supplemented with 2 and 4 g/kg of cinnamon powder in broilers. He also found that the sensory evaluation showed no change in meat flavour and odour intensity or desirability after the dietary supplementation.

Sang-Oh *et al.* (2013) reported that dietary supplementation of cinnamon powder at 5 percent level to broilers improved the quality of chicken meat including colour, flavour, texture and overall acceptability and shelf life. SafaEltazi (2014) reported that the broiler chicken fed with cinnamon showed significantly (P0.05) on cholesterol, triglyceride, low density lipoproteins (LDL), abdominal fat, gizzard and heart weights and on breast protein percentage.

2.10 Garlic

Garlic is considered as potent natural antibiotic and known as performance enhancer. Garlic and its preparations have been widely recognized as the agents for prevention and treatment of cardiovascular and other metabolic diseases, atherosclerosis, hyperlipidemia, thrombosis, hypertension and diabetes (Avato *et al*., 2000; Lutomski, 2001; Kleczkowski *et al*., 2004; Turek, 2006). The medicinal effects of garlic come from the sulfur containing compounds; high trace mineral content, and enzymes. Several scientific publications reported its benefits in animals, reducing total cholesterol and triglyceride (fat) concentrations and increase high density lipoproteins (HDL) in the blood and also an antithrombotic effect (Mansell and Reckless, 1991). Many papers indicate the positive effects of garlic as it enhance feed intake (Elagib *et al.,* 2013), feed utilization (Issa and Omar, 2012), feed conversion (Onyimonyi *et al.,* 2012), average daily weight gain (Horton *et al.,* 1991), carcass percentage, meat quality (American heart association, 1986; Ibrahiem *et al*., 2004; Onibi *et al*., 2009), reduce mortality rate (Tollba and Hassan, 2003). It also has the positive hypocholesterolemic effect, antimicrobial effect, immunological effect in broiler. But, effectiveness of garlic bulbs or garlic preparation additives to diet depends on bioactive components content, its daily intake or doses in feed.

2.11 Medicinal properties of Garlic

An Indian proverb says, garlic is "as good as ten mothers" (Belsinger *et al*., 1993). In this single sentence we can understand the medicinal value of garlic. Garlic (*Allium sativum*) is one of the earliest of cultivated plants originated from central Asia and now cultivated throughout the world but heavily in the Mediterranean and Asia (Brewster, 2008). It is a member of the Liliaceae family. People are more commonly seeking natural health care products, there has been extensive research done on garlic for its roles as a broad-spectrum antimicrobial, antioxidant and for its overall effects on the cardiovascular system (Block, 2010). Garlic contains at least 33 sulfur compounds, several enzymes, 17 amino acids, and minerals such as selenium (Newall *et al*., 1996). It contains a higher concentration sulfur containing bioactive component like alliin, allicin, ajoene, diakylpolysulphides, S-allylcysteine, diallydisulphide (Onu, 2010). This sulfur compounds are responsible for many of its medicinal effects. Allicin, which was first chemically isolated in the 1940's, has antimicrobial effects against many viruses, bacteria, fungi and parasites (Bradley, 1992).

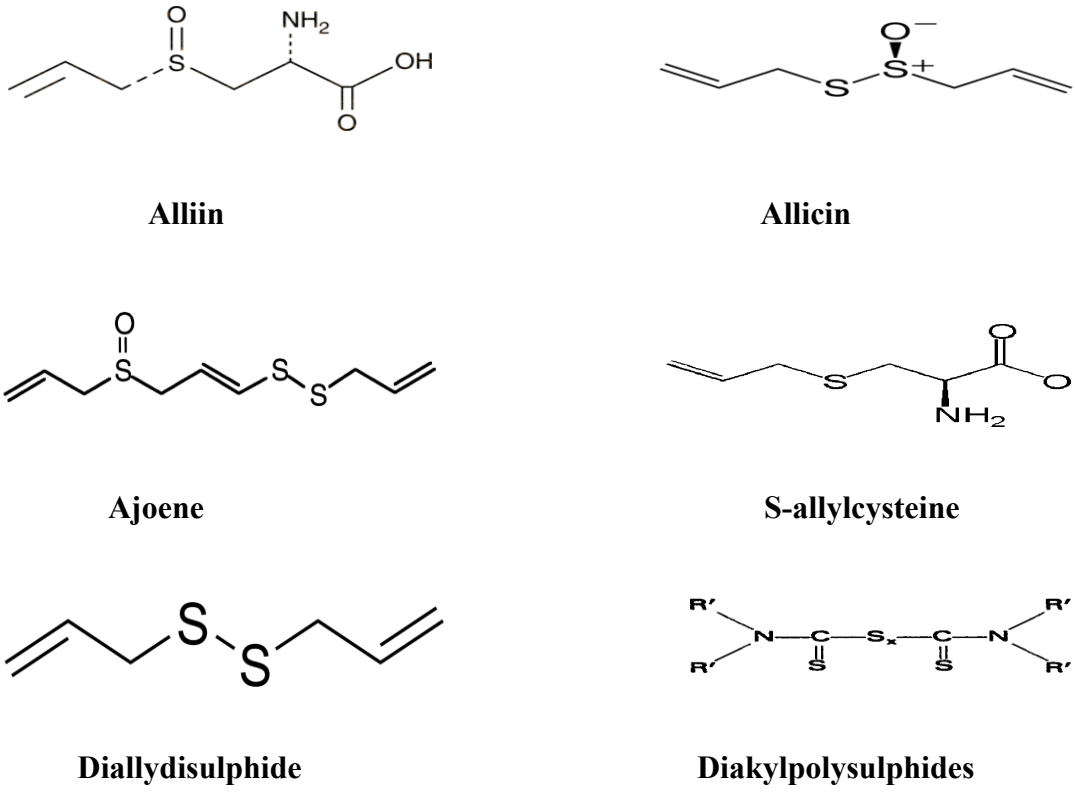

Figure 1: Major bioactive component of garlic

Approximately 1% alliin (S-allyl cysteine sulfoxide) is contained in dried, powdered garlic (Anonymous, 1997). Allicin (diallylthiosulfinate or diallyldisulfide) the most biologically active compounds activate by the enzyme allinase when crushed or cut and metabolize alliin to allicin (Block, 1985). Allicin is then metabolized to vinyldithiines. This breakdown occurs within hours at room temperature (Blania *et al.,* 1991). Aged garlic, garlic oil and steam distilled garlic do not contain significant amounts of aliin or allicin, but instead contain various products of allicin transformation; none appears to have as much physiologic activity as fresh garlic or garlic powder (Miething, 1988 and Lawson *et al*., 1991).

2.12 Antimicrobial effect of garlic

Garlic is nick named Russian penicillin for its wide spread use as a topical and systemic antimicrobial agent (Adetumbi and lau, 1983 and Agarwal, 1996). Allicin a garlic derived sulfur-containing compound has antimicrobial effects in vitro against many viruses, bacteria, fungi and parasites (Elnima *et al*., 1983). Crude garlic extracts have effect against both gram negative (*E. coli, Proteus spp, Salmonella, Citrobacter, Enterobacter, Pseudomonas*) and some gram positive (*Staphylococcus aureus)*, *Streptococcus pneumoniae*, *Streptococcus sanguis*) bacteria at room temperature but there were no significant effects if the garlic had been boiled for five minutes before testing (Sharma *et al*., 1977 and Farbman *et al*., 1993). Ajoene, shows antimicrobial activity against gram-positive bacteria, such as *Bacillus subtilis, Mycobacterium smegmatis, Staphylococcus aureus and Lactobacillus plantarum* and against gram-negative bacteria, such as *Escherichia coli*. Allicin also have some activity against *Salmonella typhimurium*, primarily by interfering with RNA synthesis (Feldberg *et al*., 1988). When chickens were supplied with garlic, there was a marked reduction in the viable count of gram negative fecal bacteria within 24 hours (Sharma *et al*., 1977). There was a comparative study on raw garlic extract and tetracycline hydrochloride in equal concentrations against rats' fecal flora showed the raw garlic extract to be a more potent antimicrobial agent than tetracycline (Shashikanth *et al*., 1984). Garlic has demonstrated antifungal effects in chicken (Prasad and sharma, 1980, Olobatoke and Mulugeta, 2011). Kassab and Kamal (2009) compared the effect of supplementation of black seed 1.0%, Garlic 1.0% and antibiotic (Enrofloxacin) in *E. coli* inoculated broiler bird and got no significant differences in mortalities and animal species (Block, 1985; Lovatto *et al*., 2005; Tatara *et al*., 2005).

2.13 Hypocholesterolemic effect of garlic

Research results showed that garlic and its preparation have the effect on lowering blood cholesterol levels in animals (Aouadi *et al*., 2000; Yeh and liu, 2001). It was suggested that garlic may decrease cholesterol (CHO) and triglyceride (TG) levels in patients with increased levels of these lipids (Zhang *et al*., 2001). In chickens diets supplemented with garlic powder had significant reductions of plasma and tissue cholesterol and plasma triacylglycerols. Garlic supplementation also significantly decreased 3-hydroxy-3-methylglutaryl reductase activity and cholesterol 7 alpha-hydroxylase activity (Konjufca *et al*., 1997). Prasad *et al*. (2009) reported that garlic can prevent fat induced hyperlipemia. Zavaragh (2011) from an investigation with Japanese quail observed that 2.0% garlic powder with basal diet decrease cholesterol and triglyceride. Horton *et al*. (1991) mentioned that inclusion of dried garlic in different level reduced the plasma cholesterol and plasma HDL concentration up to 10%. Choi *et al*. (2010) evaluated the effects of supplementing diets with garlic powder and *α*-tocopherol on performance, serum cholesterol levels and meat quality of chickens. The results suggested that increasing the levels of garlic powder and applying garlic powder plus *α*-tocopherol significantly decreased total cholesterol and low-density lipoprotein and increased high-density lipoprotein in broiler blood. The result also indicated 5.0% garlic powder or 3.0% garlic powder plus 200 IU of α-tocopherol antioxidant properties were effective for enhancing lipid and color stability. Issa and Omar (2012) investigated that the garlic powder had no significant effects on broilers weight gain, feed intake, feed conversion ratio, carcass cuts, visceral organs. However, it decreased cholesterol, triglyceride, LDL and increased HDL levels compared to control birds. Onyimonyi *et al*. (2012) evaluated the growth and hypocholesterolemic properties of broiler and concluded that incorporation of sun-dried garlic powder in the diets results in better performance, reduced serum cholesterol and further maintains haematological and serum chemistry integrity of the birds. They compared 0.25, 0.50 and 0.75% garlic with control diet and get significant gradual decrease of cholesterol. Bamidele and Adejumo (2012) revealed that garlic and ginger mixtures at the supplemented levels significantly reduced the total cholesterol and Low-Density Lipoprotein (LDL) of the growing pullets. They also mentioned that diets containing 1.00% garlic and 0.50% ginger mixtures and 2.00% and 0.75% ginger mixtures had the best results for total cholesterol and LDL of the

growing pullets. Mansoub (2011) noticed that the amount of total cholesterol and triglyceride (TG) in the serum did show significant differences, but HDL and LDL were not significantly different among control, 1.0% garlic, and 1.0% probiotic group.

Chowdhury *et al*. (2002) evaluated the sun-dried garlic paste on performance and serum and yolk cholesterol concentration in six strain of laying hen. They observed average serum cholesterol concentration decreased by 15.0, 28.0, 33.0, and 43.0% when the hen fed 2.0, 4.0, 6.0 or 8.0% garlic paste, respectively; no further reduction with 10% dietary garlic paste was observed. In case of egg cholesterol the average egg cholesterol content reduced by 5.0, 9.0, 14.0, 20.0, 24.0% respectively and maximum 32.0% reduction was noted from hens fed 10.0% garlic paste for six weeks. Qureshi *et al*. (1983b) confirmed that garlic oil and odorous components of garlic lower cholesterol levels. An odorless water-soluble component of garlic also has the same effect. The mechanism of the hypocholesterolemic action is at the level of the suppression of cholesterol biosynthesis.

2.14 Effect of garlic supplementation on broiler chickens

Although dietary supplementation of garlic powder in chickens feed has been widely used, their application effects are different. Broiler fed the different levels of garlic (*Allium sativum*) powder (1.5%, 3.0%, and 4.5%) did not show improved body weight gain (BWG) or feed conversion ratio (FCR) (Konjufca, Pesti & Bakalli, 1997). Addition of garlic did not influence average feed intake, weight gain and FCR of chickens, but reduced abdominal fat contents (Onibi, Adebisi 2009). Ao *et al*. (2010) revealed that fermented garlic powder increased white blood cells and lymphocyte counts, decreased cholesterol and cortisol in blood, but had no significant effect on BWG and FCR in broilers. However, Horton, Blethen (1991) added dried garlic (0.01%, 0.1% and 1.0%) to broiler diets and found that average daily gain increased at the two intermediary levels of garlic (0.01% and 0.1%) during the first 21 days. A previous study also found supplementation of 1.0% garlic significantly improved the BWG of broilers and could be a practical alternative to antibiotics in the feeding of broiler chicken (Karangiya *et al*., 2016). Dietary supplementation of allicin has been found to enhance antioxidative capacity and reduce blood lipid level in chickens (Gong-chen *et al*., 2014). Elmowalid *et al.* (2019) also suggested promising and useful insights into dietary garlic supplementation in broilers, which may protect consumers against antibiotic residues or toxic metabolites and lower the risk of

infection with bacterial pathogens. Present investigations demonstrate that supplementation of diets fed to broilers with by-products of garlic can enhance growth performance and antioxidative capacity, reduce the amount of cholesterol and cortisol in blood serum, besides the impact on FCR (Jang *et al*., 2018).

2.15 Research gap and scope of present investigation

Natural herbal products alternative to antibiotic growth promoters are used in order to maintain both bird performance and health (Cross et al., 2007). The use of cinnamon and garlic as a spice for human consumption is very common but considering the bioactive component their use in broiler diet is a new idea in Bangladesh. Literature on the effect of feeding cinnamon, garlic and their combination on broiler performance as well as its cost-effectiveness under Bangladesh condition are scanty. To get the safe poultry products, the poultry feed industry needs adequate information on this aspect to augment commercial broiler production in Bangladesh. Therefore the proposed study was attempted to generate more information on the effects of this two medicinal plants singly or in combination on broiler performance.

CHAPTER III

MATERIALS AND METHODS

3. 1 Statement of the experiment

The research work was conducted at Sher-e-Bangla Agricultural University, Poultry Farm, Dhaka, with 180 one day-old commercial broiler chicks Lohman Meat (Indian River) for a period of 28 days from 25th July to 22th August, 2022 to assess the potential of using cinnamon and garlic in commercial broiler diet on growth performance and carcass traits of broilers. The experiment was performed by applying different levels of cinnamon and garlic with the basal diet.

3.2 Collection of experimental broilers

A total of 180 one day-old Lohman Meat (Indian River) broiler chicks were collected from Kazi farm limited hatchery, Gazipur, Dhaka.

3.3 Experimental materials

The chicks were collected from Kazi Hatchery and carried to the university poultry farm early in the morning. The chicks were supplied glucose water with vitamin-C to drink for the first 3 hours to overcome dehydration and transportation stress. Then collected chicks were kept in electric brooders equally for 7 days by maintaining standard brooding protocol. During brooding time only basal diet was given no cinnamon and garlic was used as treatment. After successful brooding the chicks were distributed randomly five treatments with three replications of 12 chicks in each. After 28 days of nursing and feeding, data were collected for the following parameters: feed intake, live weight, body weight gain, feed conversion ratio, carcass characteristics.

3.4 Experimental treatments

The cinnamon and garlic was mixed properly with commercial dietary feed at three different level. The experimental treatments were followings

T_0 = Basal feed (Basal feed refers to feed that are high in energy)

T_1 = Basal feed + Antibiotic (Doxivet powder)

T_2 = Basal feed + 0.2% Cinnamon

T_3 = Basal feed + 0.2% Garlic

T_4 = Basal feed + 0.2% Cinnamon + 0.2% Garlic

Table 1: Layout of the experiment

Treatments	Arrangement of Treatments	Replications			Total Number of Birds
		1	2	3	
T_0	Basal feed	12 birds	12 birds	12 birds	36
T_1	Basal feed + Antibiotic	12 birds	12 birds	12 birds	36
T_2	Basal feed + 0.2% Cinnamon	12 birds	12 birds	12 birds	36
T_3	Basal feed + 0.2% Garlic	12 birds	12 birds	12 birds	36
T_4	Basal feed + 0.2% Cinnamon + 0.2% Garlic	12 birds	12 birds	12 birds	36
	Grand Total	**60**	**60**	**60**	**180**

3.5 Collection of experimental cinnamon and garlic powder

For the experiment, Pran company cinnamon and garlic powder was collected from Super shop. It was easy to collect cinnamon and garlic powder because of its availability in the market of our Bangladesh. Then mixed cinnamon and garlic powder with feed into each treatment with the given proportion in a bowl without control and antibiotic treatment every week and served that mixed feed to the broiler chicken.

3.6 Preparation of experimental house

An open sided shed type house was selected for the experiment. The experimental house was properly cleaned and washed by using tap water. Ceiling, walls, floor, feeder and waterer were thoroughly cleaned and disinfected by using bleaching powder. At the same time, all feeders, plastic buckets waterers and other necessary equipments were cleaned properly, washed and disinfected with phenyl solution and subsequently dried and left empty for a week before the arrival of chicks. Electric fans were repaired for lighting and air flow respectively and to create a favorable environment for birds. A digital hygrometer was hanged on the wall of cage for recording temperature of the shed. The house was divided into 15 pens of equal size using wood materials after proper drying. A group of 24 birds were randomly shifted to each pen of the 5 treatments. One feeder and one waterer were distributed each pen.

The stocking density was 1 m² /10 birds. Foot bath was placed in front of the house to maintain biosecurity.

3.7 Experimental diets

Starter and grower commercial Kazi broiler feed were purchased from the market. Starter and grower diet was enriched with following elements

Table 2: Chemical composition of diet

Parameters	Starter ration (0-14) days	Grower ration (15-28) days
ME (kcal/kg)	3000	3150
Protein %	21.0	19.0
Fiber %	5.0	6.0
Lysine %	1.20	1.10
Methionine %	0.50	0.47
Cysteine %	0.40	0.39
Tryptophan %	0.19	0.18
Threonine %	0.79	o.75

Source: Kazi Feed, 50 kg feed packet

The feeding program was divided into two phases including starter and grower diets that was fed from 0 to 14 days and 15 to 28 days respectively.

3.8 Management procedures

Feed intake and body weight were recorded every week. Survivability was recorded for each replication up to 28 days of age. The following management procedures were followed during the whole experiment period and these management practices as were same for all dietary groups.

3.8.1 Brooding of baby chicks and lighting program

The highest brooder temperature was 38.5 °C and lowest 27.5 °C. The highest relative humidity was 99% and lowest 55% in the poultry house. Electric brooder was used to brood chicks. Due to hot climate brooding temperature was maintained as per

requirement. Brooding temperature was adjusted (below 35°C) with house temperature. So, when the environmental temperature was above the recommendation, then no extra heat was provided. At day time only an electric bulb was used to stimulate the chicks to eat and drink. In brooding extra heat was not provided at day time except mid night to morning. Electric fans were used as per necessity to save the birds from the heat stress. Partitioning brooding was done due to different experimental treatment. Each brooder had one hover and a round chick guard to protect chicks and four portioning chambers. Sometimes day temperature was 27.5 °C to 38.5 °C. So, at that time there was no need of extra heat to brood the baby chicks, but at night a 100-watt bulb was used in each pen to rise up low temperature according to heat requirement of brooding schedule. The brooding temperature was checked every 2 hours later by digital thermometer to maintain the temperature of the brooder. For the first 4 days, lighting program will be 24 hours of light and then stepwise lowered to 21 hours of light and 3 hours of dark. The birds were grouped in five treatments.

3.8.2 Room temperature and relative humidity

Daily maximum and minimum room temperature and humidity were recorded with the digital hygrometer. Average room temperature and percentage of the relative humidity for the experimental period were recorded and collected in a fixed time every day.

Table 3: Average temperature and humidity

Week	Date	Temperature (°C)		Humidity (%)	
		Average Max.	Average Min.	Average Max.	Average Min.
1st	25.07.22-01.08.22	34.74	29.23	95.86	63.29
2nd	02.08.22-08.08.22	32.90	28.01	99.00	70.86
3rd	09.08.22-15.08.22	32.27	27.53	96.71	66.57
4th	16.08.22-22.08.22	32.26	27.27	96.43	70.00

3.8.3 Feeding and water management

Crumble feed size 2.5 mm diameter was used as starter (0-2 wks.) and pellet feed size 3 mm diameter for grower (3-4 wks.) ration. *Ad libitum* feeding was allowed for rapid growth of broiler chicks up to the end of the four weeks. Fresh clean drinking water was also supplied *Ad libitum*. Feeds were supplied 3 times: morning, noon and night. Water was supplied two times daily: morning and evening. Left over feeds and water were recorded to calculate actual intake. Digital electronic balance and measuring plastic cylinder was used to take record of feed and water. Daily water consumption (ml) and weekly feed consumption (gm)/bird were calculated to find out weekly and total consumption of feed and water. All feeders and drinkers were washed and sun-dried before starting the trial. One plastic made round feeder and one drinker were kept in the experimental pen. Feeder and drinker size were changed according to the age of the birds. Feeders were washed at the end of the week and drinkers once daily.

3.8.4 Litter management

Fresh, clean and sun dried rice husk was used as shallow litter to absorb moisture from fecal discharge of broiler chicken. The shallow litter was at a depth of 6 cm on floor. About 250g calcium oxide powder was mixed with rice husk in every pen as disinfectant. At the end of each week the litter was harrowed to prevent accumulation of toxic gases and to reduce moisture and parasite infection. After 3 weeks of age droppings were cleaned from the surface level by removing a thin layer of litter and same amount new litter was placed in each pen.

3.8.5 Lighting

At night there was provision of light in the broiler house to stimulate feed intake and rapid body growth. Four (4) energy lights were provided to ensure 24 hours light for first 2 weeks. Thereafter 23 hours light and one-hour dark were scheduled up to marketable age. At night one-hour dark was provided in two times by half an hour.

3.8.6 Ventilation

The broiler shed was south facing and open-sided. Due to wire-net cross ventilation was easy to remove polluted gases from the farm. Besides, on the basis of necessity ventilation was regulated by folding polythene screen. The open space around the farm were favorable for cross ventilation.

3.8.7 Biosecurity measures

To keep disease away from the broiler, farm the following vaccination, medication and sanitation program was undertaken. Recommended vaccination, sanitation program was performed in the farm and which help to prevent the disease from the farm. All chicks were provided Vitamin A, D, E, K, Vitamin-C, Vitamin-B Complex, Calcium and electrolytes.

3.8.8 Vaccination

Vaccines were collected from medicine shop (Ceva company) and provided to the birds according to the schedule Table 4.

Table 4: The vaccination schedule

Age of birds	Vaccine	Name of vaccine	Route of administration
3 days	Infectious Bronchitis+ Newcastle Disease	CEVAC BI L Vaccine	One drop in one eye
12 days	Gumboro	CEVAC IBD L Vaccine	One drop in one eye
17 days	Gumboro (Booster)	CEVAC IBD L Vaccine	Drinking water
22 days	Newcastle Disease	CEVAC NEW L Vaccine	Drinking water

3.8.9 Medication

Medicine were collected from medicine shop and offered to the birds according to the schedule. The medication schedule is given in Table 5.

Table 5: The medication schedule

Medicine	Composition	Dose	Period
B-Com-Vit	Vitamin B-complex	2-5ml/1L water	3-5 days (all groups)
AD3E	Vitamin A, D & E	1 ml/5L water	3 -5 days (all groups)
Electromin powder	Electrolytes	1g/2L water	4 -5 days (all groups)
Revit-C	Vitamin-C Premix	1g/5L water	4 -5 days (all groups)
Doxivet Powder	Doxicycline Hyclate USP	1g/2L water	4-5 days (T_1 antibiotic group)
Calplex	Calcium, Phosphorus and Vitamin D	10 ml/100 bird	3-5 days (all groups)

3.8.10 Sanitation

Proper hygienic measures were maintained throughout the experimental period. Cleaning and washing of broiler shed and its premises were under a routine sanitation work. Flies and insects were controlled by spraying phenol and lysol to the surroundings of the broiler shed. The attendants used farm dress and shoe. There was a provision of wearing polythene shoe at the entry gate of the broiler shed to prevent any probable contamination of diseases. Strict sanitary measures were followed during the experimental period.

3.8.11 Determination of proximate components

Proximate components of cinnamon and garlic for dry matter, crude protein and ash were estimated according to the methods of AOAC (2023).

3.8.12 Recorded parameters

The temperature and relative humidity was measured in everyday at 7:30 a.m. Besides weekly feed consumption, weekly live weight and death of chicks were recorded to calculate mortality percentage. FCR was calculated from final live weight and total feed consumption per bird in each replication. After slaughter liver, heart, spleen, proventriculus, gizzard, thigh, drumstick, back, wing and intestine were measured from each broiler chicken. Dressing yield was calculated for each replication to determine the dressing percentage.

3.9 Data collection and record keeping

Following records and calculated data were kept throughout the experimental period.

3.9.1 Live weight

Birds were weighed at the first day of experiment (initial body weight) and weekly basis for all birds from each replication. Average body weight gain of the broiler in each replication was calculated by deducting initial body weight from the final body weight.

3.9.2 Feed consumption

The amount of feed consumed by the birds in each replication of each treatment groups were calculated for every week by deducting the amount of leftover feed from the amount supplied for the particular week.

3.9.3 Feed Conversion Ratio (FCR)

Feed conversion ratio was calculated as the unit of feed consumed per unit of body weight gain. The feed conversion ratio was calculated as follows

$$\text{FCR} = \frac{\text{Feed intake (kg)}}{\text{Weight gain (kg)}}$$

3.9.4 Mortality of chicks

Daily death record for each replication was counted till 28 days to calculate the mortality.

$$\text{Mortality rate} = \frac{\text{Total number of death}}{\text{Number of birds present in house}} \times 100$$

3.9.5 Determination of dressing percentage

Three birds were taken randomly from each replication at the 28th days of age and slaughtered to calculate dressing percentage of broiler chicken. All birds were slaughtered by halal method with knife. All the live birds were weighed before slaughter. Birds were slaughtered by severing jugular vein, carotid artery and the trachea by a single incision with a sharp knife and prefer to complete bleed out at least for 2 minutes. Outer skin of the broiler chicken was removed by sharp scissor and hand. Then the carcasses were washed manually to remove loose feathers and other foreign materials from the carcass. Then the carcass was eviscerated and dissected. Liver and heart were removed from the remaining viscera and then the gall bladder was removed from the liver. Then the gizzard was removed. Lastly dressing yield was calculated by subtracting feathers, blood, head, shank, heart, liver and digestive system from the weight.

Dressing yield = Live weight – (blood + feathers + shank + head + liver + heart + digestive system)

3.10 Calculations

Each data were collected by the following formula

3.10.1 Live weight gain

The average body weight gain of each replication was calculated by deducting initial body weight from the final body weight of the birds.

Body weight gain = Final weight – Initial weight

3.10.2 Feed intake

Feed intake was calculated dividing the total feed consumption in the replication by number of the birds in each replication.

$$\text{Feed intake (g/bird)} = \frac{\text{Feed intake in a replication (gm)}}{\text{Number of birds per replication}}$$

3.10.3 Feed conversion ratio (FCR)

Feed conversion ratio (FCR) was calculated as the total feed consumption divided by weight gain in each replication.

$$\text{FCR} = \frac{\text{Feed intake (kg)}}{\text{Weight gain (kg)}}$$

3.10.4 Benefit cost ratio (BCR)

Benefit cost ratio (BCR) was calculated as the total income of the study divided by total cost production.

$$\text{BCR} = \frac{\text{Total income (Tk.)}}{\text{Total cost of production (Tk.)}}$$

3.10.5 Dressing percentage

Dressing yield was found by subtracting blood, feathers, head, shank and digestive system from live weight. Liver, heart, gizzard and neck were considered as giblet. Dressing percentage of bird was calculated by the following formula-

$$\text{DP} = \frac{\text{Dressing yield (g)}}{\text{Live weight (g)}} \text{ X } 100$$

Dressing yield = Breast, thigh, drumstick, back, wing, giblet, abdominal fat weight.

3.11 Statistical analysis

Total data were complied, tabulated and analyzed in according to the objectives of the study. Excel program was practiced for the preliminary data calculation. The collected data was subjected to the statistical analysis by applying one-way ANOVA using Statistical Package for the Social Sciences (SPSS version 25.0) in according to the principles of completely randomized design (CRD). Differences between means were tested using the Duncan's multiple comparison test, and significance was set at $P<0.05$.

Plate 1. Arrival of day-old chick (DOC)

Plate 2. Distribution of chick under different treatments

Plate 3. Vaccination of chick

Plate 4. Weighing and mixing of treatment additives within the feed

Plate 5. Supplying feeds

Plate 6. Weighing of chicks

FIGURE: SOME PICTORIAL VIEW OF EXPERIMENT

Plate 7. Feeding of chicks

Plate 8. Weighing of chicks

Plate 9. Dissection of bird

Plate 10. Weight of dressed carcass

Plate 11. Determination of proximate Components of crude protein by Kjeldahl digestion

Plate 12. Monitoring of research activities by supervisor mam

CHAPTER IV
RESULT AND DISCUSSION

Results obtained from the present study have been presented and discussed in this chapter with a view to study the effect of cinnamon and garlic powder in broiler production. The data are given in different tables and figures. The results have been discussed, and possible interpretations are given under the following headings.

4.1 Chemical composition of cinnamon and garlic

The approximate composition of cinnamon contained moisture 5.1%, crude protein 3.5%, crude fat 4%, fiber 33%. This data was the average and results obtained showed that cinnamon was low in fat and protein content. The moisture content is lower than the values reported by other scientists (Farhath *et al.,* 2001 and Hussain, 1985). The ash content, crude fiber are almost close to the value reported by Hussain (1985). Garlic powder is 6% moisture, crude protein 17%, Fat 1%. According to analysis by USDA (2003), an average clove of raw garlic has just under 5 calories, 12 mg potassium, over 5mg calcium, 4.59 mg of phosphorus, 0.94 mg of vitamin C and small amount of vitamins and minerals.

Table 6: Proximate components of cinnamon and garlic

Components	Cinnamon	Garlic
Dry matter %	88.05	86.50
Crude protein %	3.5	6.13
Ash %	3.4	5.63

4.2 Growth performance of broiler chicken

Growth performance of broiler chicken was evaluated by average live weight, average feed consumption, feed Conversion Ratio (FCR), weekly body weight gain, Carcass characteristics were taken by dressing percentage (DP), carcass weight and relative weight of internal organs.

Table 7: Growth performance of broiler chicken

Treatment	Average Live Weight (g/bird) (Mean± SE)	Average BWG (g/bird) (Mean± SE)	Average FC (g/bird) (Mean± SE)	Final FCR (Mean± SE)	Survivability (Mean± SE)
T_0	1912.33^{ab}±16.49	1872.33^{ab}±16.50	2552.27^{a}±11.03	1.34±0.01	100.00±0.00
T_1	1866.00^{b}±29.01	1826.00^{b}±29.01	2477.70^{b}±6.58	1.33±0.02	95.83±4.16
T_2	1886.00^{ab} ±21.65	1846.00^{ab}±21.66	2512.53^{ab}±16.80	1.33±0.01	95.83±4.16
T_3	1896.33^{ab} ±17.40	1856.33^{ab}±17.40	2511.07^{ab} ±18.37	1.32±0.02	95.83±4.16
T_4	1958.33^{a}±21.05	1918.33^{a}±21.05	2553.50^{a}±11.84	1.30±0.01	100.00±0.00
Level of Significance	*	*	*	NS	NS

Here, $T_{0=}$ Control (basal diet), $T_{1=}$ Control with antibiotic, $T_{2=}$ (Basal feed+ 0.2% Cinnamon), $T_{3=}$ (Basal feed+ 0.2% Garlic) $T_{4=}$ (Basal feed+ 0.2% Cinnamon+ 0.2% Garlic). Values are Mean ± SE (n=15), one way ANOVA (SPSS, Duncan method), BWG=Body weight gain, FC= Feed consumption, FCR= Feed conversion ratio.

- ✓ ^{abc} Mean values within the same column with different superscripts are significantly different (P<0.05)
- ✓ Mean within same superscripts do not differ (P>0.05) significantly
- ✓ SE= Standard Error, *= Significant, NS= Non significant

4.2.1 Final live weight

Data presented in Table 7 showed that the effect of treatments on average live weight (gram per broiler chicken) was significantly (P<0.05) difference. The relative average live weight (g) of broiler chickens at the end of 4th week in the dietary group T_0, T_1, T_2, T_3 and T_4 were 1912.33^{ab}±16.49, 1866.00^{b}±29.01, 1886.00^{ab} ±21.65, 1896.33^{ab} ±17.40 and 1958.33^{a}±21.05 respectively. The highest result was found in T_4 treatment (1958.33^{a}±21.05) and lowest result was found in T_1 treatment (1866.00^{b}±29.01). Lee *et al*. (2004) reported that the addition of cinnamon to the diet of broilers improved their growth performance. Al-Kassie (2009) found positive effect of ground thyme and cinnamon on the live weight gain and improvement of the health of broiler

chickens. Broiler fed the different levels of garlic (*Allium sativum*) powder (1.5%, 3.0%, and 4.5%) did not show improved body weight gain (BWG) (Konjufca, Pesti, 1997).

4.2.2 Weekly body weight gain

Body weight gains of broiler chickens at different weeks data presented in Figure 2. Somehow there are difference in total body weight gain among treatments. The body weight gains (g) of broiler chickens in the dietary group were T_0, T_1, T_2, T_3 and T_4 weeks at 1st week were 187.00, 182.00, 176.67, 183.67 and 192.33 respectively, at 2nd week were 331.00, 321.00, 312.00, 316.00 and 343.67 respectively, at 3rd week were 641.67, 661.67, 682.00, 688.33 and 649.00 respectively, at 4th week were 712.67, 661.33, 675.33, 668.33 and 733.33 respectively. There was no significant ($P>0.05$) differences among the treatment groups of ages. However, among the treatments the more 0.2% cinnamon and 0.2% garlic levels the more body weight gain. However, Lee *et al*., (2003), stated that cinnamaldehyde supplementation in feed had no significant effect on female broilers' weight gain, but water intake was decreased significantly.

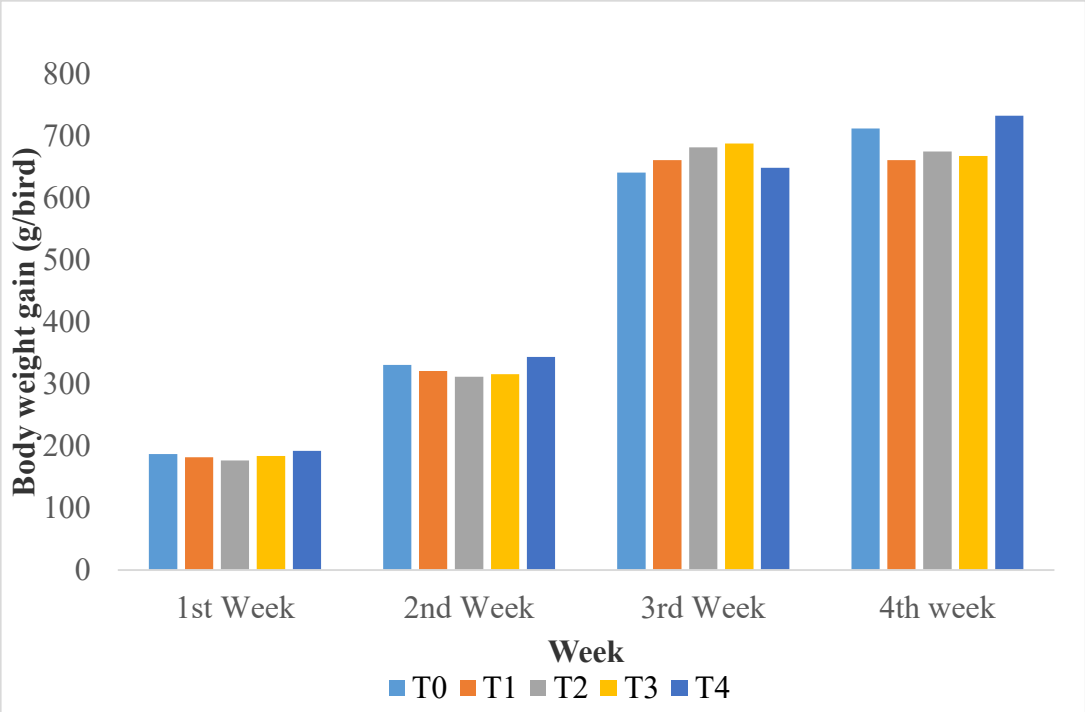

Figure 2: Weekly body weight gain (g/bird)

4.2.3 Weekly feed consumption

Data presented in figure 3 showed that the effect of treatments on weekly feed consumption (gram per broiler chicken) was discussed. The feed consumption (g/bird) of broiler chickens in the dietary group were T_0, T_1, T_2, T_3 and T_4 at 1st weeks were 204.8, 201.9, 203.2, 204.2, 204.8 respectively, at 2nd week were 395.8, 392.3, 356.5, 362.8, 384.2 respectively, at 3rd week were 717.2, 744.9, 742.7, 758.1, 733.7 respectively, at 4th week were 1234.6, 1138.6, 1210.2, 1185.9, 1230.8 respectively. Though the feed intake increases with the concentration of 0.2% cinnamon and 0.2% garlic in feed. Somehow there is no significant (P>0.05). Al-Kassie (2009), clarified that the chicks fed on diets containing 200 ppm EO resulting from a combination of thyme and cinnamon achieved significant increases in feed efficiency and FI compared to the control. Contradictory studies were reported by Symeon *et al.,* (2014); Sarica *et al*., (2009) and Lee *et al*., (2003), showing that cinnamon powder did not significantly affect the FI or FCR of birds. Lee *et al*., (2003), pointed out that cinnamaldehyde supplementation in feed had no significant influences on the FI and FCR of female broilers, however, water intake was significantly decreased.

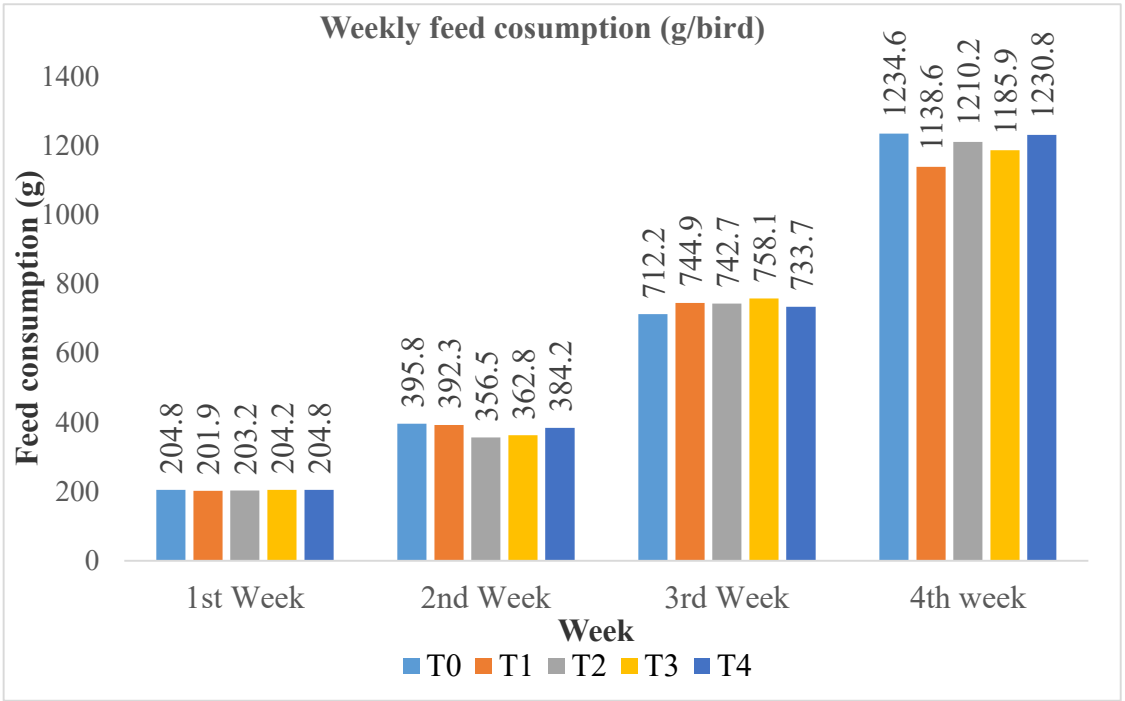

Figure 3: Weekly feed consumption (g/bird)

4.2.4 Feed conversion ratio (FCR)

The result of feed conversion ratio (FCR) of broilers under different treatment groups have been shown in figure 4. The feed conversion ratio (g/bird) of broiler chickens in the dietary group were T_0, T_1, T_2, T_3 and T_4 at 1st weeks were 0.90, 0.94, 0.94, 0.91, 0.88 respectively, at 2nd week were 1.08, 1.09, 1.06, 1.05, 1.03 respectively, at 3rd week were 1.10, 1.11, 1.08, 1.08, 1.08 respectively, at 4th week were 1.34, 1.33, 1.33, 1.33, 1.30 respectively. Al-Kassie (2009) found positive effect of ground thyme and cinnamon on the live weight gain and improvement of the health of broiler chickens, in addition to the other performance traits, feed conversion ratio and feed intake. Toghyani *et al*. (2011) found no difference in feed intake and FCR of broilers after the dietary incorporation of cinnamon powder. Sampath and Atapattu (2013) found that supplementation of dietary cinnamon powder tends (P=0.09) to increase the feed intake and feed conversion ratio (FCR) but had no effects on final live weight, weight gain, visceral organ weight, and gizzard, cloaca and total fat contents or serum cholesterol level.

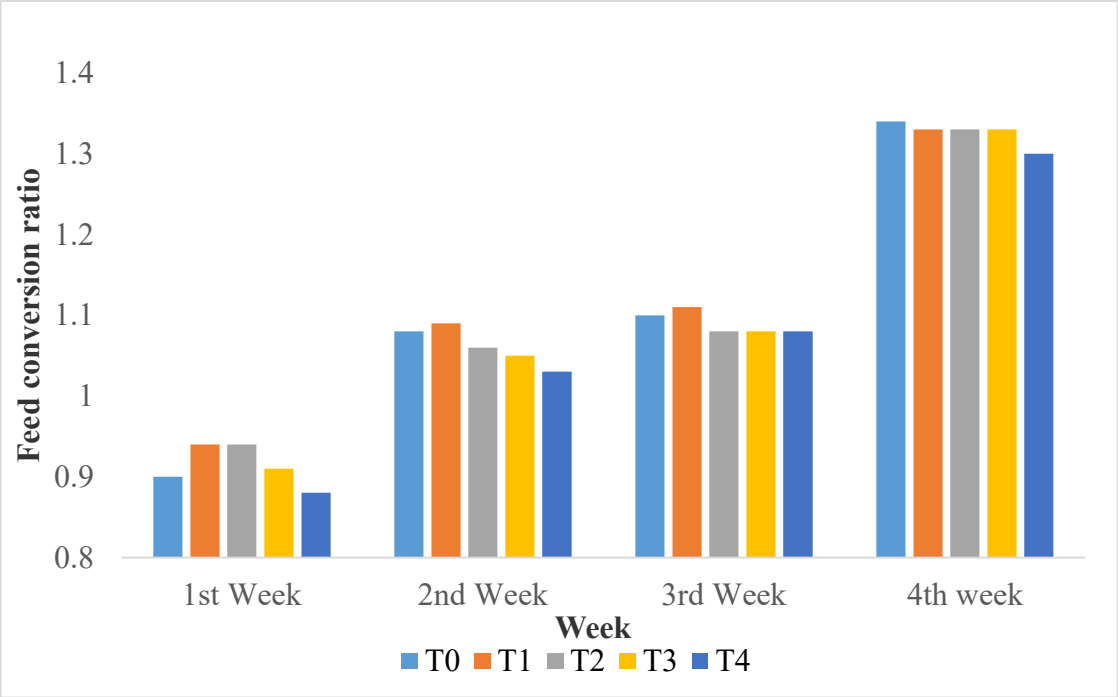

Figure 4: Weekly feed conversion ratio

4.3 Carcass characteristics

4.3.1 Dressing percentage (DP)

Data presented in Table 8 showed that the dressing percentage at T_4 group 57.60±0.73 was significant ($P<0.05$) carcass percentage compared with the other treatment group T_0 (57.27±1.27), T_1 (57.56±0.62), T_2 (56.92±0.64) and T_3 (55.77±0.44). Evaluation of dressing percentage on slaughtered representative birds revealed that T_4 group had significantly higher dressed percentage followed by T_1, T_0, T_2, and lower in T_3 groups. Koochaksaraie *et al*. (2011) revealed that supplementation of cinnamon powder at the dose of 250 to 2000 mg/kg broiler diets did not have any influence on the carcass parameters. Toghyani *et al.* (2011) observed no impact of diets on carcass parameters supplemented with 2 and 4 g/kg of cinnamon powder in broilers. He also found that the sensory evaluation showed no change in meat flavour and odour desirability after the dietary supplementation. Sang-Oh *et al.* (2013) reported that dietary supplementation of cinnamon powder at 5 percent level to broilers improved the quality of chicken meat including colour, flavour, texture and shelf life.

Table 8: Effect of cinnamon and garlic on dressing percentage of broiler chicken

Treatment	Live Weight (Mean± SE)	Eviscerated Weight (Mean± SE)	Dressing percentage (Mean± SE)
T_0	1912.33^{ab}±16.49	1095.00^{b}±17.89	57.27±1.27
T_1	1866.00^{b}±29.01	1073.67^{bc}±6.64	57.56±0.62
T_2	1886.00^{ab} ±21.65	1073.33^{bc}±7.62	56.92±0.64
T_3	1896.33^{ab} ±17.40	1057.33^{c}±4.63	55.77±0.44
T_4	1958.33^{a}±21.05	1127.67^{a}±2.19	57.60±0.73
Level of significance	*	*	NS

Here, $T_{0=}$ Control (basal diet), $T_{1=}$ Control with antibiotic, $T_{2=}$ (Basal feed+ 0.2% Cinnamon), $T_{3=}$ (Basal feed+ 0.2% Garlic) $T_{4=}$ (Basal feed+ 0.2% Cinnamon+ 0.2% Garlic). Values are Mean ± SE (n=15), one way ANOVA (SPSS, Duncan method).

- ✓ ^{abc} Mean values within the same column with different superscripts are significantly different ($P<0.05$)
- ✓ Mean within same superscripts don't differ ($P>0.05$) significantly
- ✓ SE= Standard Error, *= Significant, NS= Non significant

4.3.2 Carcass weight

Data presented in Table 9 showed that the carcass weight in the treatment groups are better than the T_4 group that containing 0.2% cinnamon and 0.2% garlic. The results revealed that the treatments had significant effects ($P<0.05$) in dressed wings, breast, thigh. However in treatment T_4 group the carcass weight is better than on any other treatment groups. Garcia *et al*. (2007) observed that a blend of oregano, cinnamon and pepper oil (200 ppm) had no influence on carcass weight of broilers. SafaEltazi (2014) reported that the broiler chicken fed with cinnamon showed significantly (P0.05) on cholesterol, triglyceride, low density lipoproteins (LDL), abdominal fat, gizzard and heart weights and on breast protein percentage.

Table 9: Effect of cinnamon and garlic on thigh, drumstick, back, wing, breast, neck weight (gm) of broiler chicken

Treatment	Breast (g/bird) (Mean± SE)	Back (g/bird) (Mean± SE)	Thigh (g/bird) (Mean± SE)	Drumstick (g/bird) (Mean± SE)	Wings (g/bird) (Mean±SE)	Neck (g/bird) (Mean± SE)
T_0	508.33±3.75	217.00^{a}±5.5	82.67±1.20	70.67^{b}±0.88	41.33±1.4	39.67±0.88
T_1	499.67±11.35	202.67^{ab}±4.2	81.33±1.76	75.00^{ab}±1.53	43.67±2.3	40.33±0.88
T_2	524.67±13.02	188.67^{b}±6.7	79.00±2.08	74.33^{ab}±2.03	40.67±2.3	41.00±0.58
T_3	498.67±24.46	195.67^{b}±4.0	81.67±2.03	77.00^{a}±1.73	42.33±2.0	41.33±0.67
T_4	534.00±7.94	193.00^{b}±5.2	84.33±2.03	78.67^{a}±1.76	43.67±2.0	39.00±1.00
Level of Significance	**NS**	*	**NS**	*	**NS**	**NS**

Here, $T_{0=}$ Control (basal diet), $T_{1=}$ Control with antibiotic, $T_{2=}$ (Basal feed+ 0.2% Cinnamon), $T_{3=}$ (Basal feed+ 0.2% Garlic) $T_{4=}$ (Basal feed+ 0.2% Cinnamon+ 0.2% Garlic). Values are Mean ± SE (n=15), one way ANOVA (SPSS, Duncan method).

- ✓ ^{abc} Mean values within the same column with different superscripts are significantly different ($P<0.05$)
- ✓ Mean within same superscripts do not differ ($P>0.05$) significantly
- ✓ SE= Standard Error, *= Significant, NS= Non significant

4.3.3 Internal organs under different treatment groups

Data presented in Table 10 showed that relative weight of internal organs (liver, heart, gizzard, proventriculus and spleen) of broilers fed diet containing cinnamon and garlic powder showed significant difference (P<0.05) among the groups. SafaEltazi (2014) reported that the broiler chicken fed with cinnamon showed significantly (P 0.05) on cholesterol, triglyceride, low density lipoproteins (LDL), abdominal fat, gizzard and heart weights and on breast protein percentage. Sampath and Atapattu (2013) found that supplementation of dietary cinnamon powder tends (P=0.09) to increase the feed intake and feed conversion ratio (FCR) but had no effects on final live weight, weight gain, visceral organ weight, and gizzard, cloaca and total fat contents or serum cholesterol level.

Table 10: Effect of feeding cinnamon and garlic on internal organs of broiler under different treatment groups

Treatment	Liver (g/bird)	Heart (g/bird)	Gizzard (g/bird)	Proventriculus (g/bird)	Spleen (g/bird)
T_0	56.33±4.67	10.67±0.88	39.67^{b}±1.20	8.00^{c}±0.00	2.00±0.00
T_1	55.33±3.84	9.00±0.58	46.00^{ab}±3.22	8.63^{b}±0.33	2.00±0.00
T_2	51.00±2.65	9.33±1.45	46.67^{ab}±2.19	8.67^{b} ±0.67	2.00±0.00
T_3	48.00±5.03	9.33±1.20	47.33^{a}±2.19	9.00^{a}±0.57	2.00±0.00
T_4	52.33±1.86	9.00±0.58	46.00^{ab}±1.16	9.33^{a}±0.67	2.00±0.00
Level of Significance	**NS**	**NS**	*	*	**NS**

Here, $T_{0=}$ Control (basal diet), $T_{1=}$ Control with antibiotic, $T_{2=}$ (Basal feed+ 0.2% Cinnamon), $T_{3=}$ (Basal feed+ 0.2% Garlic) $T_{4=}$ (Basal feed+ 0.2% Cinnamon+ 0.2% Garlic). Values are Mean ± SE (n=15), one way ANOVA (SPSS, Duncan method).

- ✓ ^{abc} Mean values within the same column with different superscripts are significantly different (P<0.05)
- ✓ Mean within same superscripts don't differ (P>0.05) significantly
- ✓ SE= Standard Error, *= Significant, NS= Non significant

4.4 Cost benefit ratio of cinnamon and garlic powder on broiler production

Profit per bird of broiler chicken were presented in Table 11. The profit per bird of broiler chicken in T_0, T_1, T_2, T_3, and T_4 were 49.43^a, 25.4^c, 40.4^b, 42.3^b, 43.27^b respectively. T_1 was significantly higher than all other groups. The dietary supplementation of cinnamon increased the cost of production. Singh *et al.* (2014) also observed the benefit cost ratio.

Table 11: Economic impact of cinnamon and garlic powder on broiler production

Treatment	Feed Cost (BDT)/ Bird	Cost of Cinnamon, Garlic & Antibiotics (BDT)/Bird	Expenditure & Other cost (BDT)/Bird	Total Production Cost (BDT)/Bird	Receipt per bird when sold @160 Tk./kg live weight	Profit per bird (BDT)	Benefit cost ratio
T_0	163.17^a	0.00	93.33	256.57^c	306^b	49.43^a	1.19^b
T_1	158.53^b	21.74	93.33	273.60^a	299^c	25.4^c	1.09^c
T_2	160.63^{ab}	7.60	93.33	261.60^b	302^b	40.4^b	1.15^b
T_3	159.80^{ab}	7.60	93.33	260.70^b	303^b	42.3^b	1.16^{ab}
T_4	163.20^a	15.20	93.33	271.73^b	313^a	41.27^b	1.16^a
Level of Significance	*	NS	NS	*	*	*	*

Here, $T_{0=}$ Control (basal diet), $T_{1=}$ Control with antibiotic, $T_{2=}$ (Basal feed+ 0.2% Cinnamon), $T_{3=}$ (Basal feed+ 0.2% Garlic) $T_{4=}$ (Basal feed+ 0.2% Cinnamon+ 0.2% Garlic). Values are Mean ± SE (n=15), one way ANOVA (SPSS, Duncan method), BDT= Bangladeshi taka.

- ✓ ^{abc} Mean values within the same column with different superscripts are significantly different ($P<0.05$)
- ✓ Mean within same superscripts do not differ ($P>0.05$) significantly
- ✓ SE= Standard Error, *= Significant, NS= Non significant

CHAPTER V

SUMMARY AND CONCLUSION

The present study was conducted at the Sher-e-Bangla Agricultural University (SAU), Dhaka Poultry Farm for a period of four weeks by applying different levels of cinnamon and garlic with commercial broiler feed. A total of 180 day-old broiler chicks were purchased from Kazi Farms hatchery, Gazipur, Dhaka. The experimental broilers were allocated randomly to 4 treatments and a control group with three replications having 12 broilers per replication. The experiment lasted for 4 weeks and the treatment of various groups consisted of group T_0= Control group, T_1= Basal feed with antibiotic, T_2=Basal feed + 0.2% cinnamon, T_3= Basal feed + 0.2% garlic, T_4= Basal feed + 0.2%+ 0.2% cinnamon. + 0.2% garlic. The performance traits viz. body weight, weight gain, feed consumption, FCR, dressed bird weight of broiler on different replication of the treatments was recorded and compared in each group. At 28 days of age, broilers were dissected to compare meat yield characteristics among different treatments. Final live weight was significantly higher in group T_4 ($1958.33^{b}\pm21.05$) compared to any other group T_0 ($1912.33^{ab}\pm16.49$), T_3 ($1896.33^{ab}\pm17.40$), T_2 ($1886^{ab}\pm21.65$) and group T_1 ($1866^{b}\pm29.01$) was comparatively lower. However better value was found in group T_4. The overall average body weight gain was also significantly higher in group T_4 ($1918.33^{a}\pm21.05$) compared to group T_0 ($1872.33.^{ab}\pm16.50$), group T_3 ($1856.33^{ab}\pm17.40$), group T_2 ($1846^{ab}\pm21.66$) and group T_1 ($1826^{b}\pm29.01$). The lowest value was found in T_1 ($1826^{b}\pm29.01$). FCR was significantly lower in group T_4 (1.30 ± 0.001) compared to group T_3 (1.32 ± 0.02), group T_2 (1.33 ± 0.01), group T_1 (1.33 ± 0.02) and group T_0 (1.34 ± 0.01). Somehow treatment group T_0 show higher FCR than other. There was significant difference in average feed consumption in group T_4 ($2553.50^{a}\pm11.84$) compared to group T_0 ($2552.27^{a}\pm11.03$), group T_2 ($2512.53^{ab}\pm16.80$), group T_3 ($2511.07^{ab}\pm18.37$) and group T_1 ($2477.70^{b}\pm6.58$). Though total feed consumption was higher in treatment group T_4 than other group. Which indicates cinnamon and garlic treatment group increase feed intake. In experiment, evaluation of dressing percentage on slaughtered representative birds revealed that T_4 (57.60 ± 0.73) group had significantly higher dressing percentage followed by T_1 (57.5 ± 0.62), T_0 (57.27 ± 1.27), T_2 (56.92 ± 0.64) and lower in T_3 (55.77 ± 0.44) group. In cinnamon and garlic treatment group (containing 0.2% cinnamon and 0.2% garlic) the weight of carcass parts are higher than in antibiotic

and control group. The results revealed that the treatments had significant effects in dressed breast, back, thigh, drumstick and wings ($P<0.05$). But in T_4 treatment group the carcass weight is better than any other treatment group. The results revealed that the treatments had significant effects in internal organs liver and gizzard ($P<0.05$), but no significant difference in heart and spleen ($P>0.05$). The results of the current study indicate that cinnamon and garlic treatment groups increase feed intake, FCR, body weight gain, live weight and dressing percentage but no significant impact on internal organs ($P>0.05$). Analyzing the above research findings on the growth performance of broilers, the cinnamon and garlic had great effect on growth performance of broiler. It can be recommended by the study that the cinnamon and garlic don't hamper growth of broiler therefore it can be used with feed for human health benefit. Although cinnamon and garlic is a spices and it has strong flavor so that broiler can easily intake this feed. Although cinnamon and garlic has a positive impact on human health. Therefore it is suggested that 0.2% cinnamon and 0.2% garlic can be used in our country to produce quality poultry meat for healthier life with safe food consumption.

REFERENCES

Adetumbi, M. A., & Lau, B. H. (1983). *Alliumsativum* (garlic)-a natural antibiotic. *Med. hypotheses* **12(3)**: 227-237.

Al-Khalil, S. 1995. A survey of plants used in Jordanian traditional medicine. *Int. J. Pharm*. **33(4)**: 317-323.

Agarwal, K. C., (1996). Therapeutic actions of garlic constituents. *Med. Res. Rev*. **16(1):** 111-124.

Al-Kassie, G. A. (2009). Influence of two plant extracts derived from thyme and cinnamon on broiler performance. *Pakistan Vet. J.* **29(4)**: 169-173.

Ashayerizadeh, O., Dastar, B., Shargh, M. S., Ashayerizadeh, A., Rahmatnejad, E., & Hossaini, S. M. R. (2009). Use of garlic (*Allium sativum*), black cumin seeds (*Nigella sativa L.*) and wild mint (*Mentha longifolia*) in broiler chickens diets. *J. of Anim. Vet. Adv.* ***8*(9)**: 1860-1863.

American Heart Association (1986) Dietary guidelines for healthy adult Americans: A statement for physicians and health professionals by the nutrition committee. *Circulation* **74**: 1465A-1468A.

Aouadi, R., Aouidet, A., Elkadhi, A., Ben Rayana, M.C., Jaafoura, H., Tritar, B. and Nagati, K. (2000). Effect of garlic (*Allium sativum*) on lipid metabolism in male rats. *Nutr. Res*. **20**: 273-280.

Avato, P., Tursi, F., Vitali, C., Miccolis, V., & Candido, V. (2000). Allylsulfide constituents of garlic volatile oil as antimicrobial agents. *Phytomedicine* **7(3)**: 239-243.

Byung, S. P., (2008). Effects of dietary cinnamon powder on savour and quality of chicken meat in broiler chicken. *Journal of Korean Society of Food Science and Nutrition* **37**: 618-624.

Brugalli, I., (2003). Alternative power: The use of herbal and nutraceutical as modulators of immunity and animal performance. In: Symposium on Management and Nutrition Poultry and Pigs, Campinas. Proceedings: *Brazilian Animal Nutrition College*, pp. 167-182.

Bamidele, M., Adejumo, A., (2012). Effect of Garlic (*Allium sativum L.*) and Ginger (*Zingiber officinale* Roscoe) Mixtures on Performance Characteristics and Cholesterol Profile of Growing Pullets. *International Journal of Poultry Science* **11(3)**: 217-220.

Belsinger, S., & Dille, C., (1993). *The garlic book: a garland of simple, savory, robust recipes*. Interweave Press.

Blania, G., & Spangenberg, B., (1991). Formation of allicin from dried garlic (*Allium sativum*): a simple HPTLC method for simultaneous determination of allicin and ajoene in dried garlic and garlic preparations. *Planta medica* **57(4)**: 371-375.

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

Block, E. (2010). Allium botany and cultivation, ancient and modern. *Garlic and other alliums: the lore and the science* 1-32.

Bradley, P. R. (1992). British herbal compendium. Volume 1. A handbook of scientific information on widely used plant drugs. Companion to Volume 1 of the British Herbal Pharmacopoeia. *British Herbal Medicine Association.*

Brewster, J. L. (2008). *Onions and other vegetable alliums* (Vol. 15). CABI.

Bywater, R. J. (2005). Identification and surveillance of antimicrobial resistance dissemination in animal production. *Poultry science* **84(4)**: 644-648.

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

Ciftci, M., Simsek, U. G., Yuce, A., Yilmaz, O., & Dalkilic, B. (2010). Effects of dietary antibiotic and cinnamon oil supplementation on antioxidant enzyme activities, cholesterol levels and fatty acid compositions of serum and meat in broiler chickens. *Acta Veterinaria Brno* **79(1)**: 33-40.

Cervantes, H. (2004).Why responsible antibiotic use enhances animal and human health. Proceedings of Midwest Poultry Federation Convention. pp 201-210.

Ceylan, N., Gunal, M. and Caliskaner, S. (1998). Effect of enzyme and antibiotic supplementation on growth performance and ileal parameters in broilers fed rye diets. University of Nebraska-Lincoln Poultry Reports

Available http://ianrpubs.unl.edu/poultry/mp70/mp70-14.htm.

Choi, I. H., Park, W. Y., & Kim, Y. J. (2010). Effects of dietary garlic powder and α-tocopherol supplementation on performance, serum cholesterol levels, and meat quality of chicken. *Poultry Science* **89(8)**: 1724-1731.

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

Craig, W. J. (1999). Health-promoting properties of common herbs. *The American journal of clinical nutrition* **70(3)**: 491s-499s.

Chattopadhyay, M. K. (2014). Use of antibiotics as feed additives: a burning question. *Frontiers in Microbiology* ***5***: 334.

Chang, S. T., Chang, L. W., Chang, W. C., and Cheng, S. S., (2008). Antibacterial activities of plant essential oils against Legionella pneumophila. *Water Research* **42(1-2)**: 278-286.

Chang, S, T., Yeh, F, H., Luo, Y, C., Lin YC, Cheng SS and Hsu RY (2013). Methods for thermal stability enhancement of leaf essential oils and their main constituents from indigenous Cinnamon (*C. osmophloeum*). *Journal of Agricultural and Food Chemistry* **61(26)**: 6293-698.

Chou, S, T., Chang, L, W., Chang, T, C., Hsu, L, S., Lin, C, Y., and Shih, Y., (2013). Cinnamomum cassia essential oil inhibits alpha-MSH-induced melanin production and oxidative stress in murine B16 melanoma cells. *International Journal of Molecular Sciences* **14(9)**: 19186-19201.

Demir, E., Sarica, S., Ozcan, M. A., & Suicmez, M. (2005). The use of natural feed additives as alternatives to an antibiotic growth promoter in broiler diets. *Archiv fur Geflugelkunde*, **69(3)**: 110-116.

Diarra, M. S., & Malouin, F. (2014). Antibiotics in Canadian poultry productions and anticipated alternatives. *Frontiers in microbiology*, **5**: 282.

Dorman, H.J.D., Deans S. G., 2000. Antimicrobial agents from plants: Antibacterial activity of plant volatile oils. *J. Appl. Microbiol*. **88**: 308–316.

Ebrahimi, M., Hoseini, A., Palizdar, M. H., Mohamadian-Tabrizi, H. R. and Porelmi, M. R. (2013). Effect of cinnamon, red pepper, ginger and cumin on broilers performance. *Research Opinion in Animal and Veterinary Science,* **3(5)**: 131-135.

Elagib, H. A., El-Amin, W. I. A., & Malik, H. E. (2013). Effect of dietary garlic (*Allium sativum*) supplementation as feed additive on broiler performance and blood profile.

Elnima, E. I., Ahmed, S. A., Mekkawi, A. G., & Mossa, J. S. (1983). The antimicrobial activity of garlic and onion extracts. *Die Pharmazie* **38(11)**: 747-748.

Engberg, R. M., Hedemann, M. S., Leser, T. D., & Jensen, B. B. (2000). Effect of zinc bacitracin and salinomycin on intestinal microflora and performance of broilers. *Poultry science* **79(9)**: 1311-1319.

Fadlalla, I. M. T., Mohammed, B. H., & Bakhiet, A. O. (2010). Effect of feeding garlic on the performance and immunity of broilers. *Asian Journal of Poultry Science* **4(4)**: 182-189.

Farbman, K. S., Barnett, E. D., Bolduc, G. R., & Klein, J. O. (1993). Antibacterial activity of garlic and onions: a historical perspective. *The Pediatric infectious disease journal* **12(7)**: 613.

Feldberg, R. S., Chang, S. C., Kotik, A. N., Nadler, M., Neuwirth, Z., Sundstrom, D. C., & Thompson, N. (1988). In vitro mechanism of inhibition of bacterial cell growth by allicin. *Antimicrobial agents and chemotherapy* **32(12)**: 1763-1768.

Frost, E. A. (2006). Herbal medicines and interactions with anesthetic agents. *Middle East Journal of Anesthesiology* **18(5)**: 851.

Garcia, V., Catala-Gregori, P., Hernandez, F., Megias, M. D., & Madrid, J. (2007). Effect of formic acid and plant extracts on growth, nutrient digestibility, intestine mucosa morphology, and meat yield of broilers. *Journal of applied poultry research* **16(4)**: 555-562.

Gold, H. S., and Moellering, R. C., (1996). Antimicrobial drug resistance. *New England Journal of Medicine* **335**: 1445–1453.

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

Huang, Y. F., Ma, H. L., Wu, D.F., Zhou, J. I., Zhou, K. S. and Qi, Z. Y. (1992). Effect of Chinese medicinal herbs additives on the growth of broilers. *Journal of Agricultural Systems* **21**: 93-96.

Horton, G. M. J., Fennell, M. J., & Prasad, B. M. (1991). Effect of dietary garlic (*Allium sativum*) on performance, carcass composition and blood chemistry changes in broiler chickens. *Canadian Journal of Animal Science* **71(3)**: 939-942.

Harms, R. H., Ruiz, N., & Miles, R. D. (1986). Influence of virginiamycin on broilers fed four levels of energy. *Poultry Science* **65(10)**: 1984-1986.

Issa, K. J., & Omar, J. A. (2012). Effect of garlic powder on performance and lipid profile of broilers.

Jakhetia, V., Patel, R., Khatri, P., Pahuja, N., Garg, S., Pandey, A., & Sharma, S. (2010). Cinnamon: a pharmacological review. *Journal of advanced scientific research* **1(02)**: 19-23.

Jamroz, D., Wiliczkiewicz, A., Wertelecki, T., Orda, J., & Skorupińska, J. (2005). Use of active substances of plant origin in chicken diets based on maize and locally grown cereals. *British Poultry Science* **46(4)**: 485-493.

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

Koochaksaraie, R. R., Irani, M., & Gharavysi, S. (2011). The effects of cinnamon powder feeding on some blood metabolites in broiler chicks. *Brazilian Journal of Poultry Science* **13(3)**: 197-202.

Kivanc, M., & Kunduhoglu, B. (1997). Antimicrobial activity of fresh plant juice on the growth of bacteria and yeasts. *Journal of Qafqaz University*, **1(1)**: 27-35.

Kleczkowski, M., Kasztelan, R., Jakubczak, A., Klucinski, W., Sitarska, E., & Cetnarowicz, A. (2004). Garlic as a biostimulator and" antibiotic" in the raising of piglets. *Medycyna Weterynaryjna* **60(4)**: 384-387.

Khodambashi Emami N., Samie A., Rahmani H.R., Ruiz-Feria C. A. (2012). The effect of peppermint essential Oil and fructooligosaccharides, as alternatives to virginiamycin, on growth performance, digestibility, gut morphology and immune response of male broilers. Anim Feed Sci Technol. **175**: 57–64.

Kassab, A. and Kamal, N. (2009). Effect of black seeds, garlic powder or enrofloxacin on E coli induced air sacculitis in broiler chickens. *Iraqi Poultry Sciences Journal* **5**: 96-110.

Konjufca, V. H., Pesti, G. M., & Bakalli, R. I. (1997). Modulation of cholesterol levels in broiler meat by dietary garlic and copper. *Poultry science* **76(9)**: 1264-1271.

Kumar, O.M. (1991) Effect of Liv-52® syrup on broiler performance in North Eastern region. *Indian Journal of Poultry Science* **22**: 37-38.

Kumar, S., Sharadamma, K. C., & Radhakrishna, P. M. (2010). Effects of a garlic active based growth promoter on growth performance and specific pathogenic intestinal microbial counts of broiler chicks. *International Journal of Poultry Science* ***9*****(3)**: 244-246.

Lawson, L. D., Wang, Z. Y. J., & Hughes, B. G. (1991). Identification and HPLC quantitation of the sulfides and dialkenyl thiosulfinates in commercial garlic products. *Planta medica* **57(04)**: 363-370.

Lee, K. W., Everts, H., Kappert, H. J., Frehner, M., Losa, R., & Beynen, A. C. (2003). Effects of dietary essential oil components on growth performance, digestive enzymes and lipid metabolism in female broiler chickens. *British poultry science* **44(3)**: 450-457.

Lee, K.W., Everts, H. and Beynen, A.C. (2004) Essential oils in broiler nutrition. International Journal of Poultry Science **3**: 738-752.

Lee, S. H., Jang, S. I., Park, M. S., Bautista, D. A., & Lillehoj, E. P. (2012). Effects of anticoccidial and antibiotic growth promoter programs on broiler performance and immune status. *Research in Veterinary Science* **93(2)**: 721-728.

Lutomski, J. (2001). The fascination of garlic- yesterday and today. *Progress Phytotherapy* **1**: 7-14.

Mansoub, N. H. (2011). Comparative effects of using garlic as probiotic on performance and serum composition of broiler chickens. *Annals of biological Research* **2(3)**: 486-490.

MAFF (1998). A review of antimicrobial resistance in the food chain. A Technical Report for the UK Ministry of Agriculture, Food and Fisheries.

Miething, H. (1988). HPLC-analysis of the volatile oil of garlic bulbs. *Phytotherapy Research* **2(3):** 149-151.

Moore, P. R., Evenson, A., Luckey, T. D., McCoy, E., Elvehjem, C., & Hart, E. B. (1946). Use of sulfasuxidine, streptothricin, and streptomycin in nutritional studies with the chick. *Journal of biological chemistry* **165**: 437-441.

Mull A and Liebert F (2007). Growth nutrient utilization and threonine requirement of growing chicken fed threonine-limiting diets with commercial blends of phytogenic feed additives. *Japanese Poultry Science* **44**: 297-304.

Nonaka IG, Morimoto S and Nishioka I (1983). Tannins and related compounds. Part 13. Isolation and structures of trimeric, tetrameric, and pentameric proanthicyanidins from cinnamon. *Journal of the Chemical Society, Perkin Transactions* **1**: 2139-2145.

Najafi, S., & Taherpour, K. (2014). Effects of dietary ginger (*Zingiber Officinale*), cinnamon (Cinnamomum), synbiotic and antibiotic supplementation on performance of broilers. *Journal of Animal Science Advances* **4(1)**: 658-667.

Olobatoke, R.Y. and Mulugeta, S.D. (2011) Effect of dietary garlic powder on layer performance, fecal bacterial load, and egg quality. *Poultry Science* **90**: 665– 670.

Onibi, G. E., Adebisi, O. E., Fajemisin, A. N., & Adetunji, A. V. (2009). Response of broiler chickens in terms of performance and meat quality to garlic (*Allium sativum*) supplementation. *African Journal of Agricultural Research* **4(5)**: 511-517.

Onu, P. N. (2010). Evaluation of two herbal spices as feed additives for finisher broilers. *Biotechnology in Animal Husbandry* **26(5-6)**: 383-392.

Onyimonyi, A. E., Chukwuma, P. C. and Igbokwe, C. (2012). Growth and hypocholesterolemic properties of dry garlic powder (*Allium sativum*) on broilers. *African Journal of Biotechnology* **11**: 2666-2671.

Prasad, G. and Sharma, V. D. (1980). Efficacy of garlic (*Allium sativum*) treatment against experimental candidiasis in chicks. *British Veterinary Journal* **136**: 448-51.

Prasad, R., Rose, M. K., Virmani, M., Garg, S. L. and Puri, J. P. (2009). Lipid profile of chicken (*Gallus domesticus*) in response to dietary supplementation of garlic (*Allium sativum). Journal of Poultry Science* **8**: 270-276.

Park, B. S., (2008). Effect of dietary cinnamon powder on savour and quality of chicken meat in broiler chickens. *Journal of Korean Society of Food Science and Nutrition* **37**: 618-624.

Qureshi, A. A., Abuirmeileh, N., Din, Z. Z., Elson, C. E., & Burger, W. C. (1983a). Inhibition of cholesterol and fatty acid biosynthesis in liver enzymes and chicken hepatocytes by polar fractions of garlic. *Lipids* **18:** 343-348.

Qureshi, A. A., Din, Z. Z., Abuirmeileh, N., Burger, W. C., Ahmad, Y., & Elson, C. E. (1983b). Suppression of avian hepatic lipid metabolism by solvent extracts of garlic: impact on serum lipids. *The Journal of nutrition* **113(9)**: 1746-1755.

Ricke, S. C. (2003). Perspectives on the use of organic acids and short chain fatty acids as antimicrobials. *Poultry science* **82(4)**: 632-639.

Rosen, G. D. (1996). Pronutrient antibiotic replacement standards discussed. *Feedstuffs* **75**: 11-13.

Ramakrishna, R. R., Platel, K. and Srinivasan, K. (2003) In vitro influence of species and spice-active principles on digestive enzymes of rat pancreas and small intestine. *Food* **47**: 408-412.

Rerksuppaphol, S., Hardikar, W.,Midolo, P. and Ward, P. (2003) Antimicrobial resistance in Helicobacter pylori isolates from children. *Journal of Paediatrics and Child Health* **39**: 332-335.

Safa-Eltazi, M. A., (2014). Effect of using cinnamon powder as natural feed additive on performance and carcass quality of broiler chickens. *International Journal of Innovative Agriculture and Biology Research* **2(3)**: 1-8.

Sampath, H. K. R., and Attapattu, N. S. B. M. (2013). Effects of cinnamon (*Cinnamon zeylanicum)* bark powder on growth performance, carcass fat and serum cholesterol levels of broiler chicken. *Proceedings of 3rd International Symposium*. SEUSL, Oluvil, Sri Lanka.

Sang-Oh, P., Chae-Min, R., Byung-Sung, P., & Jong, H. (2013). The meat quality and growth performance in broiler chickens fed diet with cinnamon powder. *Journal of Environmental biology* **34(1)**: 127.

Sarica, S., Ciftci, A., Demir, E., Kilinc, K., & Yildirim, Y. (2005). Use of an antibiotic growth promoter and two herbal natural feed additives with and without exogenous enzymes in wheat based broiler diets. *South African Journal of Animal Science* **35(1)**: 61-72.

Sharma, V. D., Sethi, M. S., Kumar, A., & Rarotra, J. R. (1977). Antibacterial property of *Allium sativum* Linn. in vivo & in vitro studies. *Indian journal of experimental biology*.

Senanayake, M. U., Lee, H. T., and Wills R. B. H., (1978). Volatile constituents of cinnamon (*Cinnamomum zeylanicum*) oils. *Journal of Agricultural and Food Chemistry* **26(4)**: 822-824.

Shashikanth, K. N., Basappa, S. C., & Murthy, V. S. (1984). A comparative study of raw garlic extract and tetracycline on caecal microflora and serum proteins of albino rats. *Folia microbiologica* **29**: 348-352.

Shirzadegan, K. (2014). Reactions of modern broiler chickens to administration of cinnamon powder in the diet. *Iranian Journal of Applied Animal Science* **4(2)**: 367-371.

Singh, P., Karimi, A., Devendra, K., Waldroup, P. W., Cho, K. K., & Kwon, Y. M. (2013). Influence of penicillin on microbial diversity of the cecal microbiota in broiler chickens. *Poultry Science* **92(1)**: 272-276.

Stefan, F. Placha, Z. F. I., and Koppel, J. (2009). Effect of Cinnamomum Zeylanicum essential oil on oxidative status in broiler chickens. *Acta Veterinarian Brunensis* **78**: 411-417.

Symeon, G. K., Athanasiou, A., Lykos, N., Charismiadou, M. A., Goliomytis, M., Demiris, N., & Deligeorgis, S. G. (2014). The effects of dietary cinnamon (*Cinnamomum zeylanicum*) oil supplementation on broiler feeding behaviour, growth performance, carcass traits and meat quality characteristics. *Annals of Animal Science* **14(4)**: 883-895.

Tatara, R. M., Sliwa, E., Dudek, K., Mosiewicz, J., Studzinski, T., (2005). Effect of aged garlic extracts and allicin administration to sows during pregnancy and lactation on body weight gain and gastrointestinal tract development of piglets. *Bulletin of the Veterinary Institute in Pulawy* **49**: 349-355.

Toghyani, M., Toghyani, M., Gheisari, A., Ghalamkari, G., & Eghbalsaied, S. (2011). Evaluation of cinnamon and garlic as antibiotic growth promoter substitutions on performance, immune responses, serum biochemical and haematological parameters in broiler chicks. *Livestock science* **138(1-3)**: 167-173.

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

Turek, S. (2006). Molecular mechanisms of cancer-preventive effects of garlic organosulfur compounds. *Herba Polonica* **51**: 77-92.

Van den Bogaard, A. E. and Stobberingh, E. E. (1999). *Antibiotic usage in animals.Drugs* **58**: 589–607.

Van den Bogaard, A. E., & Stobberingh, E. E. (2000). Epidemiology of resistance to antibiotics: links between animals and humans. *International Journal of Antimicrobial Agents* **14(4)**: 327-335.

Vohra, S. B. and M. Khan. 1981. Diuretic study on plant principles. *Ind. Drugs Pharma*. **16(1)**: 39-40.

WHO (World Health Organization) (1997). The medical impact of use of antimicrobials in food animals. Report of a WHO Meeting. Berlin, Germany.

WHO (World Health Organization) (1998). The use of quinolones in food animals and potential impact on human health. Report of a WHO meeting. Geneva, Switzerland.

Yeh, Y.Y. and Liu, L. (2001). Cholesterol lowering effect of garlic extracts and organosulfur compounds: Human and animal studies. *Journal of Nutrition* **131**: 989S-993S.

Zavaragh, F. M. (2011) Influence of garlic and sumac powder (*Rhus coriaria L.*) on performance, carcass and blood bio-chemicals of Japanese quails. *Annals of Biological Research* **2**: 542-545.

Zhang, X. H., Lowe, D., Giles, P., Fell, S., Connock, M. J. and Maslin, D. J. (2001). Gender may affect the action of garlic oil on plasma cholesterol and glucose levels of normal subjects. *Journal of Nutrition* **131**: 1471-1478.

Zhang, G. F., Yang, Z. B., Wang, Y., Yang, W. R., Jiang, S. Z., Gai, G. S., (2009). Effects of ginger root (*zingiber officinale*) processed to different particle sizes on growth performance, antioxidant status and serum metabolites of broiler chickens. *J. Poult. Sci.* **88**: 2159-2166.

Zhang, S., Zhang, M., Fang, Z., & Liu, Y. (2017). Preparation and Characterization of Blended Cloves/cinnamon essential oil Nanoemulsions. *Lebensmittel-Wissenschaft & Technologie*, **75**: 316-322.

Zhao, S., Datta, A. R., Friedman, S., Walker, R. D. and White, D. G. (2003). Antimicrobial resistant Salmonellaserovars isolated from imported foods. *International Journal of Food Microbiology* **84**: 87-92.

APPENDICS

Appendix 1. Temperature and relative humidity during experimental period

Day	Date	Temperature (%)		Humidity (°C)	
		Maximum	Minimum	Maximum	Minimum
0	25.07.22	36	31.3	94	65
1	26.07.22	38.5	28.5	95	68
2	27.07.22	34.6	29.8	91	60
3	28.07.22	34.1	28.5	99	60
4	29.07.22	34.1	28.4	96	61
5	30.07.22	33.9	29.3	97	55
6	31.07.22	32	28.8	99	74
7	01.08.22	32.3	27.9	99	74
8	O2.08.22	32.3	27.9	99	74
9	03.08.22	33.5	27.8	99	80
10	04.08.22	33.4	28.1	99	66
11	05.08.22	33.2	27.9	99	65
12	06.08.22	32.4	28.6	99	72
13	07.08.22	33.2	27.9	99	65
14	08.08.22	33.1	28.2	90	67
15	09.08.22	32.8	27.2	97	59
16	10.08.22	32.1	27.3	94	64
17	11.08.22	31.9	27.7	99	66
18	12.08.22	33	27.5	99	62
19	13.08.22	31.9	27.6	99	69
20	14.08.22	31.1	27.2	99	79
21	15.08.22	31.9	26.3	99	70
22	16.08.22	31.1	26.8	94	64
23	17.08.22	32	27.5	96	75
24	18.08.22	32.3	27.4	98	72
25	19.08.22	33.5	28.1	95	74
26	20.08.22	32.9	27.9	94	70
27	21.08.22	32.1	26.9	99	65
28	22.08.22	32	27.5	96	75

Appendix 2. Effect of cinnamon and garlic on feed consumption (g/bird) of 1st, 2nd, 3rd and 4th week under different treatment groups

Treatment	Replication	1st Week FC	2nd Week FC	3rd Week FC	4th Week FC	Final FC
	R_1	204.5	396.5	716.0	1243.0	2560.0
T_0	R_2	204.3	396.3	731.0	1234.7	2566.3
	R_3	205.5	394.5	704.5	1226.0	2530.5
	R_1	204.8	392.3	724.0	1153.0	2474.0
T1	R_2	201.5	393.5	691.0	1204.5	2490.5
	R_3	199.5	391.2	819.6	1058.3	2468.6
	R_1	203.5	350.5	732.0	1196.5	2482.5
T_2	R_2	198.5	361.5	738.0	1242.6	2540.6
	R_3	207.5	357.5	758.0	1191.5	2514.5
	R_1	201.5	362.5	833.4	1149.7	2547.1
T_3	R_2	203.5	363.5	713.5	1218.8	2499.3
	R_3	207.5	362.5	727.5	1189.3	2486.8
	R_1	206.5	396.5	738.0	1232.5	2573.5
T_4	R_2	205.5	391.5	738.0	1219.5	2554.5
	R_3	202.5	364.5	725.0	1240.5	2532.5

Appendix 3. Effect of cinnamon and garlic on feed conversion ratio (FCR) of birds under different treatments

Treatment	Replication	1st Week	2nd Week	3rd Week	4th Week
T_0	R_1	0.92	1.09	1.10	1.35
	R_2	0.89	1.05	1.11	1.32
	R_3	0.90	1.09	1.09	1.34
T_1	R_1	0.90	1.12	1.08	1.35
	R_2	0.90	1.13	1.05	1.29
	R_3	0.92	1.04	1.21	1.34
T_2	R_1	0.97	1.04	1.05	1.34
	R_2	0.91	1.06	1.10	1.35
	R_3	0.93	1.07	1.08	1.31
T_3	R_1	0.91	1.04	1.14	1.35
	R_2	0.91	1.06	1.04	1.34
	R_3	0.92	1.06	1.06	1.29
T_4	R_1	0.85	1.00	1.08	1.29
	R_2	0.92	1.09	1.11	1.33
	R_3	0.88	0.99	1.05	1.29

Appendix 4. Effect of cinnamon and garlic on body weight (BW) (g/bird) of 1st, 2nd, 3rd and 4th week under different treatments

Treatment	Replication	1st Week	2nd Week	3rd Week	4th Week
T_0	R_1	223	552	1200	1900
	R_2	230	572	1204	1945
	R_3	228	550	1195	1892
T_1	R_1	227	533	1230	1836
	R_2	223	528	1230	1924
	R_3	216	568	1161	1838
T_2	R_1	210	532	1230	1849
	R_2	218	527	1180	1885
	R_3	222	527	1230	1924
T_3	R_1	222	543	1230	1893
	R_2	223	537	1230	1868
	R_3	226	539	1230	1928
T_4	R_1	243	606	1244	1991
	R_2	224	550	1201	1919
	R_3	230	572	1230	1965

Appendix 5. Effect of cinnamon and garlic on body weight gain (BWG) (g/bird) of 1st, 2nd, 3rd and 4th week under different treatments

Treatment	Replication	1st Week	2nd Week	3rd Week	4th Week	Final BWG
T_o	R_1	183	329	648	700	1860
	R_2	190	342	632	741	1905
	R_3	188	322	645	697	1852
T_1	R_1	187	306	693	610	1796
	R_2	183	305	699	697	1884
	R_3	176	352	593	677	1798
T_2	R_1	170	322	696	621	1809
	R_2	178	309	649	709	1845
	R_3	182	305	701	696	1884
T_3	R_1	182	321	688	662	1853
	R_2	183	314	689	642	1828
	R_3	186	313	688	701	1888
T_4	R_1	203	363	638	747	1951
	R_2	184	326	651	718	1879
	R_3	190	342	658	735	1925

Appendix 6. Growth performance of broiler chicken under different treatments

Treatment	Replication	Final Live weight (g/bird)	Total FC (g/bird)	Total BWG (g/bird)	Final FCR
T_0	R_1	1900	2560.0	1860	1.35
	R_2	1945	2566.3	1905	1.32
	R_3	1892	2530.5	1852	1.34
T_1	R_1	1836	2474.0	1796	1.35
	R_2	1924	2490.5	1884	1.29
	R_3	1838	2468.6	1798	1.34
T_2	R_1	1849	2482.5	1809	1.34
	R_2	1885	2540.6	1845	1.35
	R_3	1924	2514.5	1884	1.31
T3	R_1	1893	2547.1	1853	1.35
	R_2	1868	2499.3	1828	1.34
	R_3	1928	2486.8	1888	1.29
T_4	R_1	1991	2573.5	1951	1.29
	R_2	1919	2554.5	1879	1.33
	R_3	1965	2532.5	1925	1.29

Appendix 7. Effect of cinnamon and garlic on dressing percentage of broiler chicken

Treatment	Replication	Average Live Weight	Eviscerated Weight	Dressing percentage
T_0	R_1	1900	1130	59.47
	R_2	1945	1071	55.06
	R_3	1892	1084	57.29
T_1	R_1	1836	1074	58.50
	R_2	1924	1085	56.39
	R_3	1838	1062	57.78
T_2	R_1	1849	1076	58.19
	R_2	1885	1059	56.18
	R_3	1924	1085	56.39
T_3	R_1	1893	1065	56.26
	R_2	1868	1049	56.16
	R_3	1928	1058	54.88
T_4	R_1	1991	1125	56.50
	R_2	1919	1132	58.99
	R_3	1965	1126	57.30

Appendix 8. Effect of cinnamon and garlic on thigh, drumstick, back, wing and breast weight (g/bird) of broiler chicken

Treatment	Replication	Breast	Back	Thigh	Drumstick	Wing
	R_1	508	208	82	72	41
T_0	R_2	502	227	85	69	39
	R_3	515	216	81	71	44
	R_1	522	211	78	77	43
T_1	R_2	492	200	84	72	48
	R_3	485	197	82	76	40
	R_1	523	191	83	74	37
T_2	R_2	548	176	76	71	40
	R_3	503	199	78	78	45
	R_1	532	195	82	80	46
T_3	R_2	513	203	78	77	42
	R_3	451	189	85	74	39
	R_1	537	202	81	78	40
T_4	R_2	546	184	88	82	44
	R_3	519	193	84	76	47

Appendix 9. Effect of cinnamon and garlic on internal organs of broiler chicken under different treatment groups (g/bird)

Treatment	Replication	Liver	Heart	Neck	Gizzard	Intestine	Proventriculus	Spleen
	R_1	65	11	41	39	94	8.0	2.0
T_0	R_2	55	12	40	42	92	8.0	2.0
	R_3	49	9	38	38	97	8.0	2.0
	R_1	52	10	39	45	97	9.0	2.0
T_1	R_2	63	8	42	52	94	8.0	2.0
	R_3	51	9	40	41	97	8.0	2.0
	R_1	50	7	40	51	96	10.0	2.0
T_2	R_2	56	12	41	45	97	8.0	2.0
	R_3	47	9	42	44	94	8.0	2.0
	R_1	44	10	42	49	95	9.0	2.0
T_3	R_2	58	11	40	50	97	10.0	2.0
	R_3	42	7	42	43	94	8.0	2.0
	R_1	51	8	38	48	96	10.0	2.0
T_4	R_2	56	9	41	44	94	8.0	2.0
	R_3	50	10	38	46	92	10.0	2.0

Appendix 10. Economic impact of cinnamon and garlic powder on broiler production

Treatment	Replication	Feed Cost (BDT)/Bird	Cost of Cinnamon, Garlic & Antibiotics (BDT)/Bird	Expenditure & Other cost (BDT)/Bird	Total Production Cost (BDT)/Bird	Receipt per bird when sold @160 Tk./kg live weight	Profit per bird (BDT)
	R_1	163.8	0	93.33	257.2	304	46.8
T_0	R_2	163.8	0	93.33	257.2	311	54.0
	R_3	161.9	0	93.33	255.3	303	47.5
	R_1	158.1	21.74	93.33	273.2	294	20.6
T_1	R_2	159.4	21.74	93.33	274.4	308	33.4
	R_3	158.1	21.74	93.33	273.2	294	20.9
	R_1	158.7	7.6	93.33	259.7	296	36.2
T_2	R_2	162.6	7.6	93.33	263.5	302	38.1
	R_3	160.6	7.6	93.33	261.6	308	46.3
	R_1	163.2	7.6	93.33	264.1	303	38.8
T_3	R_2	156.8	7.6	93.33	257.7	299	41.2
	R_3	159.4	7.6	93.33	260.3	308	48.2
	R_1	164.5	15.2	93.33	273.0	319	45.6
T_4	R_2	163.2	15.2	93.33	271.7	307	35.3
	R_3	161.9	15.2	93.33	270.5	314	44.0