EFFECTS OF USING GARLIC (*Allium sativum*) AND TURMERIC (*Curcuma longa*) POWDER AS AN ALTERNATIVE TO ANTIBIOTIC IN BROILER RATION

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This is to certify that the thesis entitled, "EFFECTS OF USING GARLIC (Allium sativum) AND TURMERIC (Curcuma longa) POWDER AS AN ALTERNATIVE TO ANTIBIOTIC IN BROILER RATION" Submitted to the Department of Poultry Science, Sher-E-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE (MS) IN POULTRY SCIENCE embodies the result of a piece of bona fide research work carried out by MST. MAYEEDA PARVIN, REGISTRATION NO. 12-05063 under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that such help or source of information, as has been availed of during the course of this investigation has duly been acknowledged.

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THIS PAPER IS DEDICATED

TO

MY BELOVED PARENTS

AND

RESPECTED TEACHERS

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The Author

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LIST OF ACRONYMS AND ABBREVIATION

ABBREVIATION		FULL MEANING
A.M.	=	Ante Meridian
AGPs	=	Antibiotic Growth Promoters
ANOVA	=	Analysis of Variance
BANSDOC	=	Bangladesh National Scientific and Technical Documentation Centre
BARC	=	Bangladesh Agricultural Research Council
BLRI		Bangladesh Livestock Research Institute
CBC	=	Complete Blood Count
CFU	=	Colony Forming Units
cm^2	=	Square Centimeter
CONT'D	=	Continued
CP	=	Crude Protein
CRD	=	Complete Randomized Design
DP	=	Dressing Percentage
e.g.	=	For Example
EDTA	=	Ethylene Diethyle Tetraacitic Acid
et al.	=	Associates
FC	=	Feed Consumption
FCR	=	Feed Conversion Ratio
g	=	Gram
Hb	=	Hemoglobin
i.e.	=	That is
IBV	=	Infectious Bronchitis Vaccines
Kcal	=	Kilocalorie

LIST OF ACRONYMS AND ABBREVIATION (CONT'D)

ABBREVIATION		FULL MEANING
Kg	=	Kilogram
LW	=	Live weight
M.S.	=	Master of Science
MCH	=	Mean Corpuscular Hemoglobin
MCHC	=	Mean Corpuscular Hemoglobin Concentration
MCV	=	Mean Corpuscular Volume
ml	=	Milliliter
mm	=	Millimeter
mmol	=	Millimole
No.	=	Number
NS	=	Non-significant
P	=	Phosphorus
P.M.	=	Post Meridiem
PCV	=	Packed Cell Volume
ppm	=	Parts per Million
RBC	=	Red Blood Cell
SAU	=	Sher-e-Bangla Agricultural University
SE	=	Standard Error
SPSS	=	Statistical Package for Social Sciences
viz.	=	Such as
Vs	=	Versus
WBC	=	White Blood Cell
WHO	=	World Health Organization

LIST OF SYMBOLS

SYMBOLS		FULL MEANING
*	=	5% level of significance
@	=	At the rate of
&	=	And
℃	=	Degree Celsius
>	=	Greater than
<	=	Less than
/	=	Per
%	=	Percentage
±	=	Plus-minus
:	=	Ratio

EFFECTS OF USING GARLIC (*Allium sativum*) AND TURMERIC (*Curcuma longa*) POWDER AS AN ALTERNATIVE TO ANTIBIOTIC IN BROILER RATION

ABSTRACT

The goal of this study was to determine the effects of dietary supplementation of garlic **(***Allium sativum***)** and turmeric **(***Curcuma longa*) powder as an alternative to antibiotic on production performance and health status of broiler chicken for a period of 28 days. A total of 150 Commercial broiler chicks of Cobb-500 strain randomly divided into 5 treatment groups *viz.* T_0 (Control), T_1 (antibiotic), T_2 (GP 0.5%), T_3 (TP 0.5%) and T_4 (GP 0.25% & TP 0.25%) having three replications consisting of 10 chicks in each. In this study, feed consumption (FC), body weight gain, live weight (LW), FCR and dressing percentage (DP) showed insignificant ($p>0.05$) difference among the treatments. However, comparatively ($p>0.05$) improved FC (2321.67 ± 20.63), highest LW (1625.67 ± 12.57), better FCR (1.43 ± 0.02) and highest DP (71.52 ± 0.33) were obtained in 0.5% TP treated group than other dietary groups. Whereas livability rate was not influenced ($p>0.05$) by different dietary groups. The relative weight of liver, gizzard, heart and intestine of different groups showed that there were non-significant ($p>0.05$) difference among the groups. On the other hand, abdominal fat weight (g) was significantly ($p<0.05$) lower in birds fed with 0.5%TP (20.11 ± 1.44) compared to control group. Different treatment groups were showed insignificant ($p>0.05$) effect on spleen and bursa weight. The mean weight of spleen and bursa were 2.07 ± 0.07g and 2.58 ± 0.09g respectively. Significantly ($p<0.05$) lower concentration (mmol/L) of glucose found in 0.5%TP treated group T_3 (15.62 ± 0.56) than T_0 and T_1 group. On the other hand, control (171.67 ± 6.18) group showed significantly ($p<0.05$) higher concentration **(**mg/dl**)** of cholesterol compared to other dietary groups. Significantly ($p<0.05$) higher level of Hb (g/dl) found in 0.5%TP (9.36 ± 0.30) and GP 0.25% & TP 0.25% (9.24 ± 0.17) group than T_0 and T_1 group. Significantly ($p<0.05$) higher level of RBC (million/mm^3) was obtained in 0.5%TP group (4.52 ± 0.07) compared to T_0 and T_1 group. Significantly ($p<0.05$) lower and higher percentage of neutrophils and lymphocytes respectively was found in garlic and turmeric powder treated group compared to T_0 and T_1 group. The numbers of cecal microflora (CFU/ml), *E. coli* and *Salmonella* spp. were significantly ($p<0.05$) higher in control *(*7.47 ± 0.03 and 5.83 ± 0.12 respectively) group compared to other treatment groups. Total income, net profit and BCR per bird was comparatively highest in T_3 (0.5%TP) group. Analyzing the above research findings, it obtained that 0.5% GP or 0.5% TP or their combination (0.25%GP & 0.25% TP) can be used as an alternative of antibiotic. Although, Birds fed 0.5% turmeric powder (TP) supplemented diet achieved superior result due to turmeric has ability to reduce abdominal fat and glucose, increase hemoglobin, red blood cells and lymphocyte. It also has ability to decline the *E. coli* and *Salmonella spp.*in the gut of broiler chicken and comparatively increase the net economic benefit.

CHAPTER I

INTRODUCTION

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INTRODUCTION

The poultry industry has been successfully becoming a leading industry at present in all over the world. This industry has immense scope for the country through following points: i) Changing livelihood & food habit; ii) Reduction of dependence of meat related to Cow and goat, iii) Ultimately has positive impact on GDP growth rate of the country. Commercial poultry production has been growing rapidly in Bangladesh since early 1990 by using improved genetics, manufactured feeds and management. The poultry sector is an integral part of farming systems and has created both direct and indirect employment opportunity, improved food security and enhanced supply of quality protein, contributing in economic growth rate and reducing poverty level in rural and urban areas of Bangladesh. Poultry meat and eggs are the cheapest sources of protein available in developing countries. The poultry sector of Bangladesh has employed around six million people, of whom 40 per cent are women. The industry is playing a vital role in satisfying the demand of animal protein and reducing unemployment as well as creating self-employment opportunity.

Over the years, the past few decades, the use of antibiotic as growth promoters in poultry nutrition has been associated with fast growing nature of broiler chickens and their short generation interval in order to improve the quality of the final product (Puvača *et al.*, 2013). Antimicrobials' use in animal production dates as far back as the 1910 when due to shortage of meat products, workers carried out protests and riots across America (Ogle, 2013). Scientists at that time started looking for means of producing more meat at relatively cheaper costs; resulting in the use of antibiotics and other antimicrobial agents (Dibner and Richards, 2005).

A low level and subtherapeutic dose of antimicrobials increase the efficiency of animal growth, through improving feed efficiency, preventing and controlling diseases (Niewold, 2007), improving the digestibility of nutrients (Dibner and Richards, 2005), improving the structure of intestinal flora (Norin, 1997), preventing the transmission of zoonotic pathogens (Doyle and Erickson, 2006) and improving the environment (Kobayashi, 2010).

With the global threat of antimicrobial resistance (AMR) and increasing treatment failures, the non-therapeutic use of antibiotics in animal production has been banned in some countries (Cogliani *et al*., 2011). Sweden is known to be the first country to ban the use of antimicrobials for non-therapeutic purposes between 1986 (for growth promotion) and 1988 (for prophylaxis). This move was followed by Denmark, Netherlands, United Kingdom and other European Union countries (Cogliani *et al*., 2011). These countries also moved a step further and banned the use of all essential antibiotics as prophylactic agents in 2011 (Maron *et al*., 2013). In October 2010 the government of Bangladesh imposed a complete ban on AGPs in animal feed through the Fish and Animal Feed Act-2010. Later the government also framed the Animal Feed Rules-2013 to ensure the quality of animal feeds and produce safe foods for consumers (Salim *et al*., 2018).

Many alternative substances obtained from nature and belonging to the groups of prebiotics, probiotics, phytobiotics (essential oils, powders, extracts and phytochemicals), synbiotics, organic acid, exogenous enzymes, recombinant enzymes, nucleotides, polyunsaturated fatty acids and miscellaneous compounds. Phytogenic feed additives are plant-based feed additives or botanicals that are used in natural substances used in animal nutrition. These substances are derived from herbs, spices, other plants and their extracts, like essential oils. To improve chicken healthiness and to fulfil consumer expectations in relation to food quality, poultry producers now a days commonly apply natural dietary supplements mainly medical, aromatic and spice herbs (Popović *et al*., 2018). Results from the use of the phytogenic feed additive (PFA) may include sensorial stimulation and palatability; increased enzymatic activity in the intestinal tract; improved nutrient utilization; antioxidant effects; reduced bacterial pathogenicity; improved gut integrity; and improved reproductive performance.

There are four major families of phytogenic such as essential oils, saponins, tannins and flavonoids, and their efficacy as a protective mechanism for poultry health depends largely on the plant from which they're derived. Essential oils, tannins and saponins are most commonly used in poultry production. Phytochemical composition of turmeric (Curcuma longa) includes 0.4% saponin, 0.76% alkaloid, 0.03% sterol, 1.08% tannin, 0.40% flavonoid, 0.82% phytic acid, and 0.08% phenol (Pfeiffer *et al*., 2003).Garlic (Allium sativum) bulbs, the phytochemical investigation indicates the presence of alkaloids (0.12 g/100g), flavonoids (0.05 g/100g), saponin (0.24 g/100g), tannins (2.52 g/100g) and cardiac glycosides (1.88 g/100g) (Huzaifa *et al*., 2014). Essential oils (EOs) are important aromatic components of herbs and spices, and are used as natural alternatives for replacing antibiotic growth promoters (AGPs) in poultry feed as these have antimicrobial, antifungal, antiparasitic, and antiviral properties. Enhance sex hormones, lower cholesterol, prevent harmful cytotoxins and reduce inflammation due to antioxidant properties of saponins, flavonoids and tannins. The antioxidant activities when compared between turmeric and garlic the potency of these spices was found to be in the order of Turmeric ≥ Dry garlic > Fresh garlic. The antimicrobial activity of these spices was found to be in the order of Turmeric > Garlic (Panpatil *et al*., 2013).

Garlic (*Allium sativum*) have been widely used as herbal supplement in broiler chicken diet because of its strong stimulating effect on the immune system and the very rich aromatic oils which enhance feed digestion (Gardzielewska *et al*., 2013). It possesses antibacterial, antiparasitic, antiviral, antioxidant, anticholesteremic, anti-cancerous and vasodilator characteristics (Hanieh *et al*., 2010). Garlic powder as a natural growth promoter can be potential alternative for common artificial growth promoters like antibiotics and in this respect, it can improve growth rate, feed conversion ratio (FCR), and carcass characteristics (Makwana *et al*., 2015). Garlic has been used for about 50 years as antibiotic growth promoters and to enhance growth performance in poultry and swine Dibner and Richards (2005).

Turmeric (*Curcuma longa*) can be a useful natural growth promoter and safe alternative to antibiotics (Khan R.U., *et al*., 2012). Turmeric (*Curcuma longa*) is one of such perennial herbs which contained an active component named curcumin (Mashhadani, 2015) and it range from 2 to 5% of the turmeric (Bagchi, 2012). Turmeric (*Curcuma longa*) is a popular medicinal herb, which shows a wide range of pharmacological properties, such as hypocholesteremic and hypolipidaemic (El-Khtam *et al*., 2014 and Qasem *et al*., 2015), antioxidant, antiprotozoal, antivenom, antimicrobial, anti-inflammatory, antiproliferative, antitumor and an-tiaging (Amalraj *et al*., 2017). Additionally, it has been suggested that curcumin possess hepatoprotective (Daneshyar *et al*., 2011 and Rajput *et al.*, 2012), antitumor, antiviral and anticancer activity. It is used in gastrointestinal and respiratory disorders (Gilani *et al*., 2006). The recent reports have been suggested that the efficacy of turmeric in poultry feed in order to replace antibiotics use. It has been found that the feeding of turmeric rhizome powder in the poultry diet helped to improve the morbidity and mortality of broiler chickens (Al-Kassie, 2011). It is also proven that the use of turmeric in poultry feed is helpful for the public health with no side effects.

On the basis of this above background, the experiment was planned to explore the effect of garlic (*Allium sativum*) and turmeric (*Curcuma longa*) powder as the replacement of antibiotic growth promoters, with the following objectives:

1. To evaluate the effect of garlic and turmeric powder on growth performance and immune organs characteristics of broiler chicken comparison with antibiotic and basal diet.

2. To evaluate the effect of garlic and turmeric powder on hematological parameters and cecal microbial characteristics of broiler chicken.

CHAPTER II

REVIEW OF LITERATURE

CHAPTER II
REVIEW OF LITERATURE

Performing any type of survey or experiment review of literature is important which are linked to the proposed study for the convenient of research work. During the last decade, different studies have been attempted to find nutrition-based health approaches and natural feed additives to improve performance and immunity of poultry, and strongly recommended the use of phytogenic additives.

The literature reviewed here have been limited to these which are considered compatible and related to the objectives of the present study. A total about 140 literature were reviewed to identify the background, drawbacks and prospects of research, understand previous findings and to answer the research status of this field. Among them 55 were full article and 65 abstracts, 20 were only titles and some were miscellaneous.

A brief account is given below depending on eight main headlines viz, Impact of antibiotic use in poultry production, Antibiotic growth promoters (AGPs), Antimicrobial resistance (AMR), Antimicrobial residues, Alternatives to antibiotic growth promoters, Phytogenic feed additives, Turmeric and Garlic.

Poultry meat and eggs are among the animal-source foods most widely eaten at global level, across greatly diverse cultures, traditions and religions. Demand for poultry meat and eggs is expected to continue increasing due to population growth and rising individual consumption. Research on meat production globally indicates poultry as the fastest growing livestock sector especially in developing countries. It has triggered the discovery and widespread use of a number of “feed additives”.

According to FAO (2017), chickens accounted for some 92 percent of the world’s poultry population. Chickens contribute 89 percent of world poultry meat production and the rest comes from other poultry species. Since the early 1960, global per capita consumption of poultry meat has increased fivefold. To meet growing demand, world poultry meat production soared from 9 to 122 million tons between 1961 and 2017, and egg production shot up from 15 to 87 million tons. In 2017, poultry meat represented about 37% of global meat production.

2.1 Impact of Antibiotic Use in Poultry Production

Antibiotics are naturally occurring, semi-synthetic, or synthetic compounds with antimicrobial activity and are most widely used drugs in the poultry industry. They are administered parenterally or intravenously, topically, and orally (Lawal *et al*., 2015; Adel *et al*., 2016). Antibiotic drugs are typically used to serve three purposes in poultry, (1) therapeutic use where animals (either individually or in small groups) are administered with high doses of antibiotics for relatively shorter periods, (2) prophylactic use that involves exposure of animals with moderate doses of antimicrobials for longer time durations, and (3) growth promotion where antibiotics in sub therapeutic doses, for example, 10 or 100 times less than therapeutic doses are given for a very long duration or throughout the entire lifespan of the animals (Marshall and Levy, 2011; Chowdhury *et al*., 2009). The antibiotics are known to inhibit (1) DNA replication, (2) Ribonucleic acid (RNA) and protein synthesis, (3) cell division, differentiation and development, (4) target folic acid metabolism, or (5) disrupt cell membrane and cell wall synthesis of microorganisms responsible for dissemination of infections (Kohanski *et al*., 2010; Diarra and Malouin, 2014). Dietary antibiotics have been used in the food animal industry for more than 60 years, not only to control infectious diseases, but also to increase feed efficiency and improve growth performance (Dahiya *et al*., 2006; Castanon, 2007).

Poultry industry uses antibiotics to improve meat production through increased feed conversion, growth rate promotion and disease prevention. Antimicrobials' use in animal production dates as far back as the 1910 when due to shortage of meat products, workers carried out protests and riots across America (Ogle, 2013). Scientists at that time started looking for means of producing more meat at relatively cheaper costs; resulting in the use of antibiotics and other antimicrobial agents (Dibner and Richards, 2005). Antibiotics can be used successfully at subtherapeutic doses in poultry production to promote growth (Emami *et al*., 2012) and protect the health of birds by modifying the immune status of broiler chickens (Lee *et al*., 2012). This is mainly due to the control of gastrointestinal infections and microbiota modification in the intestine.

The mechanism remains unclear, but antibiotics are likely to act by remodeling microbial diversity and relative abundance in the intestine to provide an optimal microbiota for growth (Dibner and Richards, 2005).

In chickens, subtherapeutic, in-feed antibiotics can increase body weight gain up to 8% and decrease the feed conversion ratio (feed intake/body weight gain) up to 5%, both compared with an antibiotic-free diet (Butaye *et al*., 2003). However, use of antibiotic growth promoters in food animal production has led to the development of antibiotic resistance among the commensal gut microflora, thus increasing the zoonotic risk such as potential to be transferred to humans (Lekshmi *et al*., 2017).

2.2 Antibiotic Growth Promoters (AGPs)

The term “antibiotic growth promoter” is used to describe any medicine that destroys or inhibits bacteria and is administered at a low, sub therapeutic dose. The use of antibiotics for growth promotion has arisen with the intensification of livestock farming. Infectious agents reduce the yield of farmed food animals and, to control these, the administration of sub-therapeutic antibiotics and antimicrobial agents has been shown to be effective.

Antimicrobials are given to broiler chicken in order to control diseases such as necrotic enteritis caused by *Clostridium perfringens*, and also to promote faster growth and improve conversion rates (Castanon, 2007; Fasina *et al*., 2016). The mechanisms through which dietary antibiotics exert their growth promoting effects remain to be established. Experiments with germ-free chickens have seemed to indicate that the action of the growth promoters is mediated by their antibacterial effect. Four hypotheses have been proposed to explain their action: (i) nutrients may be protected against bacterial destruction; (ii) absorption of nutrients may improve because of a thinning of the small intestinal barrier; (iii) the antibiotics may decrease the production of toxins by intestinal bacteria; and (iv) there may be a reduction in the incidence of subclinical intestinal infections (Feighner and Dashkevicz, 1987). Based on these studies, dietary antibiotic supplementation was hypothesized to promote an optimal and balanced microbiota with reduced capacity to evoke an inflammatory response and increased efficiency of energy harvest from nutrients (Huyghebaert *et al*., 2011; Lin, 2011).The intestinal microbiota has been shown to have a tremendous influence on host health and disturbances in its balance (dysbiosis) have been associated with various diseases (Turnbaugh *et al*., 2006).

While several factors, such as diet, environment and genetics can induce changes in the intestinal microbiota, the use of antimicrobials is one of the most important (Yegani and Korver, 2008). The different spectrum of selection depending on the active ingredients present in each compound should induce predictable changes on the intestinal microbiota (Costa *et al*., 2015). However, the in order to adequately address those changes, controlled environmental conditions should be used for the characterizations of changes induced by those drugs.

Changes in the cecal environment are of importance since cecal bacteria are responsible for food fermentation and short chain fatty acids (SCFA) production in chickens (Sergeant *et al*., 2014). Therefore, a better characterization of how AGPs impact the cecal microbiota of chickens could be the keystone for the development of alternative methods to improve growth efficacy in this species (Stanley *et al*., 2012).

2.3 Antimicrobial Resistance (AMR)

Antibiotic resistance (AMR) which is defined as the ability of an organism to resist the killing effects of an antibiotic to which it was normally susceptible and it has become an issue of global interest. This microbial resistance is not a new phenomenon since all microorganisms have an inherent capacity to resist some antibiotics (Hugo and Russel, 1998). However, the rapid surge in the development and spread of AMR is the main cause for concern (Aarestrup *et al*., 2008). In recent years, enough evidence highlighting a link between excessive use of antimicrobial agents and antimicrobial resistance from animals as a contributing factor to the overall burden of AR has emerged (Marshall and Levy, 2011). The extent of usage is expected to increase markedly over coming years due to intensification of farming practices in most of the developing countries (Van *et al*., 2015). The main reasons for the use of antibiotics in food-producing animals include prevention of infections, treatment of infections, promotion of growth and improvement in production in the farm animals (Mathew *et al*., 2009; Castanon *et al*., 2007).

Poultry is one of the most widespread food industries worldwide. Chicken is the most commonly farmed species, with over 90 billion tons of chicken meat produced per year. A large diversity of antimicrobials, are used to raise poultry in most countries (Landers *et al*., 2012; Sahoo *et al*., 2010; Boamah *et al*., 2016). A large number of such antimicrobials are considered to be essential in human medicine. The indiscriminate use of such essential antimicrobials in animal production is likely to accelerate the development of AR in pathogens, as well as in commensal organisms. This would result in treatment failures, economic losses and could act as source of gene pool for transmission to humans. In addition, there are also human health concerns about the presence of antimicrobial residues in meat (Aalipour *et al*., 2013; Darwish *et al*., 2013), eggs and other animal products (Addo *et al*., 2011).

Generally, when an antibiotic is used in any setting, it eliminates the susceptible bacterial strains leaving behind those with traits that can resist the drug. These resistant bacteria then multiply and become the dominating population and as such, are able to transfer (both horizontally and vertically) the genes responsible for their resistance to other bacteria (Laxminarayan *et al*., 2013). Resistant bacteria can be transferred from poultry products to humans via consuming or handling meat contaminated with pathogens (van *et al*., 2000). Once these pathogens are in the human system, they could colonize the intestines and the resistant genes could be shared or transferred to the endogenous intestinal flora, jeopardizing future treatments of infections caused by such organisms((Marshall and Levy, 2011; Hall *et al*., 2011; Jakobsen e al., 2010).

2.4 Antimicrobial Residues

Antimicrobial residues are the parent compounds, their metabolites, and associated impurities of veterinary drugs in any edible portion of an animal product. Antibiotics are used in animal agriculture especially in poultry industry, not only for therapeutic and prophylactic purposes, but also as a growth promoter to enhance the health and productivity of flocks through feed or drinking water (Ahmed and Gareib, 2016).

The massive use of antibiotics and failure to follow the withdrawal period of drugs leads to the consumption of antibiotics at low levels which may increase the risk of occurrence of microbial drug resistance and causes hypersensitivity reaction and disruption of normal intestinal flora in human (Beyene *et al*., 2016, Nisha *et al*., 2008). Several groups of antibiotics including quinolones and fluoroquinolones are frequently used in veterinary medicine for treatment and prevention of diseases, thereby reducing famers' losses (Omotoso and Omojola, 2015).

Nonga *et al*. (2009) who reported that ninety percent of the respondents frequently used tetracycline, amprolium, sulphonamides, trimethoprim, neomycine and flumequine to their chickens. Ninety percent of the respondents had knowledge on antimicrobial withdrawal period. However, 95% of farmers slaughtered their chicken before withdrawal period because were afraid of losses and were unaware of the effects of antimicrobial residues in humans. Laboratory results indicated that 70% of the farms were positive to antimicrobial residues.

Sarker *et al*. (2018) who noted that the frequency of antibiotic residues was highest in liver followed by thigh muscles and breast muscle. In breast muscle highest antibiotic was Ciprofloxacin (39%) followed by Doxycycline (26%), Amoxicillin (24%), Oxytetracycline (23%) and lowest was Enrofloxacin (21%). In thigh muscle, 42, 29, 28, 27 and 24% sample were positive for Ciprofloxacin, Oxytetracycline, Doxycycline, Amoxicillin and Enrofloxacin respectively.

2.5 Alternatives to Antibiotic Growth Promoters

It is now well established that development of antibiotic resistance result from the use of Antibiotic Growth Promoters (AGPs) in animal feed, may be compromised the efficacy of similar antibiotics in therapy for human diseases. In view of rising concerns on the extensive loss in poultry due to GI complaints and implementation of strict laws to use of harmful synthetic drug or antibiotics, creates demand of an alternative disease control resources to enhance gut health and to reduce the use of AGPs (Mirzaei-Aghsaghali, 2012).

Many alternative substances obtained from nature and belonging to the groups of prebiotics, probiotics, phytobiotics (essential oils, powders, extracts and phytochemicals), synbiotics, organic acid, exogenous enzymes, recombinant enzymes, nucleotides, polyunsaturated fatty acids and miscellaneous compounds. Such, alternative substances were referred as Natural Growth Promoters (NGPs). There are a number of such investigated NGPs that are mainly utilised for providing beneficial role for improving health of poultry against various infectious diseases rather than regular nutrition. The involvement of these NGPs in improving of intestinal morphology and nutrient absorption may also encourage the scientists to include these compounds in the diet to improve gut health, promote the growth and overall performance of birds.

2.6 Phytogenic Feed Additives

Phytogenics are a group of natural growth promoters or non-antibiotic growth promoters used as feed additives, derived from herbs, spices or other plants. The term phytogenic feed additives were coined by an Austrian multinational feed additives company named Delacon, and was first introduced to the market in the 1980s.

These substances are derived from herbs, spices, other plants and their extracts, like essential oils. They are natural, less toxic, residue free and ideal feed additives for poultry when compared to synthetic antibiotics. Most common herbs and spices for phyto feed additives in poultry production are oregano (*Origanum vulgare*), thyme (*Thymus vulgaris*), garlic (*Allium sativum*), turmeric (*Curcuma longa*), chili (*Capsicum frutescens*), cinnamon (*Cinnamomum verum*), rosemary (*Salvia rosmarinus*), sage (*Salvia officinalis*) etc., extensively used to feed broiler chickens without any hostile effect on the performance of birds.

Inclusion of phytogenic feed additives (PFA) in diets aiming to improve performance and health has been promoted for broiler chickens and other farm animals (Wallace *et al*., 2010). Supple-mentation of PA to broiler diets has been shown to improve growth performance variables (Jamroz *et al*., 2003; Pirgozliev *et al*., 2015), dietary available energy, and nutrient digestibility (Mountzouris *et al*., 2010; Bravo *et al*., 2014), as well as improve innate immunity and host disease resistance (Lee *et al*., 2013), and antioxidative status (Karadas *et al*., 2014). Addition of PFA to animal diets alters normal gut micro flora in broiler chickens (Kim *et al*., 2015), decreasing the prevalence of pathogens, preventing colonization of the gastrointestinal tract (Mitsch *et al*., 2004; Oviedo-Rond´on *et al*., 2006).

2.7 Garlic (*Allium sativum*)

Bangladesh is very rich in herbal and medicinal plants, inclusion of medicinal plants and herbs such as garlic (*Allium sativum*) in poultry diet could be a good approach. Garlic has prescribed as a folk medicine for thousands of years, from the time of the ancient Greeks to the early Egyptians (Horton *et al*., 1991). Garlic contained abundant bioactive components like sulfur containing compounds (alliin, diallylsulfides and allicin, ajoene) which act as antimicrobial (Gebreyohannes and Gebreyohannes, 2013; Jaber and Al-Mossawi, 2007), antibacterial (Tsao and Yin, 2001), antifungal (Ledezma and Apitz-Castro, 2006), antiviral (Tsao and Yin, 2001), antioxidant, antithrombotic (Fukao *et al*., 2007), anticancer. Moreover, garlic has been found to lower serum and liver cholesterol and abdominal fat percentage (Ashayerizadeh *et al*., 2009).

2.7.1 Effect of Garlic Powder on Feed Consumption

Makwana *et al.* (2019) who reported that dietary supplementation of 0.1% garlic powder significantly ($p<0.05$) improved feed intake as compared to birds supplemented with 0.5 % garlic powder and control. Adjei *et al*. (2015) and Pourali *et al*. (2010) they stated that the lowest level of dietary allicin inclusion recorded an increase in feed intake.

El-katcha *et al*. (2016) who noted that dietary allicin supplementation at 25, 50, 75 or 100 mg/Kg diet increased feed intake throughout the whole experimental period when compared with control group. Mansoub and Myandoab (2011) also reported that the positive effect of Garlic powder (1g/kg) on broiler feed intake. Ramiah *et al*. (2014) who found that birds fed diets supplemented garlic powder (0.5%) had higher feed intake than control.

On the other hand, Khaidem *et al*. (2019) who revealed that there was no significant ($p>0.05$) difference in feed intake due to different levels of garlic powder (0%, 0.25%, 0.50% and 0.75%) though the values were observed to be numerically better in garlic treated groups. Karim *et al*. (2017) noted that control group showed significantly ($p<0.05$) higher feed intake over the other dietary groups (antibiotic, garlic 0.25%, garlic 0.50% and garlic 0.75%).

Kyaw *et al*. (2017) and Karangiya *et al*. (2016) they reported that feed intake in control and 1% garlic powder group was similar and did not differ significantly. Rahimi *et al*. (2011) reported non-significant effect of garlic (0.1%) supplementation on feed intake in broilers. Onu (2010) and Aji *et al*. (2011) they indicated that garlic had no effect on feed intake.

2.7.2 Effect of Garlic Powder on Live Weight and Body Weight Gain

An experimental trial of five continuous weeks was undertaken by El-katcha *et al*. (2016) who found that dietary allicin supplementation at 25, 50 and 75mg/kg diet significantly ($P \leq 0.05$) improved final body weight and total gain when compared with control broiler chick group.

Puvača *et al*., (2019) noted that the dietary addition of garlic powder (0.5 g/100g and 1.0 g/100g) achieved final body masses which were statistically significantly ($p<0.05$) higher than masses of chickens in treatments Control diet. Sangilimadan *et al*. (2019) who explained that the groups supplemented with garlic paste of 0.25% and 0.50% had significantly ($p<0.05$) higher body weights than control at 8 weeks of age. But there was no significant difference in the body weight during 4 and 6 weeks of age.

Patel *et al*. (2017) (0.5%), Karangiya *et al*. (2016) (1.0 %), Ramiah *et al*. (2014) (0.5%) and Zekić *et al*. (2014) (2%) they reported that basal diet supplemented with garlic bulb powder significantly ($p<0.05$) improved body weight compared to control groups.

Aji *et al.* (2011) (100 mg) and Suriya *et al.* (2012) (0.25% and 0.5%) they also reported that administration of garlic resulted in improved body weight gain.

On the other hand, Karim *et al*. (2017) showed that the body weight and body weight gain at 4^{th} week and at the end of 32 days were not differ significantly ($p>0.05$) among the treatment (antibiotic, garlic 0.25%, garlic 0.50% and garlic 0.75%) groups. Kyaw *et al*. (2017) (1%), Issa and Abo Omar (2012) (0.2% and 0.4%), Rahimi *et al*. (2011) (0.1%) and Choi *et al*. (2010) (0, 1, 3, and 5%) they also observed that supplementation of garlic did not significantly ($p>0.05$) affect the body weight and weight gain broilers.

2.7.3 Effect of Garlic Powder on FCR

Sangilimadan *et al*. (2019) who explained that the dietary treatments were formulated as a control, 0.25 % and 0.50% garlic paste with basal diet. Experimental birds in 0.25% group showed significantly ($p<0.01$) better feed conversion ratio as compared to control and o.5% groups. The birds fed with basal diet and basal diet supplemented with 0.50% garlic had similar FCR.

El-katcha *et al*. (2016) who observed that allicin supplementation at 25, 50 or 75mg/Kg diet significantly ($p\leq0.05$) improved FCR of broiler chicks throughout the whole experimental period (0-5 weeks) when compared with control one. Patel *et al.* (2017) (0.5%) and Suriya *et al*. (2012) (0.5% and 0.1%) they reported that broilers supplemented with garlic had better FCR when compared to control.

Elagib *et al. (*2013) (3%) and Oleforuh-Okoleh *et al.* (2014) (14g/kg) they observed that the best performance was attained by the group of birds fed on diet garlic powder had best feed conversion efficiency.

On the other hand, Khaidem *et al.* (2019) (0%, 0.25%, 0.50% and 0.75%), Karim *et al.* (2017) (antibiotic, 0.25%, 0.50% and 0.75%), Kyaw *et al*. (2017) (0.5%) and Puvača *et al*. (2014) (0.5%) they observed that feed conversion ratio (FCR) was not significantly ($p>0.05$) improved by dietary garlic treatments compared to control.

2.7.4 Effect of Garlic Powder on Immune Organs

Borgohain *et al*. (2019) who reported that among the lymphoid organs (bursa, thymus and spleen), both bursa and thymus showed non-significant ($p\geq 0.05$) difference in percent weights between the different treatment groups (garlic powder 0.5%, 1% and 1.5%). However, the spleen weight decreased significantly ($p<0.05$) in 1% and 1.5% GP group as compared to control and 0.5% GP group.

Elagib *et al*. (2013) stated that both bursa and thymus showed non-significant difference ($p\geq0.05$) between the different treatments. Spleen weight was decreased significantly ($p<0.05$) in birds fed 3 and 5% garlic level compared to 0% level.

On the other hand, Raeesi *et al*. (2010) found significantly ($p<0.05$) higher bursa percentage in 3% garlic containing diet than control group. However, they reported that the relative weights of spleen were significantly ($p<0.05$) lower in garlic supplemented group. Karim *et al*. (2017) who observed that the treatments (antibiotic, 0.25% garlic powder, 0.50% garlic powder and 0.75% garlic powder) had no significant effect ($p>0.05$) on spleen weight in relation to body weight.

2.7.5 Effect of Garlic Powder on Visceral Organs

Borgohain *et al*. (2019) who reported that the percent weights of liver and gizzard of control group were significantly ($p<0.05$) higher than the garlic fed (0.5%, 1% and 1.5%) groups.

On the other hand, Sangilimadan *et al*. (2019) (0.25% and 0.5% garlic), Islam *et al*. (2018) (0.50%, 0.75%), Karim *et al*. (2017) (antibiotic, 0.25%GP, 0.50% GP and o.75%GP), El-katcha *et al*. (2016) (allicin- 25, 50 or 75 mg/kg diet) and Fayed *et al*. (2011) (raw garlic powder at 0.5 and 1.0 Kg/ton) they noted that insignificant ($p>0.05$) differences among different dietary garlic treatment compared to control groups in terms of weights of liver, heart and gizzard.

Issa and Omer, (2012) found no significant differences in per cent yield of gizzard among different treatment (garlic - 0.2% and 0.4%) groups. Adjei *et al*. (2015) recorded for full gizzard, empty gizzard, heart weight, full intestine weight, empty intestine weight of the experimental birds fed on allicin supplemented diets and also those of the control birds were statistically ($p>0.05$) not significant.

2.7.6 Effect of Garlic Powder on Abdominal Fat

Borgohain *et al*. (2019) who was observed that the garlic supplement elicited significant ($p<0.05$) decrease of the abdominal fat content of the experimental birds of 0.5%, 1% and 1.5% GP group as compared to control group.

Karim *et al*. (2017) noted that 0.75% garlic group showed lowest ($p<0.05$) abdominal fat compared to the other groups (antibiotic, 0.25% garlic powder and 0.50% garlic powder). Oleforuh-Okoleh *et al*. (2014) who found significant ($p<0.05$) depression of weights of abdominal fat in carcasses of broiler chicken supplemented with garlic powder (14g/kg) in feed probably due to the presence of sulfur compounds.

On the other hand, Adjei *et al*. (2015) recorded for abdominal fat weight of the experimental birds fed on allicin supplemented diets and also those of the control birds were statistically ($p>0.05$) not significant. Amouzmehr *et al*. (2012) (3.0 and 6.0%) and Rahimi *et al*. (2011) (15 ppm of virginiamycin, basal diets with a 0.1% dose garlic) they observed that relative weights of the abdominal fat pad weight were not affected by garlic treatments

2.7.7 Effect of Garlic Powder on Carcass Quality

Fayed *et al*. (2011) who noted that there was increased in dressing percentage of birds fed on low level of garlic (500 mg/kg diet) compared with other treated groups (control and 1000 mg/kg) garlic powder.

On the other hand, Borgohain *et al*. (2019) who reported that dressing percentage did not differ significantly ($p<0.05$) among different treatment groups (control, 0.5%, 1% and 1.5% GP). El-katcha *et al*. (2016) (25, 50 or 75 mg/kg diet), Kharde and Soujanya (2014) (0.5 and 1 g/kg) and Aji *et al*. (2011) (50mg and 100mg) they reported that supplementation of garlic powder had no significant ($p>0.05$) effects on dressing percentage.

2.7.8 Effect of Garlic Powder on Survivability

Sangilimadan *et al*. (2019) who explained that the birds supplemented with 0.25 % garlic paste had significantly higher livability compared to control group. Puvača *et al*. (2014) who observed that addition of garlic powder (0.5% and 1%) significantly ($p<0.05$) reduce mortality rate than control group.Patel *et al.*, (2017) who have reported that the mean percent livability was 95 % with inclusion of 0.5%garlic in broiler diet.

On the other hand, Makwana *et al.* (2019) who reported that dietary supplementation of 0.1% and 0.5% of garlic powder had insignificant effect on mortality rate. Fayed *et al*., (2011) who reported that there was no significant difference in mortality rate of the broilers due to treatment (raw garlic powder at 0.5 and 1.0 Kg/ton). Borgohain *et al*.

(2019) who reported that among the all treatment groups (garlic powder- 0%. 0.5%, 1% and 1.5%) there was no significant effect on livability rate.

2.7.9 Effect of Garlic Powder on Serum Biochemical Properties

Borgohain *et al*. (2019) who reported that dietary supplementation of garlic powder at different concentrations (0.5, 1.0 and 1.5% of garlic powder) caused a significant decrease in the mean values of total cholesterol. Puvača *et al*. (2014) (0.5%) and Issa and Omar (2012) (0.2% and 0.4%) they reported that significantly ($p<0.05$) lowest concentration of total cholesterol was recorded at garlic powder treated group.

Ratika *et al*. (2018) who observed that the mean serum cholesterol concentration (mg/dl) in broilers of group T2 (3% garlic powder) and T4 (1.5 % garlic powder + 0.25% turmeric powder) was significantly ($p<0.05$) less as compared to the broilers of control group (T1).

Karim *et al*. (2017) noted that total cholesterol was significantly ($p<0.05$) lower in the garlic group (garlic 0.25%, garlic 0.50% and garlic 0.75%) compared to the control and antibiotic groups. And also indicated that the concentration of glucose was significantly ($p<0.05$) lower in the garlic group compared to the control and antibiotic group.

Singh *et al*. (2017) who noted that Supplementation of garlic powder at 2.0% level significantly ($p<0.05$) lowered the serum glucose value as compared to control and antibiotic fed groups. Also revealed that inclusion of garlic powder at 2.0% level significantly ($p<0.05$) reduced cholesterol level as compared to control.

On the other hand, Ala Al Deen (2007) who reported that the biochemical analysis of the serum has not any significant changes in serum glucose levels in all treatment groups (10% raw garlic, 5% raw garlic, antibiotic group and control).

2.7.10 Effect of Garlic Powder on Blood Parameters

Elagib *et al. (*2013) who observed that the different levels of garlic (0, 3 and 5% garlic powder) has no significant effect ($p>0.05$) on total RBC, WBC, PCV and the differential count of white blood cells including neutrophile, eosinophile, monocytes and lymphocytes. There was a significant difference ($p<0.05$) on haemoglobin percentage between different groups, where the birds fed on 0% level showed the highest percentage whereas there was no difference ($p \geq 0.05$) between the other groups fed on 3% and 5% GP.

Eid and Iraqi (2014) who reported that the group fed on diet of garlic powder (200 g garlic powder/ton) had the highest ($p<0.05$) count of WBC, RBC, Hb, heterophyles, lymphocytes and H/L ratio compared with the other groups received 0, 100 and 150 g garlic powder/ton.

Jimoh *et al.* (2012) who observed that supplementation of garlic (0.0, 0.5, 1.0, 1.5, 2.0 and 2.5g/kg) had a non-significant difference on blood haematological (PCV, HB, RBC, WBC, Platelets, MCV, MCH, MCHC) parameters. Fadlalla *et al*. (2010) who reported that Total White Blood Cells (TWBC) of birds fed 0.3% garlic was significantly ($p<0.05$) higher compared to these fed other dietary treatments (0.15, 0.45 and 0.6%) and the lower TWBC was recorded by the control treatment.

Toghyani *et al.* (2011) who observed that mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH) and mean corpuscular hemoglobin concentration (MCHC) were not significantly influenced by the supplementation of garlic (2 and 4 g/kg garlic powder).

El-katcha *et al*. (2016) who noted that garlic extract supplementation at different levels (0.0, 25, 50, 75 or 100 mg allicin/Kg) had no significant effect on TWBCs and HB (%) counts when compared with the control group. But diet (75mg allicin/Kg) significantly ($p<0.05$) increased RBCs counts and PCV% when compared with the control. And also observed that allicin supplementation at 25, 50, 75 or 100 mg/Kg had no significant effect on lymphocytes, monocyte, esinophil and basophil percentages of broiler chicken when compared with the control.

On the other hand, Onyimonyi *et al*. (2012) and who reported that Increasing the level of garlic powder (0, 0.25, 0.50 and 0.75 percent) in the treatments had no significant effect ($p>0.05$) on the hematological integrity of the birds.

2.7.11 Effect of Garlic Powder on Microbial Load

Damanik *et al*. (2017) who reported that garlic extract (1%) was able to reduce the number of *E. coli* bacteria in boiler chicken stool. Garlic has the ability to inhibit the growth of *E. coli* bacteria.

Prihandani, *et al*. (2015) and Ramiah *et al*. (2014) (0.5%) they showed that garlic significantly reduced *E. coli* count in the gut when compared to control. The bacterial inhibitory ability is caused by the content of antimicrobial compounds contained in garlic. Kumar *et al*. (2010) who noted that the supplement (garlic active based growth promoter i.e. G-PRO nature at 250 ppm) was able to reduce the *salmonella* spp. and *E. coli* counts in the intestine when in comparison to the negative control.

On the other hand, Kyaw *et al*. (2017) who observed that no significant ($p>0.05$) effect on the *E. coli* count in the gut of broilers was observed in 1% garlic powder treated groups.

2.8 Turmeric (*Curcuma longa*)

Turmeric (*Curcuma longa*) is one of such perennial herbs which contained an active component named curcumin (Mashhadani, 2015) and it range from 2 to 5% of the turmeric (Bagchi, 2012). The therapeutic properties of curcumin included antibacterial, anticoccidial, antioxidant, hypocholesteremic and hypolipidaemic (Hussein, 2013; El-Khtam *et al*., 2014 and Qasem *et al*., 2015). It also possesses anti-inflammatory, antiseptic, nematocidal, immunomodulatory and hepatoprotective properties (Daneshyar *et al*., 2011 and Rajput *et al*., 2013). Considering the above facts in view the present study was undertaken to determine dietary supplementation of turmeric powder on the performance of broiler chicken fed at different levels with feeds.

2.8.1 Effect of Turmeric Powder on Feed Consumption

An experimental trial of six weeks was undertaken by Choudhury *et al.* (2018) who found that all the weeks that supplementation of turmeric powder at 0.25 %, 0.50 % and 0.75 % improved feed intake except fourth week of age compared to control group. Similar findings with respect to improvement of feed intake were observed by Sharma *et al*. (2015) and Hady *et al*. (2016).

Raghdad *et al.* (2012) who found that during the six weeks of experiment 0.5% of TP insignificantly ($p>0.05$) increased feed intake than the other treatment groups (0.25%, 1% and 1.5% of *Curcuma longa*) and control group. According to Al-Kassie *et al*. (2011) who observed that 0.75- 1g/kg Curcuma longa rhizome powder supplementation Increased feed consumption in broilers.

On the other hand, Alito *et al*. (2019) found the supplementation of turmeric powder in the feed of broiler chicken in treated groups (turmeric powder 2.5 g/kg, 5 g/kg and 7.5 g/kg) showed reduced feed intake in comparison to control. Arslan *et al.* (2017) (0.5 and 1.5%) and Kafi *et al.* (2017) (0.50%) they also found that turmeric powder supplementation significantly ($p>0.05$) decreased feed consumption.

El-Rayes *et al.* (2018) noted that adding turmeric to broiler chick diet did not significantly ($p>0.05$) effect on feed consumption during all experimental periods (0-42 days). Mondal *et al.* (2015) who found that the average feed consumption of broiler chick non-significantly ($p>0.05$) improved due to turmeric supplementation in the diets.

2.8.2 Effect of Turmeric Powder on Live Weight and Body Weight Gain

An experimental trial of six weeks was undertaken by Alito *et al.* (2019) who observed that final live weight significantly ($p<0.05$) higher in turmeric powder 7.5g/kg feed treated group than control, 2.5g/kg and 5g/kg TP supplemented group. Kafi *et al*. (2017); Ahlawat *et al*. (2018) who also observed highest weight on birds supplemented with 7.5g/kg turmeric powder in feed than other groups. Sethy *et al*. (2016) reported that the body weight gain was higher ($p<0.05$) in groups fed diets containing turmeric (0.5% and 1%) compared to control group

According to Arslan *et al*. (2017) noted that turmeric enhanced the secretion of digestive enzymes and hence improved nutrient absorption and ultimately resulting in improved growth performance. Also noted that supplementation at 1 and 1.5% of turmeric powder improved body weight gain. Mondal *et al*. (2015) (0.5%) and Mohamed *et al*. (2012) (0.1% and 0.2%) reported that WG in broiler chicken increased significantly due to dietary turmeric supplementations.

El-Rayes *et al.* (2018) noted that final body weight and weight gain were significantly ($p<0.05$) increased in birds fed diet supplemented with different (0.25%, 0.5% and 1%)

levels of turmeric powder as compared to the control group. Sharma *et al*. (2015) and Mashhadani (2015) who reported that supplementation of turmeric powder in the basal diet of broiler chicken improved final body weight of broiler chicken.

On the other hand, Qasem *et al.* (2015) also did not find any positive effect on body weight gain when turmeric was supplemented at the rates of 1.0 1.2, 1.4, 1.6, 1.8 and 2.0%. Ürüşan *et al.* (2017) noted that it was evidently clear that the high level of turmeric powder such as 10 g/kg is not suitable, in broiler nutrition, because of decreased BW and WG as a result of limited intake of feed.

2.8.3 Effect of Turmeric Powder on FCR

According to Attia *et al*. (2017) who reported that Turmeric supplementation at 1 g/kg feed significantly improved feed conversion ratio (FCR). Raghdad and Al-Jaleel (2012) revealed that 1% turmeric powder treated bird gave better feed conversion ratio compared to control group and other treats (0.25%, 0.5% and 1.5% turmeric powder) group. Fallah and Mirzaei (2016); Kafi *et al*. (2017); who had also reported positive effects of turmeric powder supplementation on feed conversion efficiency in broiler chicken birds.

An experimental trial of six weeks was undertaken by Choudhury *et al.* (2018) who found that the overall FCR of the entire period of experiment was best in 0.75% TP group followed by 0.5%TP, 0.25% TP and control group. El-Rayes *et al.* (2018) noted that Birds fed diet supplemented with 0.25 or 0.5% turmeric powder recorded significantly ($p<0.05$) improvement in feed conversion ratio as compared to the control group.

Alito *et al*. (2019) who observed that supplementation of turmeric powder at the rate 7.5g/kg feed was better as compared to either 5g or 2.5g per kg of feed in terms of feed conversion efficiency (FCE). Ürüşan *et al.* (2017) who revealed that adding 2 g/kg turmeric powder improved feed conversion ratio (FCR). Arslan *et al*. (2017) noted that turmeric powder was supplemented through feed at the rates of 0, 0.5, 1 and 1.5% throughout the rearing period (day 1 to 35). All levels (0.5, 1 and 1.5% turmeric powder) improved feed conversion efficiency but supplementation at the rate of 1.5% showed the best results.

On the other hand, Yaghobfar *et al*. (2011) stated that there was no significant effect of feeding turmeric powder on FCR at the level of 0.4 and 0.8%. Naderi *et al*. (2014) who also reported that Addition of turmeric powder at the level of 7.5 g/Kg, had no significant effect on FCR during the experiment, comparing to the control group. Sugiharto *et al.* (2011) reported no improvement in FCR of broiler chickens when fed diets supplemented with turmeric extract up to 800 mg/Kg live body weight.

2.8.4 Effect of Turmeric Powder on Immune Organs

Sahoo *et al.* (2019) who found that supplementation of turmeric at 0.5% and 1% level had no significant effect on the weight of the lymphoid organs (spleen, thymus gland and bursa of Fabricius) of the broiler birds. El-Rayes *et al.* (2018) noted that the inclusion of turmeric powder up to 0.25 % in broiler diet cause a significant ($P \leq 0.5$) increasing in thymus and spleen weights compared to control group. Abou-Elkhair *et al*. (2014) reported no significant differences in the spleen, thymus gland and bursa of Fabricius relative weight (% body weight) on supplementation of 0.5% turmeric in broiler diet.

On the other hand, Mashhadani (2015) who observed that there was no significant difference between ($p>0.05$) treatments (0%. 0.2%, 0.4% and 0.6% turmeric powder) on bursa of Fabricius index and spleen. Naderi *et al.* (2014) observed that relative weight of bursa of Fabricius was not significantly affected by any of the additives (avilamycin, turmeric powder (2.5g/kg and 7.5g/kg)). Attia *et al*. (2017) noted that lymphoid organs are a good markers of health status of the animal. The impact of turmeric concentrations on lymphoid organs indicates that different concentrations of turmeric did not affect spleen, thymus and Fabricius bursa percentages.

2.8.5 Effect of Turmeric Powder on Visceral Organs

Alito *et al*. (2019) (turmeric powder at the rate of 7.5, 5 & 2.5 g/kg) and Raghdad and Al-Jaleel (2012) (0.25%, 0.5%, 1% and 1.5% turmeric powder) noted that the effect of turmeric in broiler diet on the giblets traits (i.e. Liver, Gizzard, Heart %) no significant ($p<0.05$) differences of treated group as compared with control group. Attia *et al*. (2017) noted that absence of a significant effect of turmeric on the relative weight of liver and intestines due to turmeric supplementation at the rate of 0.5, 1 and 2 g/kg.

Ürüşan *et al.* (2017) it was determined that there were not significant differences between the (turmeric powder at a rate of 0, 2, 4, 6, 8, 10 g/ kg) groups in terms of the weight of the heart and the liver. Mondal *et al.* (2015) who found that Inclusion (0.5%, 1.0% and 1.5%) of turmeric powder caused slightly increased the average weight of liver, heart and gizzard but the differences were non-significant ($p>0.05$).

Mushtaq *et al.* (2014) the increased weight of the gizzard and giblet weight reflects the increasing digestive or metabolic capacity of birds. Abou-Elkhair (2014) noted that 0.5% turmeric powder showed the insignificant differences in the gizzard, heart, relative weight (% BW).

On the other hand, Yesuf *et al.* (2017) also observed that there was non-significant difference ($p\geq 0.05$) in relative weight of liver, heart and GIT among treatment (1% turmeric, 2% turmeric) groups. Arslan *et al.* (2017) who reported that the turmeric powder (0.5%, 1% and 1.5%) supplementation did not significantly ($p>0.05$) affect the liver weight. Nouzarian *et al*. (2011) who reported that, the inclusion of turmeric powder (0.33%, 0.66% and 1.0 %) in broiler diets significantly caused a decrease in relative liver weight and increase in relative heart weight, accompanied by no differences in relative gizzard weight in comparison with control group.

2.8.6 Effect of Turmeric Powder on Abdominal Fat

Mondal *et al.* (2015) who found that Inclusion (0.5%, 1.0% and 1.5%) of turmeric powder a significant ($p<0.05$) decrease in abdominal fat of broiler chicken. Among different dietary treatments, amount of abdominal fat was lowest in 0.5% turmeric powder diet compared to control diet.

Yesuf *et al.* (2017) observed that abdominal fat ratio significantly declined ($p \leq 0.05$) due to dietary supplementation with turmeric at (1 to 2 g/kg) compared to that of the control and the other dietary treatment groups birds.

Nouzarian *et al*. (2011) reported addition of turmeric powder at (3.3, 6.6 and 10 g/kg of diet), Rajput *et al.* (2012) (150-200 mg/kg of feed), Hussein (2013) (5-9 g kg^{-1} of feed), and Wang *et al.* (2015) (100 to 300 mg/kg) reported that dietary supplementation with turmeric markedly reduced the abdominal fat ratio compared to that of the control group birds.

On the other hand, Sugiharto *et al.* (2011) reported that the abdominal fat percentage showed no significant difference (p>0.05) between treatment (turmeric extract of 200, 400, 600 and 800 mg/kg-live BW) groups. This finding favorably compared to the report of Mehala and Moorthy (2008).

2.8.7 Effect of Turmeric Powder on Carcass Quality

According to Alito *et al*. (2019) who observed that the values for dressing percentage and carcass yield were better in TP 7.5g/kg group as compared to the other TP 5, 2.5 & 0 g/kg groups. Arslan *et al.* (2017) who found that Supplementation of TP at the rates of 0.5 and 1.5% significantly improved dressing percentage. Ukoha and Onunkwo (2016) recorded the highest dressed weight in birds fed a diet containing 3% turmeric powder.

Mondal *et al.* (2015) who found that significant increase (p<0.05) in dressing yield was observed in chickens fed the turmeric (0.5%, 1.0% and 1.5%) supplemented diets. Kafi *et al*. (2017) who reported that the supplied commercial broiler diet with 0.5% turmeric insignificantly (p>0.05) revealed the highest dressing percent compare to other groups.

On the other hand, El-Rayes *et al.* (2018) who reported that the impact of turmeric supplementation levels (0, 0.25, 0.5, and 1 %) on relative dressing percentage were not statistically (p>0.05) influenced by the dietary treatments. Hady *et al*. (2016) and Wang *et al.* (2015) reported turmeric has no effect in dressing percentage birds in consistence with the previous findings and current studies.

Raghdad and Al-Jaleel (2012) reported that no significant (p<0.05) differences in dressing percentage of turmeric powder (0.25%, 0.5%, 1% and 1.5% turmeric powder) treated group as compared with control group.

2.8.8 Effect of Turmeric Powder on Survivability

An experimental trial of six weeks was undertaken Choudhury *et al.* (2018) observed that the per cent livability of all the experimental (0.75%, 0.5%, 0.25% & 0% of turmeric powder) groups was 100%. Mondal *et al.* (2015) observed that survivability of broilers did not vary significantly (p>0.05) among different treatment (0%, 0.5%, 1.0% and 1.5% turmeric powder) groups during the whole experimental period.

Attia *et al*. (2017) were reported that in broiler chicken supplemented with diet containing turmeric powder as phytogenic growth promoter. In addition, Al-Kassie *et al*. (2011) noted that curcumin of turmeric had a role on the immune stimulating factor in immune system which reduced the mortality rate in chicken.

On the other hand, Al-Jaleel (2012) found variable mortality rates in broiler chicken fed control and turmeric treated diets.

2.8.9 Effect of Turmeric Powder on Serum Biochemical Properties

Fallah & Mirzaei (2016) noted that no significant differences in blood glucose due to 5 g/kg turmeric powder supplementation in broiler diet. Arslan *et al.* (2017) also found that serum total cholesterol was reduced and HDL-cholesterol was increased, while LDL-cholesterol and triglycerides remained unaffected due to turmeric (0.5%, 1% and 1.5%) supplementation. Choudhury *et al.* (2018) noted that the total serum cholesterol was significantly ($P \leq 0.01$) lower in TP-0.75% and TP-0.5% as compared to control and TP-0.25% group.

Qasem *et al*. (2016) who suggested that inclusion of turmeric powder (1.0 1.2, 1.4, 1.6, 1.8 and 2.0%) in the broiler diet reduced serum glucose level as compared to non-supplemented group. Oyebanji *et al.* (2018) noted that Cholesterol was significantly ($p<0.05$) different across the treatments, the bird fed diets supplemented with turmeric at 10 g/kg of feed and 20 g/kg of feed had significantly low cholesterol values compared with control birds. Faghani *et al.* (2014) who noted that cholesterol level decreased significantly in 100 mg/kg of turmeric extract, 200 mg/kg of turmeric extract group.

Daneshyar *et al.* (2011) that TP supplementationat the rate of 0.75% significantly decreased serum cholesterol, but had no significant effect at the rate of 0.5%. Al-Kassie *et al*. (2011) who reported that supplementation of 2.5 g/kg herbal mixture reduced blood cholesterol and mortality of Arbor Acres broiler chickens.

On the other hand, Mehala and Moorthy (2008) who observed that TUR supplementation alone was not significantly affect serum glucose, total cholesterol, HDL-cholesterol, LDL-cholesterol, or triglycerides. Sethy *et al*. (2016) who demonstrated that total cholesterol were not changed significantly ($p>0.05$) in all treated groups (0.5% and 1% turmeric powder) throughout the experimental period.

Choudhury *et al.* (2018) who noted that the mean values of serum glucose did not differ significantly among different treatment (Turmeric powder- 0%, 0.25%, 0.5% and 0.75%) groups. This indicated that turmeric powder supplementation had no effect on the levels of serum glucose in broiler chicken.

2.8.10 Effect of Turmeric Powder on Blood Parameters

Choudhury *et al.* (2018) who found that there were no significant differences in value of total RBC count between control and turmeric (0.25% and 0.5%) treated groups. The total lymphocyte count showed significant ($p \leq 0.05$) increase in all the three turmeric (0.25%, 0.5% and 0.75%) treated groups as compared to the control group.

Sethy *et al*. (2016) reported that the mean hemoglobin (Hb) values increased significantly ($p<0.05$) in turmeric (0.5% and 1%) fed groups compared to control group but PCV values were in normal range and were found to be comparable ($p>0.05$) in all the three (turmeric- 0%, 0.5% and 1%) groups.

Ukoha and Ununkwo (2016) who observed significantly ($p \leq 0.05$) higher values in total RBC count in broiler chicken supplemented with 0.50, 1.00, 2.00 and 3.00% turmeric powder. Rudrappa (2009) who reported that the significant increase in the RBC count might be due to the presence of iron which was an essential co-factor for cytochrome oxidase enzymes at cellular level metabolisms and required for red blood cell production. Attia *et al*. (2017) (1g/kg), Sadeghi *et al*. (2012) and Al-Noori *et al*. (2011) they noted that the increase in the Hgb and PCV of broilers supplemented with turmeric.

Oyebanji *et al.* (2018) noted that the hematological parameters of boiler chickens was showed that there were significant differences ($p<0.05$) among the means of the PCV (%), RBC, Hb, lymphocytes, heterophils, monocytes, eosinophils and basophils. The PCV & hemoglobin of birds fed 10 g of turmeric per kg of feed was significantly higher ($p< 0.05$) compared to birds in treatments control, turmeric at 20 g/kg of feed and selcon forte at 0.5 g/kg of feed. Significantly higher RBC & lymphocyte were found in treated group than control group birds. The heterophils of birds in the control was significantly ($p<0.05$) higher to other treatments.

Naderi *et al.* (2014) who observed that the percentage of packed cell volume (PCV) and monocytes in peripheral blood were not affected by dietary additives. However, Turmeric powder at the levels of 2.5 g/Kg and 7.5 g/Kg of the diet significantly increased lymphocytes percentage compared with the control group ($p<0.05$). Also, the percentage of heterophils significantly was reduced by turmeric powder at the level of 2.5 g/Kg of the diet ($p<0.05$).

On the other hand, research conducted by Kafi *et al*. (2017) on broilers fed turmeric (0.5% of feed) noted that, blood parameters (HB, PCV, and ESR) were not significantly different to the control. The findings of Al-Jaleel (2012) and Sugiharto *et al*. (2011) also indicated that there were no significant ($p>0.05$) differences in Hb, PCV and total WBC count due to supplementation of turmeric powder in the feed of broiler chicken. Raghdad *et al.* (2012) who showed the effect of turmeric on blood characteristics of broiler (PCV, RBC, Hb, WBC, H/L Ratio), it revealed that there are no significant differences among treatments (turmeric powder- 0.25%, 0.5%, 1% and 1.5%) for (PCV, RBC, Hb, WBC) traits.

2.8.11 Effect of Turmeric Powder on Microbial Load

Sahoo *et al.* (2019) who noted that turmeric supplementation at 1% and 0.5% level could limit the growth of pathogenic bacteria, i.e. *E. coli*. Asmara *et al.* (2018) who observed that the birds fed with control diet had the highest number of S. aureus and E. coli, while the birds fed with the diets added with 2 and 3 g/kg turmeric powder had the lowest number of bacteria. The study reveals that increasing levels of turmeric powder in diets had positive effects on bird's performance and the number of intestinal bacteria.

El-Rayes *et al.* (2018) noted that coliform group, fecal *E. coli*, *Staphylococcus aureus*, *Salmonella* spp., *Shigella* spp., and *Listeria* spp. count were significantly ($p<0.05$) decreased for all supplemented (Turmeric powder- 0.25%, 0.5% and 1%) groups as compared to the control.

Mashhadani (2015) in his experiment on feeding 0, 0.2%, 0.4% and 0.6% turmeric powder in broiler diet and reported that significantly higher lactobacillus count in turmeric fed groups than that of control groups but no significant differences was reported in *E. coli* count. Lawhavinit *et al*. (2010) stated that turmeric could inhibit *S. aureus* of chicken.

Ürüşan *et al*. (2017) who noted that the lowest *E. coli* content was determined in the groups of birds fed with the diets added with 6, 8 and 10 g/kg turmeric powder. Gupata *et al*. (2015) reported that, the ability of rhizome of *C. longa* extracts to inhibit the growth of tested pathogen is an indication of its broad-spectrum antimicrobial potential that can be used to management of microbial infections.

Panpatil *et al*. (2013) observed that the antimicrobial activity was found to be highest in turmeric, followed by ginger and garlic against *Escherichia coli*, *Salmonella typhi* and *Staphylococcus aureus.* Hussein (2013) who reported that turmeric could control and limit the growth and colonization of numerous pathogenic and non-pathogenic species of bacteria in chicken's gut resulting in balanced gut microbial ecosystem that leads to better feed utilization reflected by improved feed conversion ratio.

CHAPTER III

MATERIALS & METHODS

CHAPTER III
MATERIALS & METHODS

3.1 Statement of the Experiment

The research was conducted in the experimental trial shed at Sher-e-Bangla Agricultural University Poultry Farm, Dhaka, with 150-day-old (Cobb 500) straight run commercial broiler chicks for a period of 28 days from 31st October to 27th November, 2018 to assess the feasibility of using garlic powder (GP) and turmeric powder (TP) in commercial broiler diet on growth performance, carcass characteristics, blood profile, immune status and gut health status of broiler chicken. This research helps to make a conclusion about GP and TP as an alternative of antibiotic.

3.2 Collection of Experimental Broilers

A total of 150-day-old Cobb 500 commercial broiler chicks were collected from a renowned hatchery, Gazipur, Dhaka.

3.3 Experimental Materials

The collected chicks were carried to the University poultry farm early in the morning. Then they were kept in electric brooders equally for 3 days by maintaining standard brooding protocol. During brooding time 150 chicks were divided in 4 (GP, TP, GP + TP and control + antibiotic) chambers according to treated diet for the first 3 days. GP, TP and GP + TP chambers were contained randomly selected 30 birds each and these birds were given minimal dose of 0.25% GP , 0.25% TP and 0.25% GP + 0.25% TP respectively with basal diet. On the other hand, control + antibiotic chamber was contained randomly selected 60 birds and these birds were given only basal diet. After three days chicks were selected from brooders and distributed randomly in five (5) dietary treatment groups according to their previous selection. Each treatment had three (3) replications with 10 birds per replication.

3.4 Experimental Treatments

T_0 = Basal diets (Control)

T_1 = Basal diets + Antibiotics (Doxivet ® - 1g/2 litre of drinking water)

T_2 = Basal diets + 0.5% Garlic Powder (0.5 kg GP/ 100kg of the feeds)

T_3 = Basal diets + 0.5% Turmeric powder (0.5 kg TP/ 100kg of the feeds)

T_4 = Basal diets + 0.25% Garlic Powder & 0.25% Turmeric powder (0.25 kg GP & 0.25 kg TP / 100kg of the feeds)

Table 1. Layout of the experiment-

Treatments with Replications (10 birds/ replication)			**No. of birds**
T_3R_2 (n=10)	T_4R_2 (n=10)	T_2R_2 (n=10)	30
T_4R_1 (n=10)	T_1R_2 (n=10)	T_4R_3 (n=10)	30
T_1R_3 (n=10)	T_3R_3 (n=10)	T_0R_3 (n=10)	30
T_0R_2 (n=10)	T_0R_1 (n=10)	T_1R_1 (n=10)	30
T_2R_1 (n=10)	T_2R_3 (n=10)	T_3R_1 (n=10)	30
Total			150

3.5 Preparation of Experimental House

The experimental broiler shed was carefully dry cleaned and then washed up by using tap water. Ceiling wall and floor were thoroughly cleaned and disinfected by spraying diluted Iodophor disinfectant solution (3 ml/liter water). After proper drying, the house was divided into 15 pens of equal size using wood materials and wire net. The height of wire net was 36 cm. A group of 10 birds were randomly allocated to each pen (replication) of the 5 (five) treatments. The stocking density was $1m^2$/10 birds.

3.6 Experimental Diets

Nutrient composition of basal diets for broiler chickens obtained by proximate analysis of feed.

Table 2: Nutrient composition in starter and grower ration-

Nutrient composition	**Starter diet (0-14 days)**	**Grower diet (14-28 days)**
ME	3000 kcal/kg	3100 kcal/kg
Crude Protein	21.0%	19.0 %
Crude Fat	6.0%	6.0%
Fiber	5.0%	5.0%
Ash	8.0%	8.0%
Lysine	1.20%	1.10%
Methionine	0.49%	0.47%

Feed were supplied 4 times daily by following Cobb 500 Manual and ad libitum drinking water 2 times daily.

3.6.1 Collection of Garlic and Turmeric

Garlic and turmeric powder were mixed in commercial basal diets according to treatment level. Garlic cloves & fresh turmeric rhizomes purchased from local spices market and these were cleaned and sliced into small pieces and dried sufficiently in the sunlight to remove moisture content. After drying, required amount of turmeric and garlic was prepared by fine grinding and passing through 1 mm sieve to make powder form. The obtained powder was incorporated into the experimental diets to assess the feasibility of using garlic powder (GP), turmeric powder (TP) & their combination.

Table 3. Nutritional composition of garlic

Nutrient Components	Amount per 100 Gram
Calories	149 kcal
Water	58.58 g
Protein	6.36 g
Fat	0.5 g
Carbohydrate available	33.06 g
Total dietary fiber	2.1 g
Ash	1.5 g
Calcium	181 mg
Phosphorus	153 mg
Iron	1.7 mg
Sodium	17 mg
Potassium	401 mg
Zinc	1.16 mg
Copper	0.299 mg
β-carotene	5 μg
Thiamine	0.2 mg
Riboflavin	0.11 mg
Niacin	0.7 mg
Vitamin B-6	1.235 mg
Folate	3 μg
Vitamin E	0.08 mg

(Source: USDA, 2019)

Table 4. Nutritional composition of turmeric

Nutrient Components	Amount per 100 Gram
Calories	335 kcal
Water	11.50 g
Protein	6.90 g
Fat	8.40 g
Carbohydrate available	47.30 g
Total dietary fiber	21.10 g
Ash	4.80 g
Calcium	168 mg
Phosphorus	279 mg
Iron	33.2 mg
Sodium	35 mg
Potassium	2720 mg
Zinc	3.78 mg
Copper	0.80 mg
β-carotene	15 µg
Thiamine	0.09 mg
Riboflavin	0.17 mg
Niacin	4.4 mg
Vitamin B-6	1.80 mg
Folate	39 µ g
Vitamin E	3.1 mg

(Source: Shaheen *et al*., 2013)

3.7 Management Procedures

Feed intake and Body weight were recorded every week and survivability was recorded for each replication up to 28 days of age. The following management procedures were followed during the whole experimental period.

3.7.1 Brooding of Baby Chicks

The average temperature was 26.8^0C and the RH was 72% in the poultry house. Common brooding was done for three days. After three days the chicks were distributed in the pen randomly. There were 10 chicks in each pen and the pen space was $1m^2$. Due to temperate climate brooding temperature was maintained as per requirement. Brooding temperature was adjusted (below 35^0C) with house temperature. When the environmental temperature was above the recommendation, then no extra heat was provided. At day time few 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.

3.7.2 Room Temperature and Relative Humidity

Daily room temperature (˚C) and humidity (%) were recorded every six hours with a thermometer and a wet and dry bulb thermometer respectively and also recorded maximum and minimum temperature of that day. Averages of room temperature and percent relative humidity for the experimental period were recorded and presented in Appendix 1 & 2.

3.7.3 Litter Management

Rice husk was used as litter at a depth of 6cm. At the end of each day, litter was stirred to prevent accumulation of harmful gases and to reduce parasite infestation. At 3 weeks of age, droppings on the upper layer of the litter were cleaned and for necessity fresh litter was added.

3.7.4 Feeding and Watering

Feed and clean fresh water was offered to the birds *ad libitum*. One large feeder and one big round drinker were provided in each pen for 10 birds. Feeders were cleaned at the end of each week and drinkers were washed daily in the morning before supplying water. Feces and dirt contamination in the feeder and drinker were avoided by raising the feeder and drinker at a manageable height by using brick.

3.7.5 Lighting

At night there was provision of light in the broiler farm to stimulate feed intake and body growth. For first 2 weeks 24 hours light was used. Thereafter 18 hours light and 6 hours dark were scheduled up to 28 days.

3.7.6 Biosecurity Measures

Biosecurity parameters were properly maintained during the whole experimental period. Entry of wild birds and animals were prohibited. Footbath was used in front of the shed door to avoid the risk of pathogen transmission. Vaccination schedule is strictly maintain to prevent diseases. Proper sanitation program was undertaken in the farm and its premises. All groups of broiler chicks were supplied Vitamin B-Complex, Vitamin-ADEK, Vitamin-C, Calcium and electrolytes. Strict sanitary measures were taken during the experimental period. Disinfectant (Virkon) was used to disinfect the feeders and waterers and the house also.

3.7.7 Vaccination

The vaccines were collected from medicine shop (Ceva Company) and administered to the experimental birds according to the vaccination schedule. The vaccination schedule is shown in Table 5.

Table 5. Vaccination schedule

Age of birds	Name of Disease	Name of vaccine	Route of administration
4 days	IB + ND	CEVAC BI L	One drop in eye
9 days	Gumboro	CEVAC IBDL	Drinking Water
17days	Gumboro	CEVAC IBDL	Drinking Water
21 days	IB + ND	CEVAC BI L	Drinking Water

3.7. 8 Ventilation

The experimental broiler shed was south facing and open-sided. Due to wire-net cross ventilation it was easy to remove polluted gases from the farm. Besides ventilation was regulated as per requirement by folding polythene screen. Electric fan was used to reduce the birds from heat stress.

3.8 Study Parameters

3.8.1 Recorded parameters

Data was recorded on Weekly live weight, weekly feed consumption and death of chicks to calculate mortality percent. FCR was calculated from final live weight and total feed consumption per bird in each replication. After slaughter gizzard, liver, spleen, intestine, heart and bursa weight were measured from each broiler chicken. Dressing yield was calculated for each replication to find out dressing percentage. Blood sample was analysis from each replication to measure, Complete blood count (CBC), glucose and cholesterol concentration. Cecal content was collected to measure microbial load in the gut.

3.9 Data collection

3.9.1 Feed Consumption

Daily feed consumption record of each replication was kept to get weekly and total feed consumption record per bird.

3.9.2 Live Weight

The initial day-old live weight and weekly live weight of each replication was kept to get final live weight record per bird.

3.9.3 Dressing Yield

Dressing yield= Live weight- (blood + feathers + head + shank+ digestive system + Liver+ Heart)

3.9.4 Death Records

Daily death record for each replication was counted up to 28 days of age to calculate livability.

3.9.5 Dressing Procedures of Broiler Chicken

Three birds were picked up at random from each replicate at the 28th day of age and sacrificed in halal method to estimate dressing percent of broiler chicken. All birds to be slaughtered were weighed and fasted for overnight (12 hours) but drinking water was provided ad-libitum during fasting to facilitate proper bleeding. All the live birds were weighed again prior to slaughter. Birds were slaughtered by severing jugular vein, carotid artery and the trachea by a single incision with a sharp knife and allowed to complete bleed out at least for 2 minutes. Outer skin was removed by sharp scissor and hand. Then the carcasses were washed manually to remove loose singed feathers and other foreign materials from the surface of the carcass. Afterward the carcasses were eviscerated and dissected according to the methods by Jones and Farrel (1992). Heart and liver were removed from the remaining viscera by cutting them loose and then the gall bladder was removed from the liver. Cutting it loose in front of the proventriculus and then cutting with both incoming and outgoing tracts removed the gizzard. Dressing yield was found by subtracting blood, feathers, head, shank, liver, heart and digestive system from live weight.

3.9.6 Blood Sample Analysis

Blood samples (1 ml/bird) were collected into ethylene diamine tetraacetic acid (EDTA) tubes from the wing veins. Samples were transferred to the laboratory for analysis within 1 hour of collection. Glucose, Cholesterol and CBC was measured from Rainbow diagnosis center, Dhanmondi, Dhaka by maintaining standard protocol.

3.9.7 Estimation of *Escherichia coli* (*E. coli*) and *Salmonella* spp. Population in Broiler Chicken Cecum

EMB agar (eosin methylene blue agar) and *Salmonella-shigella (SS)* agar was used to culture the *E. coli* bacteria and *salmonella* spp. bacteria respectively. The population of *Escherichia coli* and *Salmonella* spp. was estimated as CFU/ ml (colony forming unit). EMB (Company name- HIMEDIA EMB agar) agar and SS (Company name- HIMEDIA SS agar) was purchased from Hatkhola Scientific Market, Dhaka. The composition of HIMEDIA EMB agar and HIMEDIA SS agar is presented in table 7 and 8 respectively.

Table 6. Composition of EMB agar

Ingredients	Amount (grams/liter)
Peptic digest of animal tissue	10.00
Di potassium phosphate	2.00
Lactose	10.00
Eosin – Y	0.40
Methylene blue	0.065
Agar	15.00

Table 7. Composition of SS agar

Ingredients	Amount (grams/liter)
Beef extract	5.00
Peptic digest of animal tissue	5.00
Lactose	10.00
Bile salts mixture	5.50
Sodium citrate	10.00
Sodium thiosulfate	8.50
Ferric citrate	1.00
Brilliant green	0.00033
Neutral red	0.025
Agar	12.00

3.9.8 Preparation of Dilution

At the end of the experiment, 3 birds of each replicating group were slaughtered for extraction of cecal contents. Four sterilized test tubes with 9 ml of PBS were used. One gram of cecal content from each sample was mixed in 9 ml of Phosphate-buffered saline (PBS) in a test tube and shake well, its ratio was 1:10 and dilution factor was 10^{-1}. Then 1 ml liquid was collected from 1:10 ratio in test tube and mixed in 9 ml of PBS in a test tube. Its ratio was 1:100 and dilution factor was 10^{-2}. Then, 1:1000 and 1:10000 ration was made in same way and their dilution factor was 10^{-3} and 10^{-4}respectively. Finally, same procedure was followed up to 10^{-9} dilution factor and 1ml was discarded.

3.9.9 Preparation of Agar Medium

Only 36 grams EMB and 63.02 grams SS agar powder was mixed in 1000 ml distilled water respectively. Mix until suspension was uniform. It was heated to dissolve the medium completely. Dispensed and sterilized by autoclaving at 15 lbs. pressure (121°C) for 15 minutes. Then it was poured into the petri dish. It made cool and shake the medium in order to oxidize the methylene blue (i.e. to restore its blue color) and to suspend the flocculent precipitate. 0.1 ml of liquid of 1:10000 ratio test tube was collected for each sample by micropipette and poured to petri dish which was partially filled with EMB medium. The sample was spread evenly over the surface of agar using the sterile glass spreader and carefully rotating the Petridis underneath at the same time. The plate is incubated at 37°C for 24 h. Discrete colonies on plates were counted using colony counter and estimated in CFU/ml. This procedure also followed for SS agar medium.

3.10 Calculations

3.10.1 Feed Consumption

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

$$\text{Feed Consumption} = \frac{\text{Feed intake in a replication}}{\text{No. of birds in a replication}}$$

3.10.2 Body 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

3.10.3 Feed Conversion Ratio

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

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

3.10.4 Dressing Percentage

Dressing yield was found by subtracting blood, feathers, head, shank, digestive system, liver, heart weight from live weight. Dressing percentage of bird was calculated by the following formulae-

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

3.10.5 Bacterial Colony Count

After 24 hours *E. coli* and *salmonella* spp. colonies were counted by colony counter and following formula was used to estimate *E. coli* and *salmonella* spp. population.

$$\text{CFU/ml} = \frac{\text{No. of colonies} \times \text{Reciprocal of dilution factor}}{\text{Volume inoculated}}$$

3.11 Economic analysis

3.11.1 Total Cost Record

The production cost was divided into two, one is individual cost and another is common cost. Individual cost included feed cost and cost of dietary supplementation for each replication. Common cost included sum price of DOC, litter, vaccine, medicine and others that were equally divided to each replication. All expenses were calculated on the basis of market price at the time of experimental period (Appendix 12**)**.

3.11.2 Total Income Record

Due to difference of final live weight, the selling price of birds was calculated for every individual replication. The price of poultry manure and feed bags were also considered to compute total income. All income were calculated on the basis of market value at the time of experimental period (Appendix 13).

3.11.3 Net profit

Net profit per bird was found out by deducting the total cost from the total income according to replication under each treatment (Appendix 14).

$$\text{Net profit per bird} = \text{Total income per bird} - \text{Total cost per bird}$$

3.11.4 Benefit cost ratio (BCR)

BCR was calculated through dividing the total income by the total cost of production according to replication under each treatment (Appendix 14).

$$\text{BCR} = \frac{\text{Total income}}{\text{Total cost of production}}$$

3.12 Statistical Analysis

Total data were complied, tabulated and analyzed in accordance with the objectives of the study. Excel Program was practiced for preliminary data calculation. The data collected on various parameters were subjected to one-way ANOVA using with the principles of completely randomized design (CRD) procedure of SPSS software. Treatment means were tested using the Duncan's multiple range test and statistical differences declared at $p<0.05$.

CHAPTER IV

RESULT &

DISCUSSION

CHAPTER IV
RESULT AND DISCUSSION

4.1 Production Index of Broiler Chicken

Calculation of Production Index (PI) is one the major parameter to assess the successfulness of broiler chicken production which compare broiler results from different flocks, region and treatment groups. The performance of broiler chickens is measured through five factors. These factors are:

- The level of feed consumption
- The achievement of body weight
- Feed Conversion Ratio
- Dressing Percentage
- Survivability rate

Measurement and assessment of the five factors reflect the quality of maintenance and performance maintenance of broiler chickens.

4.1.1 Weekly Feed Consumption (FC)

Table- 8 shows the feed consumption (g/bird) of broiler birds at different weeks. The mean FC (g/bird) of broiler birds at the end of 4th week in different groups T_0, T_1, T_2, T_3 and T_4 were 954.23 ±14.28, 932.30 ± 23.29, 945.40 ±10.19, 968.03±16.15 and 933.20±31.07g respectively. It is evident from the table that the feed consumption (g/bird) of broiler birds in different week were insignificantly different among the dietary groups. Numerically highest FC (g/bird) was found in T_3 (0.5% TP) group and lowest in T_1 (antibiotic) group. However, the broiler birds of T_2 (0.5% GP), T_3 (0.5% TP) and T_4 (0.25% GP & 0.25% TP) both group consumed insignificantly ($p>0.05$) higher feed than T_1 (antibiotic) group.

Table 8. Effects of garlic & turmeric powder on weekly feed consumption (g/bird) of broiler chickens

Treatment groups	1st Week	2nd Week	3rd Week	4th Week
T_0	179.90 ±.67	428.67 ±1.33	735.00 ±13.53	954.23 ±14.28
T_1	179.83 ± .60	428.17 ±1.38	743.13 ±7.02	932.30 ± 23.29
T_2	179.67 ± .44	435.67 ±6.32	738.93 ±5.81	945.40 ±10.19
T_3	179.67 ± .20	426.80 ±2.25	747.17 ±7.06	968.03 ± 16.15
T_4	180.00 ± .12	429.40 ±.06	750.07 ±.33	933.20 ±31.07
Mean ± SE	179.81 ± .18	429.74 ±1.44	742.86 ±3.34	946.83 ±8.48
Level of Significance	**NS**	**NS**	**NS**	**NS**

Here, T_0 = (Control), T_1 = (Antibiotic), T_2 = (0.5% Garlic Powder), T_3 = (0.5% Turmeric powder) and T_4 = (0.25% Garlic Powder & 0.25% Turmeric powder).
Values are Mean ± SE (n=15) one way ANOVA (SPSS)
SE= Standard Error
NS =Non-Significant

The present study results well corroborated with the observation of Khaidem *et al.* (2019) who revealed that there was no significant (p>0.05) difference in feed intake due to different levels of garlic powder (0%, 0.25%, 0.50% and 0.75%). Rahimi *et al*. (2011) reported non-significant effect of garlic (0.1%) supplementation on feed intake in broilers. On the other hand, these findings were disagreed with El-katcha *et al*. (2016) who noted that dietary allicin supplementation at 25, 50, 75 or 100 mg/Kg diet increased feed intake throughout the whole experimental period when compared with control group.

Above result showed that at the end of 4th week 0.5% TP groups showed insignificantly (p>0.05) better feed intake than control and other groups. These findings favorably compared to earlier report of Choudhury *et al*. (2018) who found that all the weeks (0-6 weeks) the treated groups supplementation of turmeric powder at 0.25 %, 0.50 % and 0.75 % insignificantly (p>0.05) improved feed intake compared to control group. Similar findings with respect to improvement of feed intake were observed by Sharma *et al*. (2015), Raghdad *et al*. (2012) (0.5%) and Hady *et al*. (2016). Nouzarian *et al*. (2011) reported no significant difference in feed intake between the control and turmeric powder treated groups of broiler chicken. The present findings were in contrast to Alito *et al*. (2019) (TP-2.5 g/kg, 5 g/kg and 7.5 g/kg) and Kafi *et al.* (2017) (0.50%) they found that turmeric powder supplementation significantly ($p<0.05$) decreased feed consumption comparison to control.

4.1.2 Weekly Body Weight Gains (BWG)

From the perusal of data (Table 9), it was observed that the BWG (g/bird) of birds at different weeks were insignificant ($p>0.05$) among the treatment groups. The data was also presented in figure 1. The mean body weight gains (g) of broiler chicks at the end of 4th week in different groups T_0, T_1, T_2, T_3 and T_4 were 500.93 ± 16.80, 541.10 ± 37.82, 514.97 ± 50.57, 583.00 ± 12.66 and 543.07 ± 34.49 respectively. Here, 0.5% TP treated group T_3 (583.00 ± 12.66) showed (Figure 1) insignificantly ($p>0.05$) highest body weight gain and lowest in T_0 (control) group at the end of 4th week. However, broiler birds of T_3 (0.5% TP) group performed better weight gain than T_1 (antibiotic) group. On the other hand, birds of T_2 (0.5% GP) group gain lower than T_1 (antibiotic) group. It is also evident from the table- 9 that the birds of T_4 (0.25% GP & 0.25% TP) group performed little higher BWG than T_1 (antibiotic) group of birds.

Table 9. Effects of garlic & turmeric powder on weekly body weight gain (BWG) (g/bird) of broiler chicken

Treatment groups	1st Week	2nd week	3rd week	4th week
T_0	181.87 ± 1.99	321.63 ± 8.23	545.83 ± 6.32	500.93±16.80
T_1	184.33 ± 0.89	326.60 ± 4.44	538.07±14.47	541.10±37.82
T_2	182.63 ± 1.51	328.20 ± 2.49	548.83 ± 8.53	514.97±50.57
T_3	183.63 ± 0.67	323.30 ± 4.31	535.73 ± 3.94	583.00±12.66
T_4	182.97 ± 0.19	310.07 ± 5.89	544.63 ± 5.05	543.07±34.49
Mean ± SE	183.09 ± 0.52	321.96 ± 2.67	542.62 ± 3.48	536.61±14.73
Level of Significance	**NS**	**NS**	**NS**	**NS**

Here, T_0 = (Control), T_1 = (Antibiotic), T_2 = (0.5% Garlic Powder), T_3 = (0.5% Turmeric powder) and T_4 = (0.25% Garlic Powder & 0.25% Turmeric powder).
Values are Mean ± SE (n=15) one way ANOVA (SPSS)
SE= Standard Error
NS =Non-Significant

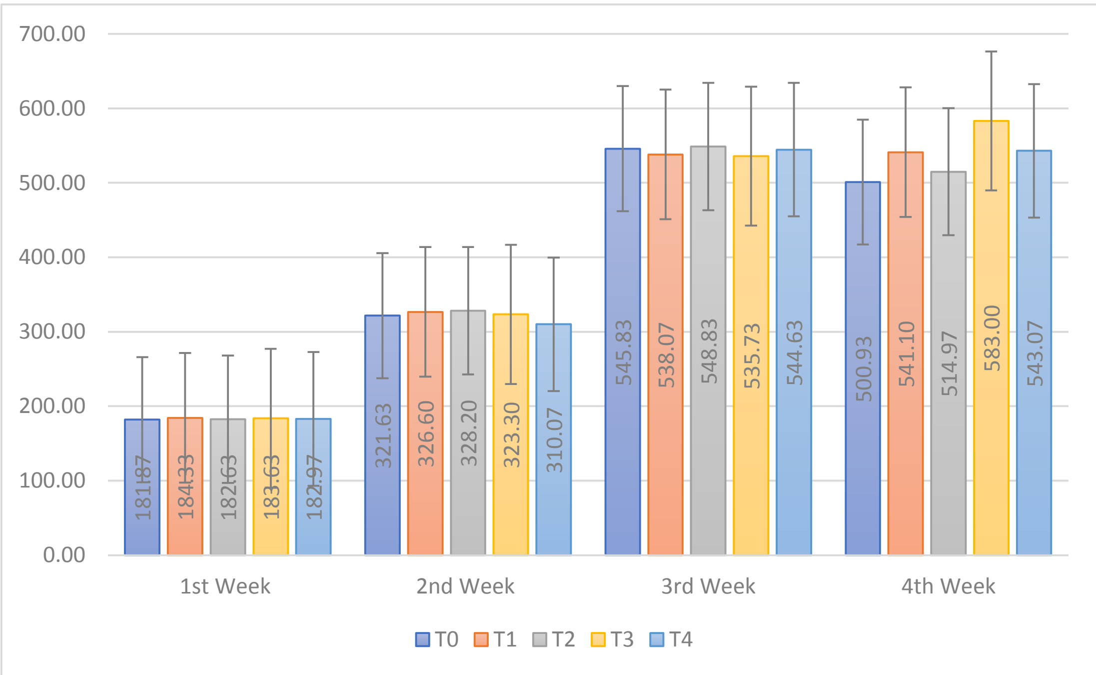

Figure 1. Effects of garlic & turmeric powder on weekly body weight gain (g/bird) of broiler chickens

This findings favorably compared to earlier report of Karim *et al*. (2017) who showed that the body weight and body weight gain at 4^{th} week and at the end of 32 days were not differ significantly ($p>0.05$) among the treatment (antibiotic, garlic 0.25% , garlic 0.50% and garlic 0.75%) groups. The present findings were in contrast to Puvača *et al*. (2019) noted that the dietary addition of garlic powder (0.5 g/100g and 1.0 g/100g) achieved final body masses which were statistically significantly ($p<0.05$) higher than masses of chickens in treatments control diet.

Present findings showed that at the end of 4th week 0.5% TP groups showed insignificantly ($p>0.05$) highest body weight gain than control and other groups. This findings favorably compared to earlier report of Kafi *et al*. (2017); Ahlawat *et al*. (2018) who also observed highest weight on birds supplemented with 7.5g/kg turmeric powder in feed than other groups. Present study also supported the observation of Namagirilakshmi (2005), who stated that broiler fed on turmeric either at 0.25, 0.50, 0.75 or 1% level did not significantly affect body weight gain. On the other hand, present findings were in contrast to El-Rayes *et al.* (2018) (0.25%, 0.5% and 1%) and Sethy *et al*. (2016) (0.5% and 1%) reported that the body weight gain was significantly higher ($p<0.05$) in groups fed diets containing turmeric powder as compared to the control group.

4.1.3 Weekly Feed Conversion Ratio (FCR)

The mean FCR of broiler chicks at the end of 4^{th} week (Table 10) in different groups T_0, T_1, T_2, T_3 and T_4 were 1.91 ± 0.05, 1.74 ± 0.13, 1.87 ± 0.19, 1.66 ± 0.06 and 1.73 ± 0.06 respectively. The overall FCR of broiler in different groups were not significantly ($p>0.05$) different at any week. However, among all the groups T_3 (0.5% TP) showed best FCR followed by other groups. On the other hand, feed conversion efficiency (FCE) of birds in T_2 (0.5% GP) group was lower than T_1 (antibiotic) group. However, FCE of broiler birds in T_4 (0.25% GP & 0.25% TP) group was little higher than T_1 (antibiotic) group.

Table 10. Effects of garlic & turmeric powder on weekly FCR of broiler chickens

Treatment	1st week	2nd week	3rd week	4th week
T_0	0.99 ± 0.01	1.33 ± 0.04	1.35 ± 0.04	1.91 ± 0.05
T_1	0.98 ± 0.01	1.31 ± 0.02	1.38 ± 0.04	1.74 ± 0.13
T_2	0.98 ± 0.01	1.33 ± 0.03	1.35 ± 0.02	1.87 ± 0.19
T_3	0.98 ± 0.00	1.32 ± 0.02	1.39 ± 0.02	1.66 ± 0.06
T_4	0.98 ± 0.00	1.39 ± 0.03	1.38 ± 0.01	1.73 ± 0.06
Mean ± SE	0.98 ± 0.00	1.34 ± 0.01	1.37 ± 0.01	1.78 ± 0.05
Level of Significance	**NS**	**NS**	**NS**	**NS**

Here, T_0 = (Control), T_1 = (Antibiotic), T_2 = (0.5% Garlic Powder), T_3 = (0.5% Turmeric powder) and T_4 = (0.25% Garlic Powder & 0.25% Turmeric powder).
Values are Mean ± SE (n=15) one way ANOVA (SPSS)
SE= Standard Error
NS =Non-Significant

Present findings were in line with Khaidem *et al.* (2019) who revealed that there was no significant (p>0.05) difference in feed conversion efficiency due to different levels of garlic powder (0%, 0.25%, 0.50% and 0.75%). Puvača *et al*. (2014) they observed that feed conversion ratio (FCR) was not significantly (p>0.05) improved by dietary garlic treatments compared to control. The present findings were inconsistent to El-katcha *et al*. (2016) who observed that allicin supplementation at 25, 50 or 75mg/Kg diet significantly (P≤0.05) improved FCR of broiler chicks throughout the whole experimental period (0-5 weeks) when compared with control one.

Present findings showed that the best FCR found in 0.5% TP treated group than control and other groups. These findings favorably compared to earlier report of Hussein (2013); Fallah and Mirzaei (2016); Kafi *et al*. (2017); who had also reported positive effects of turmeric powder supplementation on feed conversion efficiency in broiler chicken birds. These results were also supported by Yaghobfar *et al*. (2011) who stated that there was no significant effect of feeding turmeric powder on FCR at the level of 0.4 and 0.8%. Not in line with current study, El-Rayes *et al*. (2018) (0.25 or 0.5%) and Mashhadani (2015) (0.4%) indicated that FCR was significantly improved (p<0.05) in turmeric powder supplemented group as compared to the control group.

4.1.4 Total Feed Consumption

From the perusal of data (Table 11), it was observed that the total feed consumption (g/bird) during the entire period of the experiment for T_0, T_1, T_2, T_3 and T_4 were 2297.80 ± 24.74, 2283.43 ± 19.48, 2299.67 ± 12.78, 2321.67 ± 20.63 and 2292.67 ± 31.29g respectively. There were no significant (p>0.05) difference in the values of different dietary groups. However, highest feed intake found in 0.5% TP treated T_3 (2321.67 ± 20.63g) group compared to other groups. On the other hand, the birds of T_2, T_3 and T_4 groups consumed higher feed than T_1 group.

With respect to feed consumption of broiler chicken Kyaw *et al*. (2017) and Karangiya *et al*. (2016) they reported that feed intake in control and 1% garlic powder group was similar and did not differ significantly. The present findings were disagreed with Islam *et al*. (2018) reported that significantly (p<0.05) higher feed intake was observed at garlic (0.75%) group and lowest at control group of birds.

Concomitant to the results El-Rayes *et al*. (2018) reported that adding turmeric to broiler chick diet did not significantly (p>0.05) effect on feed consumption during all experimental periods (0-42 days). Here, insignificantly (p>0.05) highest feed intake found in 0.5% TP treated group, these findings also supported Mondal *et al*. (2015) who found that the average feed consumption of broiler chick non-significantly (p>0.05) improved due to turmeric supplementation in the diets. Whereas, the present findings were in contrast to Arslan *et al*. (2017) who found that turmeric powder supplementation significantly (p>0.05) decreased feed consumption at the rates of 0.5 and 1.5%. Hussein (2013) who reported that turmeric supplementation reduced feed intake.

Table 11: Effects of dietary supplementation of garlic & turmeric powder on Production performance of broiler chicken-

Parameters	T_0	T_1	T_2	T_3	T_4	Mean ± SE	Level of significance
Total Feed Consumption (g)/bird	2297.80±24.74	2283.43±19.48	2299.67±12.78	2321.67±20.63	2292.67±31.29	2299.25±9.17	NS
Final Live weight (g)/bird	1550.27±16.28	1590.10±26.03	1574.63±43.25	1625.67±12.57	1580.73±34.49	1584.28±12.72	NS
FCR	1.48 ± 0.02	1.44 ± 0.03	1.46 ± 0.04	1.43 ± 0.02	1.45 ± 0.02	1.45 ± 0.01	NS
Livability (%)	100 ± 0.00	100 ± 0.00	100 ± 0.00	100 ± 0.00	100 ± 0.00	100 ± 0.00	NS
Dressing percentage (%)	68.29 ± 1.54	68.59 ± 2.01	68.81 ± 1.23	71.52 ± 0.33	70.66 ± 1.55	69.57 ± 0.64	NS

Here, T_0 = (Control), T_1 = (Antibiotic), T_2 = (0.5% Garlic Powder), T_3 = (0.5% Turmeric powder) and T_4 = (0.25% Garlic Powder & 0.25% Turmeric powder).
Values are Mean ± SE (n=15) one way ANOVA (SPSS)
SE= Standard Error
NS =Non-Significant

4.1.5 Final Live Weight

Data presented in Table- 11 showed that the effect of treatments on final live weight (g/bird) was not significantly ($p>0.05$) different among the dietary groups. The relative final live weight (g) of broiler chickens in the dietary group T_0, T_1, T_2, T_3 and T_4 were 1550.27 ± 16.28, 1590.10 ± 26.03, 1574.63 ± 43.25, 1625.67 ± 12.57 and 1580.73 ± 34.49g respectively. Highest live weight was attained in T_3 (0.5% TP) group among the treatment groups, whereas lowest in T_0 (control) group. On the other hand, the live weight of broiler birds in dietary group T_2 (0.5% GP) and T_4 (0.25% GP & 0.25% TP) were lower than antibiotics group T_1.

Concomitant to the present findings Kyaw *et al*. (2017) (1%), Issa and Abo Omar (2012) (0.2% and 0.4%) and Rahimi *et al*. (2011) (0.1%) they observed that supplementation of garlic did not significantly ($p>0.05$) affect the body weight and weight gain of broilers. Contrary result was found by Patel *et al*. (2017) reported that basal diet supplemented with 0.5% garlic bulb powder significantly ($p<0.05$) improved body weight compared to control groups up to 42 days in broilers. El-katcha *et al*. (2016) found that dietary allicin supplementation at 25, 50 and 75mg/kg diet significantly ($P\leq0.05$) improved final body weight and total gain when compared with control broiler chick group.

Present findings showed that at the end of the whole experimental period (0-28 days) insignificantly ($p>0.05$) highest live weight (g/bird) was found in 0.5% turmeric treated group than control group. These findings favorably compared to earlier report of Sharma *et al*. (2015) and Mashhadani (2015) who reported that supplementation of turmeric powder in the basal diet of broiler chicken improved final body weight of broiler chicken. The present findings were in contrast to Alito *et al*. (2019) (7.5g/kg), Sethy *et al*. (2016) (0.5% and 1%) and Mondal *et al*. (2015) (0.5%) they reported that body weight gain and final live weight in broiler chicken increased significantly due to dietary turmeric supplementations.

4.1.6 Final Feed Conversion Ratio

The result for final feed conversion ratio (FCR) for different treatment groups of the experiment are shown in Table 11. The relative FCR of broiler chickens in the dietary groups T_0, T_1, T_2, T_3 and T_4 were 1.48 ± 0.02, 1.44 ± 0.03, 1.46 ± 0.04, 1.43 ± 0.02 and 1.45 ± 0.02 respectively. The effect of treatments on FCR of broiler chicken was not significant ($p>0.05$). However, numerically improved FCR was found in 0.5%TP treated T_3 (1.43 ± 0.02) group followed by antibiotic treated T_1 (1.44 ± .03), 0.25% GP+ 0.25% TP treated T_4 (1.45 ± .02), 0.5% GP treated T_2 (1.46 ± .04) and control T_0 (1.48 ± .02) groups.

These findings were well corroborated with the observation of Karim *et al*. (2017) noted that total FCR were not differ significantly ($p>0.05$) among the treatment groups (antibiotic, garlic 0.25%, garlic 0.50% and garlic 0.75%). Fadlalla *et al*., (2010), who reported that garlic powder (0, 0.15, 0.45, 0.3 and 0.6%) had no significant effect on the feed conversion ratio of birds. Contrary result was found by Patel *et al*. (2017) (0.5%) and Suriya *et al*. (2012) (0.5% and 0.1%) they reported that broilers supplemented with garlic had better FCR when compared to control.

Present findings showed that at the end of 28 days of experiment best FCR found in 0.5% TP treated group than control and other groups. In harmony with the present results Fallah and Mirzaei (2016) and Kafi *et al*. (2017) who had reported that positive effects of turmeric powder supplementation on feed conversion efficiency in broiler chicken birds. Naderi *et al*. (2014) who also reported that addition of turmeric powder at the level of 7.5 g/Kg had no significant effect on FCR comparing to the control group. The present findings were in contrast to Alito *et al*. (2019) (7.5g/kg) and Attia *et al*. (2017) (1 g/kg) they reported that Turmeric supplementation feed significantly improved feed conversion ratio (FCR) of broiler chicken.

4.1.7 Livability

The livability rate showed on (table 11) different groups were not significantly ($p>0.05$) different and all the groups were showed livability 100± 0.00 %.

These findings were well corroborated with the observation of Makwana *et al*. (2019) who reported that dietary supplementation of 0.1% and 0.5% of garlic powder had insignificant effect on mortality rate. Borgohain *et al*. (2019) who reported that among the all treatment groups (garlic powder- 0%. 0.5%, 1% and 1.5%) there was no significant effect on livability rate. Contrary to the present observation Sangilimadan *et al*. (2019) who explained that the birds supplemented with 0.25 % garlic paste had significantly higher livability compared to control group.

These findings favorably compared to earlier report of Choudhury *et al.* (2018) who observed that the per cent livability of all the experimental (0.75%, 0.5%, 0.25% & 0% of turmeric powder) groups was 100%. Mondal *et al.* (2015) observed that survivability of broilers did not vary significantly ($p>0.05$) among different treatment (0%, 0.5%, 1.0% and 1.5% turmeric powder) groups during the whole experimental period. Contrary to the present observation Al-Jaleel (2012) found variable mortality rates in broiler chicken fed control and turmeric treated diets.

4.1.8 Dressing Percentage (DP)

From the perusal of data (Table- 11) it was observed that the DP in the dietary groups T_0, T_1, T_2, T_3 and T_4 were 68.29 ± 1.54, 68.59 ± 2.01, 68.81 ± 1.23, 71.52 ± 0.33 and 70.66 ± 1.55 respectively. There were no significant ($p>0.05$) difference of DP among the dietary treatment groups (Table- 11, Figure- 2). However, highest DP (%) was found in 0.5% TP treated T_3 (71.52 ± 0.33) group followed by 0.25% GP+ 0.25% TP treated T_4 (70.66 ± 1.55), 0.5% GP treated T_2 (68.81 ± 1.23), antibiotic treated T_1 (68.59 ± 2.01) and also control T_0 (68.29 ± 1.54) groups. Dressing percentage was also higher in group T_2 and T_4 compared with that of antibiotic group T_1.

Borgohain *et al*. (2019) who reported that dressing percentage did not differ significantly ($p<0.05$) among different treatment groups (control, 0.5%, 1% and 1.5% GP). El-katcha *et al*. (2016) (25, 50 or 75 mg/kg diet) and Kharde and Soujanya (2014) (0.5 and 1 g/kg) they reported that supplementation of garlic powder had no significant ($p>0.05$) effects on dressing percentage. Contrary to the present observation Fayed *et al*., (2011) who noted that there was increased in dressing percentage of birds fed on low level of garlic (500 mg/kg diet) compared with other treated groups (control and 1000 mg/kg garlic powder).

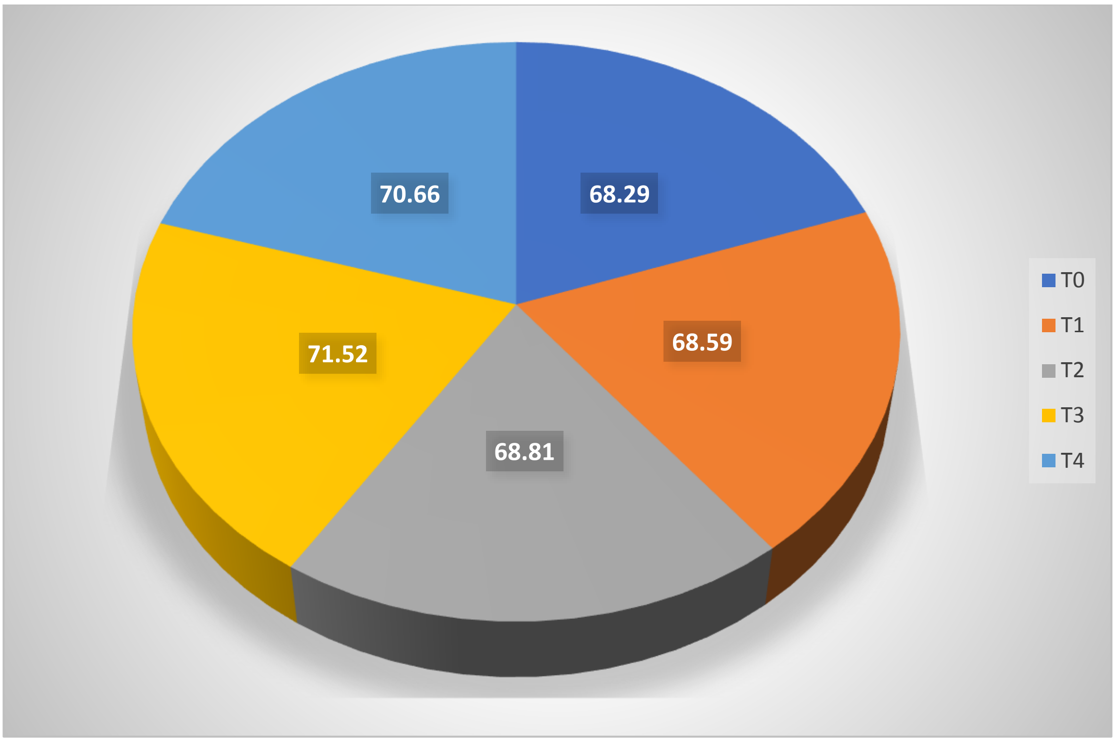

Figure 2. Effects of dietary supplementation of garlic & turmeric powder on dressing percentage of broiler chicken

These findings revealed that different treatment groups had insignificant ($p>0.05$) effect on DP of broiler chicken but highest DP (%) was found in 0.5% TP treated group than the other treated groups and control group. These findings favorably compared to earlier report of Kafi *et al*. (2017) who reported that the supplied commercial broiler diet with 0.5% turmeric insignificantly ($p>0.05$) revealed the highest dressing percent compare to other groups. El-Rayes *et al.* (2018) also reported that the relative dressing percentage were not statistically ($p>0.05$) influenced by the dietary treatments (TP levels: 0, 0.25, 0.5, and 1 %). The present findings were in contrast to Mondal *et al*. (2015) who found that significant increase ($p<0.05$) in dressing yield was observed in chickens fed the turmeric (0.5%, 1.0% and 1.5%) supplemented diets. Arslan *et al*. (2017) found that Supplementation of TP at the rates of 0.5 and 1.5% significantly improved dressing percentage.

4.2 Visceral organs

4.2.1 Relative Giblet Weight (Liver, Heart and Gizzard)

Data presented in Table- 12 showed that the effect of treatments on liver weight (g/bird) was not significant (p>0.05). The mean liver weight (g) of different treatment groups T_0, T_1, T_2, T_3 and T_4 were 37.89 ± 1.94, 36.78 ± 1.69, 41.06 ± 1.14, 39.88 ± 0.92 and 39.39 ± 0.75g respectively. However, highest liver weight was found in 0.5% GP treated T_2 (41.06 ± 1.14g) group and lowest in antibiotic treated T_1 (36.78 ± 1.69g) group.

Table 12. Effects of dietary supplementation of garlic & turmeric powder on Giblet, Intestine and Abdominal fat weight of broiler chicken under different Treatments-

Parameters	Liver weight (g)	Heart weight (g)	Gizzard weight (g)	Intestine weight (g)	Abdominal fat weight (g)
T_0	37.89 ± 1.94	8.72 ± 0.43	40.67±1.56	91.44 ± 3.62	25.11±1.71^{a}
T_1	36.78 ± 1.69	8.06 ± 0.53	42.61±2.04	95.33 ± 5.05	23.78±1.34^{ab}
T_2	41.06 ± 1.14	8.67 ± 0.31	42.44±2.24	98.56 ± 4.97	22.78±1.13^{ab}
T_3	39.88 ± 0.92	8.83 ± 0.46	44.50±2.31	100.78±6.57	20.11±1.44^{b}
T_4	39.39 ± 0.75	9.17 ± 0.49	40.83±1.79	93.00 ± 4.79	21.39±1.81^{ab}
Mean ± SE	38.98 ± 0.63	8.69 ± 0.20	42.21±0.88	95.82 ± 2.23	22.63±0.69
Level of significance	**NS**	**NS**	**NS**	**NS**	*****

^{a,b} values with different superscripts in the same column differ significantly (p<0.05).
Here, T_0 = (Control), T_1 = (Antibiotic), T_2 = (0.5% Garlic Powder), T_3 = (0.5% Turmeric powder) and T_4 = (0.25% Garlic Powder & 0.25% Turmeric powder).
Values are Mean ± SE (n=15) one way ANOVA (SPSS).
SE= Standard Error
NS =Non-Significant
*** means significant at 5% level of significance (p<0.05)**

The comparative weight of heart (g) of broiler chicken in the dietary group T_0, T_1, T_2, T_3 and T_4 were 8.72±.43, 8.06±.53, 8.67±.31, 8.83±0.46, and 9.17±0.49g respectively. The qualified weight of heart of different groups showed that there was no significant (p>0.05) difference (Table 12). Numerically highest and lowest heart weight (g) were found in 0.25% GP+ 0.25% TP treated T_4 (9.17 ± 0.49g) and antibiotic treated T_1 (8.06 ± 0.53g) group respectively.

Data presented in (Table- 12) was showed that, the comparative weight of gizzard (with gizzard content) of different groups did not show any significant (p>0.05) difference among the groups. The comparative weight of Gizzard (g) of broiler chicks in the dietary groups T_0, T_1, T_2, T_3 and T_4 were 40.67±1.56, 42.61±2.04, 44.50±2.31, 42.44±2.24 & 40.83±1.79 respectively. However, the highest gizzard weight (g) was found in 0.5% TP treated group T_3 (44.50±2.31) followed by other dietary groups.

These findings were in line with Karim *et al*. (2017) who observed that the treatments (antibiotic, 0.25% garlic powder, 0.50% garlic powder and o.75% garlic powder) had no significant effect (p>0.05) on liver, heart, gizzard weight in relation to body weight. Sangilimadan *et al*. (2019) noted that non-significant (p>0.05) differences among different dietary treatment groups (control, 0.25% and 0.5% garlic) in terms of weights of liver, heart and gizzard. However, The present findings were disagreed with Borgohain *et al*. (2019) who reported that the percent weights of liver and gizzard of control group were significantly (p<0.05) higher than the garlic fed (0.5%, 1% and 1.5%) groups

In harmony with the present results Alito *et al*. (2019) explained that the values for the organ (Liver, Gizzard, and Heart) weight (g) did not vary between control and treatment (turmeric powder at the rate of 7.5, 5 & 2.5 g/kg) groups. Arslan *et al.* (2017) who reported that the turmeric powder (0.5%, 1% and 1.5%) supplementation did not significantly (p>0.05) affect the liver weight. These findings also supported Mondal *et al.* (2015) who found that inclusion (0.5%, 1.0% and 1.5%) of turmeric powder caused slightly increased the average weight of liver, heart and gizzard but the differences were non-significant (p>0.05). The present findings were inconsistent to El-Rayes *et al.* (2018) who noted that the inclusion of turmeric powder up to 0.25 % in broiler diet cause a significant (p≤0.5) increasing in heart weight, compared to control group. Contrary to the present observation Nouzarian *et al*. (2011) reported that, the inclusion of turmeric powder (0.33%, 0.66% and 1.0 %) in broiler diets significantly caused a decrease in relative liver weight and increase in relative heart weight in comparison with control group.

4.2.2 Weight of Intestine

The mean intestine weight (g/bird) (Table 12) of different experimental groups did not differ significantly among the groups ($p>0.05$). Among the different dietary groups, highest weight of intestine found in 0.5% TP treated group T_3 (100.78 ± 6.57) followed by 0.5% GP treated group T_2 (98.56 ± 4.97), antibiotic treated group T_1 (95.33 ± 5.05), 0.25% GP+ 0.25% TP treated group T_4 (93.00 ± 4.79) and Control T_0(91.44 ± 3.62) group.

Concomitant to the results Adjei *et al*. (2015) recorded that full intestine weight, empty intestine weight of the experimental birds fed on allicin supplemented diets and also those of the control birds were statistically ($p>0.05$) not significant. El-katcha *et al*. (2016) who reported that allicin supplementation at different levels (25, 50 or 75 mg/kg diet) had no significant effect on small intestine and cecum relative weights.

The above result supported by Attia *et al*. (2017) who noted that absence of a significant effect of turmeric on the relative weight of intestines due to turmeric supplementation at the rate of 0.5, 1 and 2 g/kg.

4.2.3 Weight of Abdominal Fat

Different treatment groups (Table 12) showed significant ($p<0.05$) effect on abdominal fat weight (g) of broiler chicken. The comparative weight of abdominal fat (g) of broiler chicken in the dietary group T_0, T_1, T_2, T_3 and T_4 were 25.11±1.71, 23.78±1.34, 22.78±1.13, 20.11±1.44 and 21.39±1.81 respectively. Here, significantly ($p<0.05$) lower abdominal fat found in 0.5% TP treated group T_3 (20.11 ± 1.44) than the control group T_0 (25.11 ± 1.71).

Fat deposition in the abdominal area of broilers is regarded as waste in the poultry industry, since it represents a loss in the market and reduced consumer acceptability. Present result also showed that weight of abdominal fat insignificantly ($p>0.05$) lower in 0.5% GP treated group than control group. These present findings were in agreement with Adjei *et al*. (2015), Amouzmehr *et al*. (2012) (3.0 and 6.0%) and Rahimi *et al*. (2011) (15 ppm of virginiamycin, basal diets with a 0.1% dose garlic) they observed that relative weights of the abdominal fat pad weight were not affected by garlic treatments. These findings were in contrast to Borgohain *et al*. (2019) who observed that the garlic (0.5%, 1% and 1.5% garlic) supplement elicited significant ($p<0.05$) decrease of the abdominal fat as compared to control group. Karim *et al*. (2017) noted that 0.75% garlic group showed lowest ($p<0.05$) abdominal fat compared to the other groups (antibiotic, 0.25% garlic powder and 0.50% garlic powder).

The results of the current study indicated that turmeric supplementation of broiler diets has the potential to reduce this type of waste by reducing abdominal fat content. In accordance with the current results, Yesuf *et al.* (2017) (1 to 2 g/kg), Rajput *et al*. (2013) (150-200 mg/kg of feed), Hussein (2013) (5-9 g kg-1 of feed) and Wang *et al*. (2015) (100, 200 and 300 mg/kg) reported that dietary supplementation with turmeric markedly ($p<0.05$) reduced the abdominal fat ratio compared to that of the control group birds. The present findings were disagreed with Sugiharto *et al.* (2011) reported that the abdominal fat percentage showed no significant difference ($p>0.05$) between treatment (turmeric extract of 200, 400, 600 and 800 mg/kg-live BW) groups.

4.3 Immune Organs

Table 13 showed that, the mean weight (g) of different immune organs of different treated groups. The comparative weight of spleen (g) of broiler chicken in the dietary group T_0, T_1, T_2, T_3 and T_4 were1.89±0.11, 1.89± 0.23, 2.11± 0.14, 2.22± 0.12 and 2.22± 0.17 respectively. The relative weight of spleen of different groups showed that there were no significant ($p>0.05$) difference among the groups. However, insignificantly ($p>0.05$) the highest value found in 0.5% TP treated group T_3 (2.22 ± 0.12) and 0.25% GP+ 0.25% TP treated group T_4 (2.22± 0.17) compared to other groups.

The relative weight (g) of Bursa of different groups showed that there were no significant ($p>0.05$) difference among the groups. However, 0.5% TP treated group T_3 (2.83 ± 0.20) showed highest weight (g) of bursa followed by 0.25% GP+ 0.25% TP treated group T_4 (2.78 ± 0.19), 0.5% GP treated group T_2 (2.67 ± 0.30), control group T_0 (2.33 ± 0.08) and antibiotic treated group T_1 (2.28 ± 0.12).

Table 13. Effects of dietary supplementation of garlic & turmeric powder on immune organs (Spleen and Bursa) of broiler chicken -

Parameters	Spleen weight (g)	Bursa weight (g)
T_0	1.89 ± 0.11	2.33 ± 0.08
T_1	1.89 ± 0.23	2.28 ± 0.12
T_2	2.11 ± 0.14	2.67 ± 0.30
T_3	2.22 ± 0.12	2.83 ± 0.20
T_4	2.22 ± 0.17	2.78 ± 0.19
Mean ± SE	2.07 ± 0.07	2.58 ± 0.09
Level of Significance	**NS**	**NS**

Here, T_0 = (Control), T_1 = (Antibiotic), T_2 = (0.5% Garlic Powder), T_3 = (0.5% Turmeric powder) and T_4 = (0.25% Garlic Powder & 0.25% Turmeric powder).
Values are Mean ± SE (n=15) one way ANOVA (SPSS)
SE= Standard Error
NS =Non-Significant

These findings revealed that different treatment groups had insignificant ($p>0.05$) effect on immune organs (spleen and bursa) weight. These findings were in line with Borgohain *et al*. (2019) who reported that between the lymphoid organs (bursa and spleen), bursa showed no significant ($p\geq 0.05$) difference in per cent weights among the different treatment groups (garlic powder 0.5%, 1% and 1.5%). Karim *et al*. (2017) who observed that the treatment groups (antibiotic, 0.25% garlic powder, 0.50% garlic powder and 0.75% garlic powder) had no significant effect ($p>0.05$) on spleen weight in relation to body weight. Contrary to the present observation Rahimi *et al*. (2011) reported that relative weight of bursa in the garlic group (0.1%) showed a significant ($p< 0.05$) increase as compared with antibiotic and control groups. Elagib *et al*. (2013) stated that spleen weight was decreased significantly ($p<0.05$) in birds fed 3 and 5% garlic level compared to 0% level.

These findings favorably compared to earlier report of Sahoo *et al*. (2019) also found that supplementation of turmeric at 0.5% and 1% level had no significant effect on the weight of the lymphoid organs (spleen and bursa of Fabricius) of the broiler birds.

Mashhadani (2015), and Abou-Elkhair *et al*. (2014) noted that the relative weight of bursa of Fabricius and spleen were not statistically ($p>0.05$) influenced due to TP supplementation. Naderi *et al.* (2014) observed that the weight of bursa of Fabricius in turmeric supplemented groups (2.5g/kg and 7.5g/kg) was numerically higher than that of control and antibiotic supplemented groups. The present findings were in contrast to El-Rayes *et al*. (2018) noted that the inclusion of turmeric powder up to 0.25 % in broiler diet cause a significant ($p\leq0.5$) increasing in spleen weights compared to control group.

4.4 Serum Biochemical Parameters

4.4.1 Total Glucose

The data on table 14 presented in figure 3 showed that, different dietary group had significant ($p< 0.05$) effect on serum glucose level (mmol/L) of broiler chicken. The table showed that 0.5% TP treated group T_3 (15.62 ±0.56) contained lower concentration (mmol/L) of glucose which was statistically significant ($p<0.05$) than the control group T_0 (18.19± 0.71) & antibiotic treated group T_1 (17.71± 0.24). 0.5% GP treated T_2 (17.17± 0.55) group and combined group T_4 (16.89± 0.50) showed numerically lower Glucose level than control (18.19± 0.71) and antibiotic (17.71± 0.24) group.

Table 14: Effects of dietary supplementation of garlic & turmeric powder on Serum biochemical parameters of broiler chicken

Parameters	Glucose (mmol/L)	Cholesterol (mg/dl)
T_0	18.19 ± 0.71^{a}	171.67 ± 6.18^{a}
T_1	17.71 ± 0.24^{a}	152.56 ± 3.83^{b}
T_2	17.17 ± 0.55^{ab}	152.00 ± 5.63^{b}
T_3	15.62 ± 0.56^{b}	152.33 ± 4.49^{b}
T_4	16.89 ± 0.50^{ab}	151.89 ± 3.54^{b}
Mean ± SE	17.12 ± 0.26	156.09 ± 2.38
Level of Significance	*	*

^{a,b} values with different superscripts in the same column differ significantly (P<0.05).
Here, T_0 = (Control), T_1 = (Antibiotic), T_2 = (0.5% Garlic Powder), T_3 = (0.5% Turmeric powder) and T_4 = (0.25% Garlic Powder & 0.25% Turmeric powder).
Values are Mean ± SE (n=15) one way ANOVA (SPSS).
SE= Standard Error
NS =Non-Significant
*** means significant at 5% level of significance (p<0.05)**

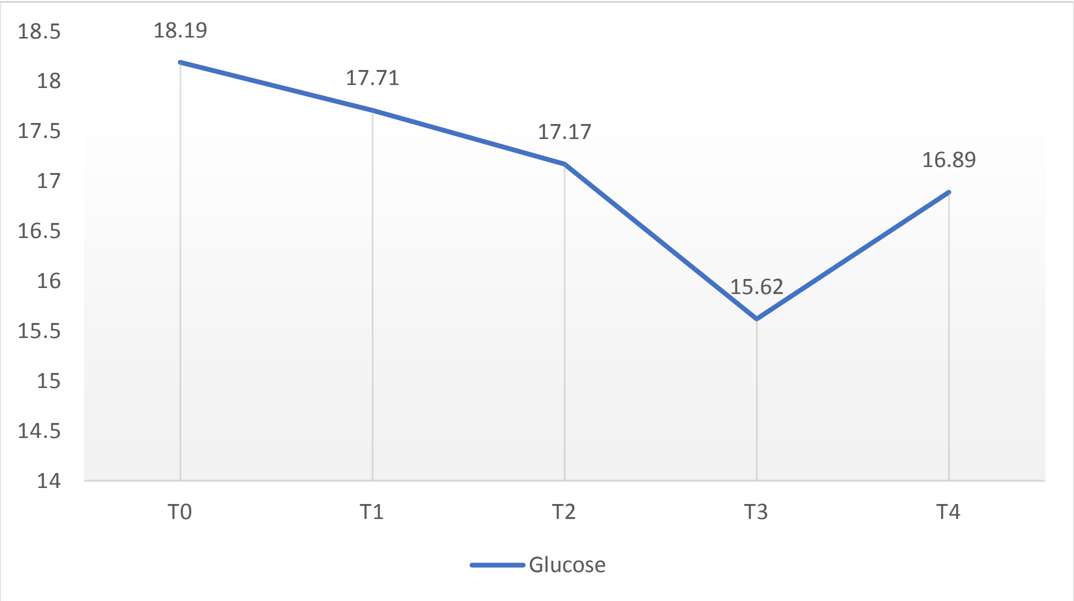

Figure 3. Effects of dietary supplementation of garlic & turmeric powder on serum glucose of broiler chicken

Concomitant to the results Ala Al Deen (2007) who reported that serum glucose levels has not any significant changes due to garlic supplementation. Kim (2010) showed that garlic did not affect glucose level significantly in blood of birds. The present findings were in contrast to Karim *et al*. (2017) noted that the concentration of glucose was significantly ($p<0.05$) lower in the garlic group (0.25%, 0.5% and 0.75% garlic) compared to the control and antibiotic groups. Singh *et al*. (2017) noted that Supplementation of garlic powder at 2.0% level significantly ($p<0.05$) lowered the serum glucose value as compared to control and antibiotic fed groups.

Present result showed that 0.5% TP group significantly reduced the blood glucose level than control and antibiotic group. These results were in line with Qasem *et al*. (2016) (1.0 1.2, 1.4, 1.6, 1.8 and 2.0%) and Ahmadi (2010) (0.3 g/kg) they indicated that serum glucose levels were significantly lower in broiler chickens fed turmeric powderg as a dietary supplement and that this effect was owing to better utilization of glucose. According to Kumari *et al*. (2007) it is possible that turmeric powder increases the activity of glucose transporters, which are a family of transmembrane proteins that help to carry glucose across the plasma lemma. The contrary result was found by Choudhury *et al.* (2018) (TP- 0%, 0.25%, 0.5% and 0.75%) and Fallah and Mirzaei (2016) (5g/kg) they found no significant differences in glucose levels in broiler chicken supplemented with turmeric powder.

4.4.2 Total Cholesterol

The data of table 14 presented in figure 4 showed that, total cholesterol concentration (mg/dl) in the serum of different groups T_0, T_1, T_2, T_3 and T_4 were 171.67 ± 6.18, 152.56 ± 3.83, 152.00 ± 5.63, 152.33 ± 4.49 and 151.89 ± 3.54 respectively. Here, total serum cholesterol concentration (mg/dl) in control group T_0 (171.67 ± 6.18) was significantly ($p<0.05$) higher followed by other groups. However, T_1, T_2, T_3 and T_4 groups are statistically similar but the lowest concentration of total cholesterol was showed in 0.25% GP+ 0.25% TP treated group T_4 (151.89 ± 3.54) than other groups.

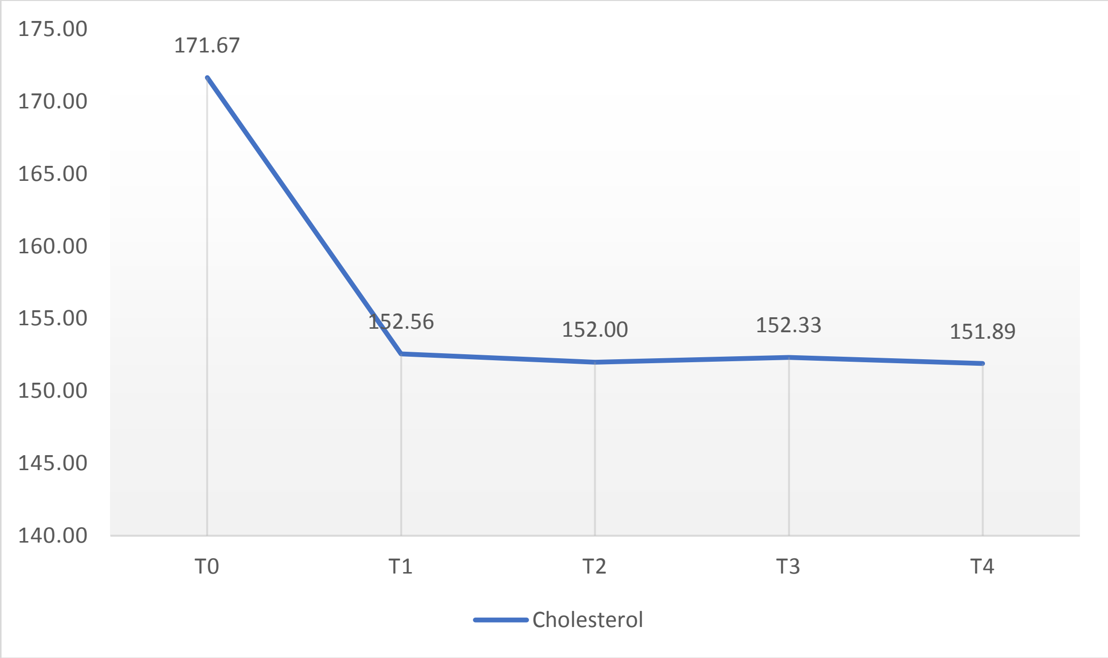

Figure 4. Effects of dietary supplementation of garlic & turmeric powder on serum cholesterol of broiler chicken

These results were supported Ratika *et al*. (2018) who observed that the mean serum cholesterol concentration (mg/dl) in broilers of group T_2 (3% garlic powder) and T4 (1.5 % garlic powder + 0.25% turmeric powder) was significantly ($p<0.05$) less as compared to the broilers of control group (T_1). Karim *et al*. (2017) who noted that total cholesterol was significantly ($p<0.05$) lower in the garlic group (garlic 0.25%, garlic 0.50% and garlic 0.75%) compared to the control groups. Borgohain *et al*. (2019) who reported that dietary supplementation of garlic powder at different concentrations (0.5, 1.0 and 1.5% of garlic powder) caused a significant decrease in the mean values of total cholesterol.

The present study was well corroborated with the observation of Arslan *et al.* (2017) who found that Serum total cholesterol was reduced due to turmeric (0.5%, 1% and 1.5%) supplementation. Choudhury *et al.* (2018) noted that the total serum cholesterol was significantly ($P\leq0.01$) lower in 0.75% and 0.5% turmeric powder treated group as compared to control group. Oyebanji *et al.* (2018) noted that Cholesterol was significantly ($p<0.05$) lower in turmeric at 10 g/kg of feed and 20 g/kg of feed compared with control birds. In contrary Sethy *et al*. (2016) who demonstrated that total cholesterol were not changed significantly ($p>0.05$) in all treated groups (0.5% and 1% turmeric powder) throughout the experimental period.

4.5 Hematological Parameters

The summarized value of blood CBC (Table 15) of different treated groups of broiler chicken showed in (Figure- 5 & Figure- 6). Concerning the treatment effect on blood constituents, the results indicated significant ($p<0.05$) differences due to supplementation of 0.5% GP, 0.5% TP, 0.25% GP & 0.25% TP & antibiotic except, WBC, monocytes, eosinophil, platelets, PCV, MCV, MCH, and MCHC which were insignificantly affected ($p>0.05$). Figure- 5 showed that, concentration of Hb (g/dl) significantly ($p<0.05$) higher in 0.5% TP treated group T_3 (9.36 ± 0.30) and 0.25% GP+ 0.25% TP treated T_4 (9.24 ± 0.17) compared to antibiotic T_1 (8.38 ± 0.27) and control T_0 (7.92 ± 0.17) group. Significantly ($p<0.05$) higher concentration of RBC was found in 0.5% TP treated group T_3 (4.52 ± 0.07) compared to antibiotic T_1 (3.92 ± 0.19) and control T_0 (3.65 ± 0.10) group. Neutrophils (%) was significantly ($p< 0.05$) lower in 0.5% GP treated T_2 (29.83 ± 1.82), 0.5% TP treated T_3 (31.44 ± 1.89) and 0.25% GP & 0.25% TP treated T_4 (29.95 ± 1.13) group compared to control T_0 (37.83 ± 2.00) group. In Figure- 6 lymphocytes (%) was significantly ($p< 0.05$) higher in 0.5% GP treated T_2 (70.50 ± 1.81), 0.5% TP treated T_3 (66.88 ± 2.46) and 0.25% GP+ 0.25% TP treated T_4 (70.10 ± 1.15) group compared to control T_0 (60.50 ± 0.99) and antibiotic T_1 (61.44 ± 1.63) group. Among the groups the average concentration (%) of WBC (10.52 ± 0.16 thousand/ mm^3), monocytes (3.29 ± 0.15%), eosinophil (1.84 ± 0.08%), platelets ($26.37 \pm 0.46\times10^4/mm^3$), PCV (37.34 ± 0.61 %), MCV (82.12 ± 0.46 FI), MCH (30.26 ± 0.19 pg) and MCHC (32.67 ± 0.12 g/dl) were near about equal in both treated and control group which was a sign of indication that there were no extraordinary side effects of treatment groups.

Table 15. Effects of supplementation of garlic & turmeric powder to broiler diets on blood parameters-

Parameters	T_0	T_1	T_2	T_3	T_4	Mean ± SE	Level of significance
Hb (g/dl)	7.92 ± 0.17^{b}	8.38 ± 0.27^{b}	8.68 ± 0.41^{ab}	9.36 ± 0.30^{a}	9.24 ± 0.17^{a}	8.72 ± 0.14	*
RBC (million/mm^3)	3.65 ± 0.10^{c}	3.92 ± 0.19^{bc}	4.07 ± 0.21^{abc}	4.52 ± 0.07^{a}	4.17 ± 0.16^{ab}	4.06 ± 0.08	*
WBC (thousand/ mm^3)	10.62 ± 0.39	10.19 ± 0.39	10.82 ± 0.42	10.31 ± 0.36	10.65 ± 0.22	10.52 ± 0.16	NS
Neutrophils (%)	37.83 ± 2.00^{a}	35.67 ± 2.67^{ab}	29.83 ± 1.82^{b}	31.44 ± 1.89^{b}	29.95 ± 1.13^{b}	32.91 ± 0.96	*
Lymphocytes (%)	60.50 ± 0.99^{b}	61.44 ± 1.63^{b}	70.50 ± 1.81^{a}	66.88 ± 2.46^{a}	70.10 ± 1.15^{a}	65.96 ± 0.95	*
Monocytes (%)	3.11 ± 0.35	3.11 ± 0.31	3.56 ± 0.29	3.12 ± 0.40	3.50 ± 0.40	3.29 ± 0.15	NS
Eosinophils (%)	1.78 ± 0.15	1.78 ± 0.15	1.67 ± 0.17	2.12 ± 0.23	1.90 ± 0.23	1.84 ± 0.08	NS
Platelets (×10^4/mm^3)	26.06 ± 0.98	26.22 ± 0.74	27.83 ± 0.99	26.41 ± 1.35	25.45 ± 1.11	26.37 ± 0.46	NS
PCV (%)	36.32 ± 1.15	39.75 ± 2.19	37.27 ± 1.10	37.58 ± 1.18	35.75 ± 0.63	37.34 ± 0.61	NS
MCV (FI)	81.32 ± 0.58	82.20 ± 1.48	82.71 ± 1.37	83.11 ± 0.74	81.27 ± 0.65	82.12 ± 0.46	NS
MCH (pg)	29.77 ± 0.49	30.10 ± 0.58	29.99 ± 0.22	30.75 ± 0.38	30.68 ± 0.30	30.26 ± 0.19	NS
MCHC (g/dl)	32.59 ± 0.32	33.06 ± 0.31	32.27 ± 0.22	32.98 ± 0.28	32.47 ± 0.14	32.67 ± 0.12	NS

^{a,b,c}, values with different superscripts in the same row differ significantly (P<0.05).

Here, T_0 = (Control), T_1 = (Antibiotic), T_2 = (0.5% Garlic Powder), T_3 = (0.5% Turmeric powder) and T_4 = (0.25% Garlic Powder & 0.25% Turmeric powder).

Values are Mean ± SE (n=15) one way ANOVA (SPSS).

SE= Standard Error

NS =Non-Significant

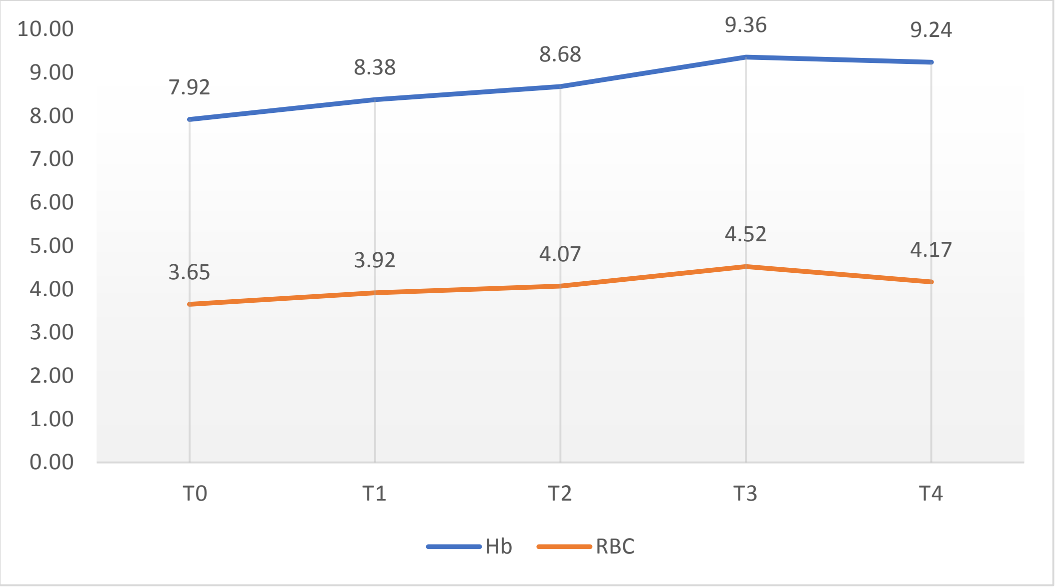

Figure 5. Effects of dietary supplementation of garlic & turmeric powder on blood parameters (Hb & RBC) of broiler chicken

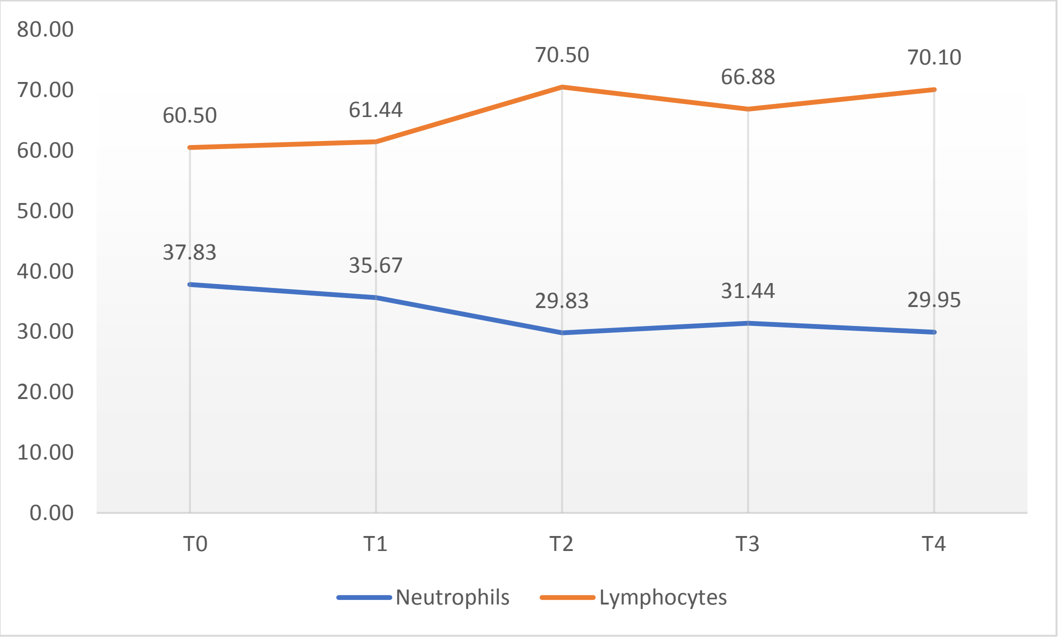

Figure 6. Effects of dietary supplementation of garlic & turmeric powder on blood parameters (neutrophils & lymphocytes) of broiler chicken

The present results were well corroborated with the observation of Jimoh *et al.* (2012) who observed that supplementation of garlic (0.0, 0.5, 1.0, 1.5, 2.0 and 2.5g/kg) had a non-significant difference on blood haematological (PCV, Hb, RBC, Platelets, MCV, MCH, MCHC) parameters. El-katcha *et al*. (2016) noted that garlic supplementation at different levels had no significant effect on WBCs counts when compared with the control. Elagib *et al*. (2013) who observed that the different levels of garlic (0, 3 and 5% garlic powder) has no significant effect ($p>0.05$) on total RBC, PCV. Eid and Iraqi (2014) who reported that the group fed on diet of garlic powder (200 g garlic powder/ton) had the highest ($p<0.05$) count of WBC and lymphocytes compared with the control group. The present findings were in contrast to El-katcha *et al*. (2016) who noted that garlic extract supplementation (75mg allicin/Kg) significantly ($p<0.05$) increased RBCs counts when compared with the control.

In harmony with the present results Oyebanji *et al.* (2018) noted that hemoglobin of birds fed 10 g of turmeric per kg of feed was significantly higher ($p< 0.05$) compared to birds in treatments control and turmeric at 20 g/kg of feed. Significantly higher RBC, lymphocyte were found in treated group than control group birds. The neutrophils of birds in the control was significantly ($p<0.05$) higher to other treatments. Choudhury *et al.* (2018) who found that the total lymphocyte count showed significant ($P\leq0.05$) increase in all the three turmeric (0.25%, 0.5% and 0.75%) treated groups as compared to the control group. Naderi *et al.* (2014) who observed that turmeric powder at the levels of 2.5 g/Kg and 7.5 g/Kg of the diet significantly increased lymphocytes percentage compared with the control group ($p<0.05$). Also, the percentage of neutrophils significantly was reduced by turmeric powder at the level of 2.5 g/Kg of the diet ($p<0.05$). Ukoha and Unukwo (2016) who observed significantly ($P\leq0.05$) higher values in total RBC count in broiler chicken supplemented with 0.50, 1.00, 2.00 and 3.00% turmeric powder. In contrary, research conducted by Kafi *et al*. (2017) on broilers fed turmeric (0.5% of feed) noted that, blood parameters (Hb, and ESR) were not significantly different to the control. Raghdad *et al.* (2012) who revealed that there are no significant differences among treatments (turmeric powder- 0.25%, 0.5%, 1% and 1.5%) for (RBC and Hb) traits.

4.6 Intestinal Microbial Load

The data on table- 16 showed that, *E. coli* count (CFU/ml) was significantly ($p<0.05$) decreased in birds fed 0.5% of turmeric powder (5.33 ± 0.44), 0.5% of garlic powder (5.97 ± 0.41) and antibiotic (6.03 ± 0.29) treated group than the control (7.47 ± 0.03) group. *Salmonella* spp. count (CFU/ml) also had significant ($p<0.05$) decrease in T_1, T_2, T_3 and T_4 group (4.73 ± 0.12, 4.63 ± 0.22, 4.50 ± 0.53 and 4.10 ± 0.15 respectively) than the control group T_0 (5.83 ± 0.12) (figure- 7)

Table 16. Effects of supplementation of garlic & turmeric powder to broiler diets on microbial load (CFU/ml) in the cecum of broiler

Treatment	***E. coli*** **(EMB) × 10^6 (CFU/ml)**	***Salmonella*** **spp. (SS) × 10^6 (CFU/ml)**
T_0	7.47 ± 0.03^{a}	5.83 ± 0.12^{a}
T_1	6.03 ± 0.29^{bc}	4.73 ± 0.12^{b}
T_2	5.97 ± 0.41^{bc}	4.63 ± 0.22^{b}
T_3	5.33 ± 0.44^{c}	4.50 ± 0.53^{b}
T_4	6.80 ± 0.17^{ab}	4.10 ± 0.15^{b}
Mean ±SE	6.32 ± 0.23	4.76 ± 0.19
Level of significance	*	*

^{a,b,c}, values with different superscripts in the same column differ significantly ($P<0.05$).
Here, T_0 = (Control), T_1 = (Antibiotic), T_2 = (0.5% Garlic Powder), T_3 = (0.5% Turmeric powder) and T_4 = (0.25% Garlic Powder & 0.25% Turmeric powder).
Values are Mean ± SE (n=15) one way ANOVA (SPSS).
SE= Standard Error
NS =Non-Significant
*** means significant at 5% level of significance ($p<0.05$)**

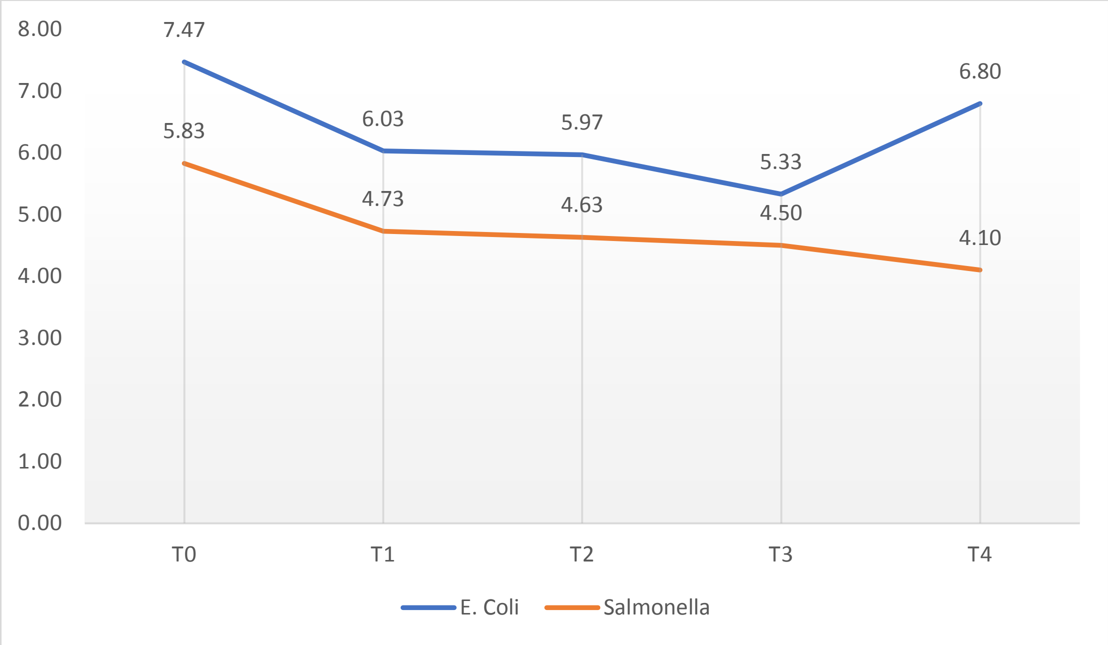

Figure 7. Effects of dietary supplementation of garlic & turmeric powder on microbial load (CFU/ml) in the caecum of broiler chicken

In harmony with the present results Damanik *et al*. (2017) who reported that garlic has the ability to inhibit the growth of *E. coli* bacteria. Prihandani, *et al*. (2015) and Ramiah *et al*. (2014) (0.5%) they showed that garlic significantly reduced *E. coli* count in the gut when compared to control. In contrary Kyaw*et al*. (2017) who observed that no significant (p>0.05) effect on the *E. coli* count in the gut of broilers was observed in 1% garlic powder treated groups.

The present investigation were well corroborated with the observation of Sahoo *et al.* (2019) who noted that turmeric supplementation at 1% and 0.5% level could limit the growth of pathogenic bacteria, i.e. *E. coli*. Asmara *et al.* (2018) who observed that the birds fed with control diet had the highest number of S. aureus and E. coli, while the birds fed with the diets added with 2 and 3 g/kg turmeric powder had the lowest number of bacteria. El-Rayes *et al.* (2018) noted that coliform group, fecal *E. coli*, *Staphylococcus aureus*, *Salmonella* spp., *Shigella* spp., and *Listeria* spp. count were significantly (p<0.05) decreased for all supplemented (Turmeric powder- 0.25%, 0.5% and 1%) groups as compared to the control. Panpatil *et al.* (2013) observed that the antimicrobial activity was found to be highest in turmeric against *Escherichia coli, Salmonella typhi* and *Staphylococcus aureus.*

4.7 Economics of Production

Table-17 showed that the cost of production per broiler including the additional cost of dietary supplementation was found to be (Tk.) 161.43 ± 1.09, 170.26 ± 0.86, 165.54 ± 0.59, 166.20 ± 0.94 and 165.05 ± 1.43 for T_0, T_1, T_2, T_3 and T_4 groups respectively. The cost of production per broiler in T_1 (antibiotic group) was significantly ($p<0.05$) highest as compared to T_0, T_2, T_3 and T_4 groups. Significantly ($p<0.05$) lowest cost of production per broiler found in T_0 (Control) group. However, total income (TK.) per broiler was found to be numerically ($p>0.05$) highest in T_3 group (220.01 ± 1.51) followed by T_1 (215.74 ± 3.13), T_4 (214.62 ± 4.14), T_2 (213.88 ± 5.19) and T_0 (210.96 ± 1.95) group. Net profit (Tk.) per broiler was found to be comparatively ($p>0.05$) highest in T_3 (53.81 ± 2.40) group followed by T_4 (49.57 ± 2.95), T_0 (49.53 ± 1.88), T_2 (48.35 ± 5.01) and T_1 (45.48 ± 3.15), group. Net profit (Tk.) per broiler was found to be comparatively ($p>0.05$) lowest in T_1 (Antibiotic) group compared to other groups. BCR was comparatively ($p>0.05$) highest in T_3 (1.32 ± 0.02) group and lowest in T_1 (1.27 ± 0.02) groups. Among the treatment groups T_3 (0.5% TP) performed better than others.

Table 17. Effects of supplementation of garlic & turmeric powder in economic impact on broiler rearing

Treatment groups	Total cost (Tk./bird)	Total income (Tk./bird)	Net profit (Tk./bird)	Benefit cost ratio (BCR)
T_0	161.43 ± 1.09^c	210.96 ± 1.95	49.53 ± 1.88	1.31 ± 0.01
T_1	170.26 ± 0.86^a	215.74 ± 3.13	45.48 ± 3.15	1.27 ± 0.02
T_2	165.54 ± 0.59^b	213.88 ± 5.19	48.35 ± 5.01	1.29 ± 0.03
T_3	166.20 ± 0.94^b	220.01 ± 1.51	53.81 ± 2.40	1.32 ± 0.02
T_4	165.05 ± 1.43^b	214.62 ± 4.14	49.57 ± 2.95	1.30 ± 0.02
Mean ± SE	165.70 ± 0.85	215.04 ± 1.53	49.35 ± 1.42	1.30 ± 0.01
Level of Significance	*	NS	NS	NS

^{a,b,c}, values with different superscripts in the same column differ significantly (P<0.05).
Here, T_0 = (Control), T_1 = (Antibiotic), T_2 = (0.5% Garlic Powder), T_3 = (0.5% Turmeric powder) and T_4 = (0.25% Garlic Powder & 0.25% Turmeric powder).
Values are Mean ± SE (n=15) one way ANOVA (SPSS).
SE= Standard Error
NS =Non-Significant
*** means significant at 5% level of significance (p<0.05)**

Above result showed that total cost of production and total income was higher than control group. The present investigation were well corroborated with the observation of Singh *et al.* (2015) who observed that increased returns due to garlic supplementation and advocated its use for better profitability. Aji *et al.* (2011) reported increased cost when birds were supplemented with garlic as compared to control. In contrary Khaidem *et al.* (2019) who observed that addition of garlic at 0.25 to 0.50% resulted in least cost of production kg^{-1} gain and higher net profit.

Concomitant to the results Alito *et al.* (2019), Mondal *et al.* (2015) and Kafi *et al.* (2017) who found the return of birds was high in turmeric treated groups as compared to control group.

CHAPTER V

SUMMARY & CONCLUSION

CHAPTER V
SUMMARY AND CONCLUSION

A feeding trial was conducted on 150 day-old Cobb 500 broiler chicks for a period of 28 days in the Poultry Farm of Sher-e-Bangla Agricultural University, Dhaka. Commercial broiler chicks of Cobb 500 strain randomly divided into 5 treatment groups *viz.* T_0 (Control), T_1 (antibiotic), T_2 (GP 0.5%), T_3 (TP 0.5%) and T_4 (GP 0.25% & TP 0.25%) having three replications consisting of 10 chicks each.

To investigate the effect of dietary supplementation of garlic powder, turmeric powder and antibiotic 28 days of age, 45 broilers were sacrificed in halal method. Growth performance parameters, serum biochemical, blood parameters and gut health status were measured.

There were no significant difference ($p>0.05$) on the feed consumption, Live weight and FCR of broiler chicken among different treatment groups. However, numerically ($p>0.05$) improved FC, higher BWG, live weight and better FCR were found in 0.5% TP treated T_3 group compared to other groups. This indicated that turmeric have relatively better effect on growth performances of broiler.

Dressing percentage (DP) showed insignificant difference ($p>0.05$) among the various treatments, but comparatively highest DP was found in 0.5%TP treated T_3 group compared to other groups. Whereas no dietary effect on livability of broiler chicken.

The average weight of liver, heart, gizzard and intestine were not showed any significant difference ($p>0.05$) for each parameters. Abdominal fat weight was significantly ($p<0.05$) lower in birds fed 0.5%TP compare to control group. Insignificant difference ($p>0.05$) were found in both bursa and spleen weights among the different treatments.

The serum biochemical parameters viz. glucose and cholesterol concentration was measured. Different treatment groups were showed significant ($p<0.05$) effect on serum glucose and cholesterol level. Significantly ($p<0.05$) lower concentration of glucose found in 0.5%TP treated T_3 group than control (T_0) and antibiotic (T_1) group. On the other hand, T_1, T_2, T_3 and T_4 showed significantly ($p<0.05$) lower concentration of cholesterol than control (T_0) group.

In case of blood parameter, no significant difference ($p>0.05$) were found in WBC, Monocytes, Eosinophil, HCT/PCV, MCV and MCHC values due to different dietary treatment supplementation. Significantly ($p<0.05$) higher level of Hb (g/dl) found in 0.5%TP and GP 0.25%+TP 0.25% group than antibiotic and control group. Significantly ($p<0.05$) higher level of RBC found in T_3 group compared to T_0 and T_1 group. Significantly ($p<0.05$) lower percentage of neutrophils were found in T_2, T_3 and T_4 group compared to T_0 and T_1 group. In case of lymphocyte percentage significantly ($p<0.05$) higher in T_2, T_3 and T_4 group compared to T_0 and T_1 group.

The numbers of cecum microbial load (*E. coli* and *Salmonella* spp.) were significantly ($p<0.05$) higher in control group compared to other treated and antibiotic groups.

Total cost per bird was significantly highest ($P<0.05$) in group T_1 (antibiotic) than other groups and lowest in control group (T0). Total income, net profit and BCR per bird was comparatively highest in T_3 (0.5%TP) group and among the treatment groups T3 (0.5%TP) performed better than others.

On the basis of analysis of the above mentioned research findings, it can be concluded that garlic, turmeric powder supplementation had very effective impact on production performance, serum biochemical and hematological parameters, immune stimulation and microbial state of broiler chicken. 0.5% GP or 0.5% TP or their combination (0.25%GP +0.25% TP) can be used as an alternative of antibiotic. Birds fed 0.5% turmeric powder (TP) supplemented diet achieved superior result due to turmeric has the ability to reduce abdominal fat and glucose, increase hemoglobin, red blood cells and lymphocyte. It also has ability to minimize the *E. coli* in the ceca of broiler and comparatively higher net profit and BCR in 0.5% turmeric powder treated group. Therefore, the present study recommends that implementation of these formulations in the field aspect for commercial broiler production which is safe, sound, and environmentally suitable for our country. However, further more experimental trials are required to assess the impact of these natural additives on the better quality of broiler meat production to ensure the safety of human consumption.

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APPENDICES

Appendix 1. Recorded Temperature (^{0} C) during Experiment

Age in Weeks	Period	Room Temperature (^{0}C)		
		Average Maximum Temperature	**Average Minimum Temperature**	**Average**
1st week	**31.10.18 – 06.11.18**	30.2	26.7	28.5
2nd week	**07.11.18 – 13.11.18**	29.7	23.6	26.6
3rd week	**14.11.18 – 20.11.18**	30.1	22.7	26.4
4th week	**21.11.18 – 27.11.18**	29.1	22.2	25.6

Appendix 2. Relative Humidity (%) during Experiment

Age in Weeks	Period	Relative Humidity (RH) (%)		
		Average Maximum RH (%)	Average Minimum RH (%)	Average
1st week	**31.10.18 – 06.11.18**	83	61	73
2nd week	**07.11.18 – 13.11.18**	82	62	72
3rd week	**14.11.18 – 20.11.18**	81	61	71
4th week	**21.11.18 – 27.11.18**	82	63	72

Appendix 3. Feed Consumption (g/bird) of 1st, 2nd, 3rd and 4th Week under Different Treatment Groups

Treatments	Replication	1st Week	2nd Week	3rd Week	4th Week
	R_1	181.2	430	708	930.7
T_0	R_2	179	430	750	952
	R_3	179.5	426.0	747	980
	R_1	181	429.5	750.5	948.4
T_1	R_2	179.5	429.6	749.8	886.4
	R_3	179	425.4	729.1	962.1
	R_1	180.5	448.3	730.6	965.4
T_2	R_2	179.5	429.5	750.1	932
	R_3	179	429.2	736.1	938.8
	R_1	180	429.8	750.2	1000
T_3	R_2	179.7	422.4	757.6	956
	R_3	179.3	428.2	733.7	948.1
	R_1	180.2	429.5	749.9	930.1
T_4	R_2	180	429.4	749.6	881
	R_3	179.8	429.3	750.7	988.5

Appendix 4. Body Weight Gain (g/bird) of 1st, 2nd, 3rd and 4th Week under Different Treatment Groups

Treatments	Replication	1st Week	2nd week	3rd week	4th week
	R_1	183.5	310.5	554	498.9
T_0	R_2	184.2	316.7	550.1	472.9
	R_3	177.9	337.7	533.4	531
	R_1	183.3	325.7	512	611.3
T_1	R_2	183.6	319.4	562	530.4
	R_3	186.1	334.7	540.2	481.6
	R_1	180.7	323.8	534.5	551.7
T_2	R_2	181.6	332.4	548	578.2
	R_3	185.6	328.4	564	415
	R_1	182.6	314.8	543.6	567
T_3	R_2	184.9	328.8	531.3	574
	R_3	183.4	326.3	532.3	608
	R_1	183.2	299.8	548	514.7
T_4	R_2	182.6	310.2	551.2	502.8
	R_3	183.1	320.2	534.7	611.7

Appendix 5. FCR of 1st, 2nd, 3rd and 4th Week under Different Treatment Groups

Treatments	Replication	1st week	2nd week	3rd week	4th week
T_0	R_1	0.99	1.38	1.28	1.86
	R_2	0.97	1.36	1.36	2.01
	R_3	1.01	1.26	1.40	1.84
T_1	R_1	0.99	1.32	1.46	1.55
	R_2	0.98	1.35	1.33	1.67
	R_3	0.96	1.27	1.35	1.99
T_2	R_1	0.99	1.38	1.37	1.74
	R_2	0.99	1.29	1.37	1.61
	R_3	0.96	1.31	1.30	2.26
T_3	R_1	0.99	1.36	1.38	1.76
	R_2	0.97	1.28	1.42	1.66
	R_3	0.98	1.31	1.38	1.56
T_4	R_1	0.98	1.43	1.37	1.81
	R_2	0.98	1.38	1.36	1.75
	R_3	0.98	1.34	1.40	1.62

Appendix 6. Average Live Weight, Eviscerated Weight and Dressing Percentage of Broiler Chicken of Different Replication under Different Treatment Groups

Treatments	Replication	Live weight (g)	Eviscerated weight (g)	Dressing Percentage (%)
	R_1	1590.72	1100	69.15108
T_0	R_2	1640.23	1155	70.41695
	R_3	1493	975	65.30476
	R_1	1632.32	1170	71.67712
T_1	R_2	1595.42	1105	69.26076
	R_3	1542.64	1000	64.82394
	R_1	1546.94	1085	70.13847
T_2	R_2	1523.94	1011	66.34119
	R_3	1580	1105	69.93671
	R_1	1608.83	1160	72.10209
T_3	R_2	1619.5	1149	70.94782
	R_3	1650.46	1180	71.49522
	R_1	1545.7	1060	68.57734
T_4	R_2	1546.82	1140	73.69959
	R_3	1649.73	1150	69.70838

Appendix 7. Weight of Internal Organs (g/bird) of Broiler Chicken under Different Treatment Groups

Treatments	Replication	Liver weight (g)	Heart weight (g)	Gizzard weight (g)	Intestine weight (g)	Spleen weight (g)	Bursa weight (g)	Abdominal fat weight (g)
	R_1 (1)	39.5	8.5	38	73	2	2.5	32
	R_1(2)	37	9.5	35	78	2	2.5	25
	R_1(3)	25.5	9	36	104	2.5	2.5	24
	R_2(1)	45.5	7.5	36	91	2	2	16
T_0	R_2(2)	39.5	8.5	43	98	2	2.5	22
	R_2(3)	40	10	48	85	2	2	31
	R_3(1)	42	11	42	103	1.5	2.5	30
	R_3(2)	32.5	7	42	98	1.5	2	24
	R_3(3)	39.5	7.5	46	93	1.5	2.5	22
	R_1 (1)	48	8.5	54	91	1.5	2.5	21
T_1	R_1(2)	40	9	42	87	3.5	2	20
	R_1(3)	32	7.5	49	102	1.5	2	24

	$R_2(1)$	37.5	8.5	44	110	1	2	29.5
	$R_2(2)$	31.5	6.5	39.5	68	2	2	24.5
	$R_2(3)$	32.5	6.5	43	110	2	2	23
	$R_3(1)$	36.5	6	33	94	1.5	2.5	28
	$R_3(2)$	37	9	38	114	2	3	17
	$R_3(3)$	36	11	41	82	2	2.5	27
	R_1 (1)	42.54	9	36	97	2	3	18.5
	$R_1(2)$	46.5	9.5	37	104	2	3.5	23.5
	$R_1(3)$	37	8.5	49	98	2	3	20
	$R_2(1)$	41	10	41	103	2	4	20.5
T_2	$R_2(2)$	41	7.5	42	94	1.5	2	22
	$R_2(3)$	38	7	32	80	3	1	26
	$R_3(1)$	46	9	44	131	2.5	2	24
	$R_3(2)$	39	9	49	99	2	2.5	21
	$R_3(3)$	38.5	8.5	52	81	2	3	29.5

	R_1 (1)	38	6.5	49	82	2.5	2.5	21
	R_1(2)	34	11	46	82	2	3.5	12
	R_1(3)	41	9	52	71	2.5	3	18
	R_2(1)	41	9.5	54	123	1.5	2.5	18.5
T_3	R_2(2)	39	8	43	104	2.5	3	27
	R_2(3)	42	8	31	96	2.5	2.5	22
	R_3(1)	40	9	44	113	2	4	24.5
	R_3(2)	42.03	8	41.5	129	2.5	2.5	18
	R_3(3)	40	10.5	40	107	2	2	20
	R_1 (1)	39.5	9	40.5	75	2	3.5	25
	R_1(2)	41	10	45	86	2	2.5	27
	R_1(3)	35	7.5	36	74	2	3	19.5
T_4	R_2(1)	41.51	7.5	48	100	3	2	20.5
	R_2(2)	38	11	39	116	3	3.5	11.5
	R_2(3)	40	8.5	46	90	2.5	2.5	16

$R_3(1)$	42.5	9.5	41	95	2	3	19.5
$R_3(2)$	39	8	30.5	90	1.5	2	26.5
$R_3(3)$	38	11.5	41.5	111	2	3	27

Appendix 8. Serum Biochemical Data in Different Treatment Groups

Treatments	Replication	Glucose (mmol/L)	Cholesterol (mg/dl)
	R_1 (1)	18.37	198
	R_1(2)	20.31	193
	R_1(3)	13.65	161
	R_2(1)	18.20	180
T_0	R_2(2)	20.25	185
	R_2(3)	16.11	150
	R_3(1)	18.15	145
	R_3(2)	18.87	168
	R_3(3)	19.76	165
	R_1 (1)	16.21	151
	R_1(2)	17.98	144
	R_1(3)	18.2	138
	R_2(1)	17.60	162
T_1	R_2(2)	18.11	142
	R_2(3)	17.43	154
	R_3(1)	18.76	150
	R_3(2)	17.48	176
	R_3(3)	17.65	156
	R_1 (1)	17.04	150
	R_1(2)	15.45	144
	R_1(3)	20.12	136
	R_2(1)	18.8	150
T_2	R_2(2)	15.5	165

	$R_2(3)$	17.24	141
	$R_3(1)$	16.03	151
	$R_3(2)$	15.87	140
	$R_3(3)$	18.48	191
T_3	R_1 (1)	12.93	149
	$R_1(2)$	15	180
	$R_1(3)$	15	152
	$R_2(1)$	13.93	170
	$R_2(2)$	15.22	145
	$R_2(3)$	17.7	142
	$R_3(1)$	15.65	144
	$R_3(2)$	17.54	142
	$R_3(3)$	17.59	147
T_4	R_1 (1)	13.32	171
	$R_1(2)$	16.37	155
	$R_1(3)$	18.15	150
	$R_2(1)$	16.29	152
	$R_2(2)$	17.16	148
	$R_2(3)$	17.23	156
	$R_3(1)$	17.32	135
	$R_3(2)$	17.93	160
	$R_3(3)$	18.26	140

Appendix 9. Data of Complete Blood Count (CBC) under Different Treatment Groups

Treatments	Replication	Hb (g/dl)	RBC (10^6/ mm^3)	WBC (10^3 /mm^3)	Neutrophil (%)	Lymphocyte (%)	Monocyte (%)	Eosinophil (%)	Platelet (10^4/ mm^3)	PCV (%)	MCV (Fl)	MCH (pg)	MCHC (g/dl)
T0	R_1 (1)	7.5	3.59	9.8	42	58	3	2	29	36.41	84.45	28.21	32.78
	R_1(2)	7.3	3.2	10.4	38	63	2	2	25.5	40.5	83.21	29.63	33.45
	R_1(3)	8.3	3.64	9.5	36	64	4	1	28.5	36.47	79.52	29.32	32.14
	R_2(1)	7.4	3.65	12.5	37	63	4	2	25.5	36.32	82.5	29.24	32.33
	R_2(2)	8.1	3.9	11.5	40	62	2	2	27	37.42	79.34	31.25	31.14
	R_2(3)	8.6	3.45	10.7	36.5	62.5	2	1	28	35.23	80.5	27	34.29
	R_3(1)	8.6	4.25	9	45	56	5	2	20	37.8	80.15	31.11	32.42
	R_3(2)	7.5	3.79	10.2	42	58	3	2	28	28.12	75.89	27.15	31.62
	R_3(3)	8	3.4	12	24	58	3	2	23	38.63	81.47	29.56	33.11
T1	R_1 (1)	8.3	3.25	9.5	22	60	2	2	27.5	36.21	81.44	28.45	32.49
	R_1(2)	7.23	3.44	10.5	26	64	4	2	27	50.23	80.25	32.46	34.76
	R_1(3)	8.6	3.45	11.5	46	54	3	2	29	48.59	80.56	32	33.47
	R_2(1)	9.5	4.5	10.5	35	69	3	2	24	39.75	82.3	31	33.5

	R2(2)	8.6	3.6	9.5	38	60	4	1	22	42.75	80.2	29.09	33.5
	R2(3)	7.6	4.37	9.3	34	65	2	2	28	36.76	84.12	30	32.17
	R3(1)	8.4	4.1	9.2	45	56	2	2	26	33.84	79.29	29.87	32.55
	R3(2)	9.6	4.87	9.2	34	66	4	1	27.5	39.44	93.21	30.21	33.44
	R3(3)	7.6	3.74	12.5	41	59	4	2	25	30.21	78.45	27.19	31.63
	R1 (1)	9	3.22	13	39	62	3	1	23	36.89	79.54	29.56	32.49
	R1(2)	8.2	3.98	9	38	63	5	1	27	32.56	78.54	29.65	31.25
	R1(3)	11	4.21	10.9	24	76	3	2	26	34.87	79.65	28.41	32.69
	R2(1)	9	3.5	9.5	30	75	4	2	27	37.37	82.12	29.22	32.24
T2	R2(2)	8	3.6	10.5	29	69	3	1	30.5	40.35	86.5	28.34	31.26
	R2(3)	8	4.89	11.5	30.5	67.5	5	2	26	34.08	79.5	31.1	33.31
	R3(1)	8.16	3.75	10.9	24	76	3	2	27.5	43.44	90.32	30.54	32.36
	R3(2)	10	4.65	12.1	26	74	3	2	31	37.89	86.54	29.54	32.25
	R3(3)	6.8	4.87	10	28	72	3	2	32.5	37.94	81.66	29.58	32.58
	R1 (1)	9.5	4.63	11.5	30	62	2	2	30	42.68	97.25	31.22	31.64
T3	R1(2)	10.5	4.85	10	27	74	4	2	31.2	40.59	95.41	32.32	33.48
	R1(3)	9.23	4.66	11.5	22	78	4	3	21	30.89	83.96	32.32	34.48

	$R_2(1)$	10	4.3	10	35	70	3	3	26	38.58	85.5	32.24	33.25
	$R_2(2)$	8.2	4.25	9.6	30	65	5	2	29	37.54	90	33.26	32.25
	$R_2(3)$	10	4.4	10.25	33.5	68	2	2	23.1	36.63	84.5	32.08	34.5
	$R_3(1)$	8.16	4.55	11.5	39	58	3	1	28.5	33.87	81.21	32.32	34.48
	$R_3(2)$	9.3	4.56	10.2	35	60	2	2	22.5	39.66	85.63	33.49	33.48
	$R_3(3)$	9.6	4.12	8.2	26	74	5	1	23	37.8	76.55	33.49	32.48
	R_1 (1)	8.6	3.92	11.4	30	70	4	3	27	36.8	72.75	32.11	33.47
	$R_1(2)$	10	4.86	10.3	32	69	3	2	24	39	75.75	30.58	32.49
	$R_1(3)$	9	3.36	10.6	26	74	2	1	30	36.16	77.75	30.45	32.58
	$R_2(1)$	9.5	4.5	10.26	30	70	5	2	29	35.75	75.5	30.25	32.25
T4	$R_2(2)$	8.7	4.4	9.5	32	67	3	3	22	36.85	80.5	29.5	32.33
	$R_2(3)$	9.4	3.3	11.11	28.5	72	4	2	26	34.65	75.62	32.25	32.16
	$R_3(1)$	9	4.36	10.3	27	73	2	2	23.5	36.16	77.75	30.28	32.23
	$R_3(2)$	8.6	4.36	10.7	30	70	5	1	30	32.56	79.72	30.54	32.56
	$R_3(3)$	10	4.54	11.7	38	62	2	2	20	33.86	79.52	30.12	32.14

Appendix 10. Effects of Different Treatment on No. of *E. coli* and *Salmonella* spp. Colony in the Cecum of Broilers

Treatments	Replication	No. of *E. coli* Colony (Average)	No. of *Salmonella* spp. Colony (Average)
T_0	R_1	75	60
	R_2	75	56
	R_3	74	59
T_1	R_1	65	45
	R_2	55	48
	R_3	61	49
T_2	R_1	67	48
	R_2	53	49
	R_3	59	42
T_3	R_1	45	53
	R_2	60	35
	R_3	55	47
T_4	R_1	71	39
	R_2	65	44
	R_3	68	40

Appendix 11. Market rating of cost and income during rearing period

Parameters			Cost
Individual source of cost	Feed		44 Tk./kg
	Treatment	Antibiotic	167 Tk./100g packet
		Garlic powder	350 Tk./kg
		Turmeric powder	320 Tk./kg
Common source of cost	DOC (150 birds)		4050 Tk.
	Litter (10 sacks)		1200 Tk.
	Medication		300 Tk.
	Vaccine		500 Tk.
	Others		3000 Tk.
Individual source of income	Bird		120 Tk./kg
Common source of income	Poultry manure		3600 Tk.
	Feed bag		140 Tk.

Appendix 12. Cost of production of the birds under different treatment groups

Treatments	Replication	Feed cost	Treatment cost	Common cost	Total Cost
T_0	R_1	99.00	0.00	60.33	159.33
	R_2	101.68	0.00	60.33	162.01
	R_3	102.63	0.00	60.33	162.96
T_1	R_1	101.61	9.46	60.33	171.40
	R_2	98.79	9.46	60.33	168.58
	R_3	101.01	9.46	60.33	170.80
T_2	R_1	102.29	4.07	60.33	166.69
	R_2	100.81	4.01	60.33	165.15
	R_3	100.46	4.00	60.33	164.78
T_3	R_1	103.84	3.78	60.33	167.95
	R_2	101.89	3.71	60.33	165.93
	R_3	100.73	3.66	60.33	164.72
T_4	R_1	100.75	3.84	60.33	164.91
	R_2	98.56	3.75	60.33	162.64
	R_3	103.33	3.93	60.33	167.59

Appendix 13. Selling price and total income of the birds under different treatment groups

Treatments	Replication	Live weight (g)	Selling price @120tk/kg	Common profit per replication	Total income
T_0	R1	1546.90	185.63	24.93	210.56
	R2	1523.90	182.87	24.93	207.80
	R3	1580.00	189.60	24.93	214.53
T_1	R1	1632.30	195.88	24.93	220.81
	R2	1595.40	191.45	24.93	216.38
	R3	1542.60	185.11	24.93	210.04
T_2	R1	1590.70	190.88	24.93	215.81
	R2	1640.20	196.82	24.93	221.75
	R3	1493.00	179.16	24.93	204.09
T_3	R1	1608.00	192.96	24.93	217.89
	R2	1619.00	194.28	24.93	219.21
	R3	1650.00	198.00	24.93	222.93
T_4	R1	1545.70	185.48	24.93	210.41
	R2	1546.80	185.62	24.93	210.55
	R3	1649.70	197.96	24.93	222.89

Appendix 14. Net profit and BCR of the birds under different treatment groups

Treatments	Replication	Total income	Total cost	Net Profit	Benefit cost ratio (BCR)
T_0	R1	210.56	159.33	51.23	1.32
	R2	207.80	162.01	45.78	1.28
	R3	214.53	162.96	51.57	1.32
T_1	R1	220.81	171.40	49.40	1.29
	R2	216.38	168.58	47.79	1.28
	R3	210.04	170.80	39.25	1.23
T_2	R1	215.81	166.69	49.12	1.29
	R2	221.75	165.15	56.61	1.34
	R3	204.09	164.78	39.31	1.24
T_3	R1	217.89	167.95	49.94	1.30
	R2	219.21	165.93	53.28	1.32
	R3	222.93	164.72	58.21	1.35
T_4	R1	210.41	164.91	45.50	1.28
	R2	210.55	162.64	47.90	1.29
	R3	222.89	167.59	55.31	1.33

Appendix 15. Some Pictorial View of the Conducted Study

Cleaning & Bio-security Measurement of Farm

Preparation of Brooder

Receiving of DOC

Vaccination of Chick

Brooding of Chick

Appendix 15. Some Pictorial View of the Conducted Study (Cont'd)


Garlic & Turmeric Powder


Mixing of Garlic & Turmeric Powder with Feed

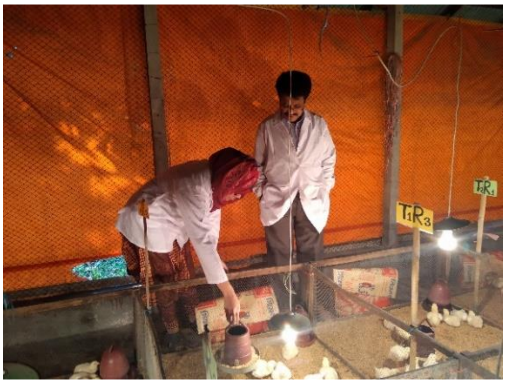
Weighing of Bird

Collection of Blood

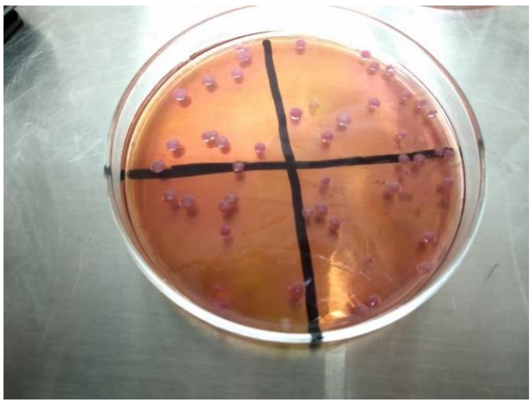
Appendix 15. Some Pictorial View of the Conducted Study (Cont'd)

. Weiging of Dressed Broiler & Internal Organs

Appendix 15. Some Pictorial View of the Conducted Study (Cont'd)

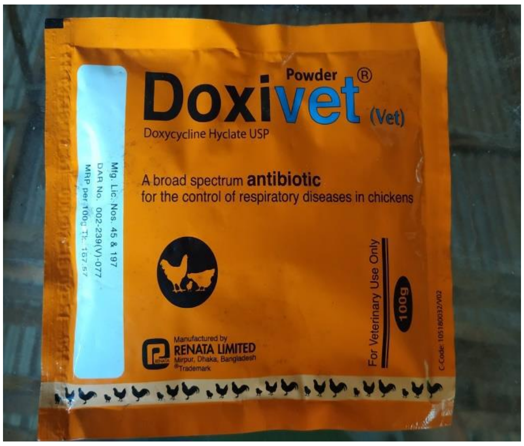


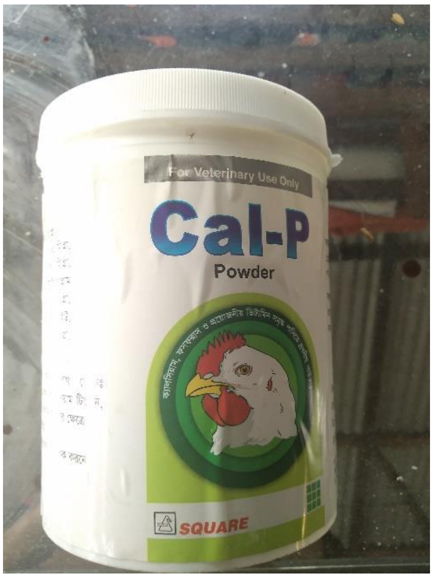
Supervision of Research Work

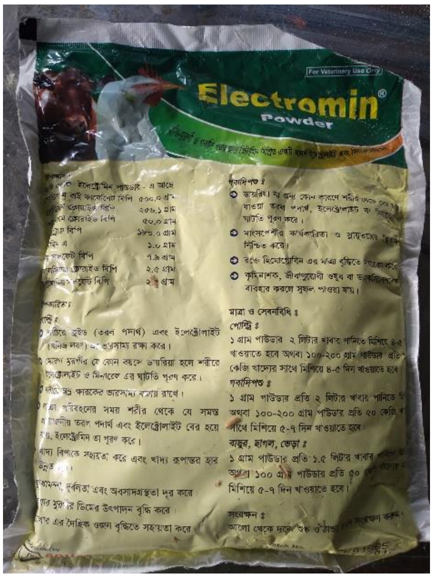


Culture & Colony Count of *E. coli* & *Salmonella* spp. Bacteria

Appendix 15. Some Pictorial View of the Conducted Study (Cont'd)







Medicine & Vaccine Used during the Research Period