EFFECTS OF TURMERIC OIL *(Curcuma longa)* AS ALTERNATIVE FEED ADDITIVES IN BROILER DIET

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CERTIFICATE

*This is to certify that the thesis entitled "**EFFECTS OF TURMERIC OIL (CURCUMA LONGA) AS ALTERNATIVE FEED ADDITIVES IN BROILER DIET**" submitted to the Faculty of Animal Science & Veterinary Medicine, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **Master of Science in Poultry Science**, embodies the result of a piece of bona fide research work carried out by MD.KIYUM HOSSAION NIBIR, Registration No. **17-08293** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

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

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Dedicated To

My Beloved

Parents

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LIST OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

.

LIST OF APPENDICES

ACRONYMS AND ABBREVIATIONS

Abbreviation		Full meaning
A.M	=	Ante meridian
ACTH	=	Adreno Corticotropic hormone
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
Ca	=	Calcium
CAT	=	Catalase
CF	=	Crude Fibre
CFU	=	Colony Forming Units
Cm	=	Centimeter
cm^2	=	Squre Centimeter
CONTD.	=	Continued
CP	=	Crude Protein
CRD	=	Complete Randomized Design
Dr.	=	Doctor
e.g.	=	For Example
EDTA	=	Ethylene Diethyle Tetraacitic Acid
et al.	=	Associates
FC	=	Feed Consumption
FCR	=	Feed Conversion Ratio
FOS	=	Fructo-oligosaccharides
g	=	Gram
GSH	=	Glutathione
Hb	=	Haemoglobin
i.e.	=	That is
IBV	=	Infectious Bronchitis Vaccines
kcal	=	Kilo-calorie
Kg	=	Kilogram
LSD	=	Least Significant Difference
Ltd.	=	Limited
M.S.	=	Master of Science
ME	=	Metabolizable Energy
MOS	=	Mannan-oligosaccharides

ACRONYMS AND ABBREVIATIONS (CONT'D)

Abbreviation		Full meaning
MCHC	=	Mean Corpuscular Hemoglobin Concentration
ml	=	Mililitre
mm	=	Milimeter
mmol	=	Milimol
MT	=	Metric ton
N	=	Nitrogen
NDV	=	Newcastle Disease Vaccine
No.	=	Number
NS	=	Non-significant
P	=	Phosphorus
PCV	=	Packed Cell Volume
Pp	=	Page to page
ppm	=	Parts per Million
PRP	=	Parboiled Rice Polish
RBC	=	White Blood Cell
SAU	=	Sher-e-Bangla Agricultural University
SED	=	Standard Error Difference
SPSS	=	Statistical Package for Social Sciences
viz.	=	Such as
Vs	=	Versus
WBC	=	White Blood Cell
WHO	=	World Health Organization
WPSA	=	World's Poultry Science Association

LIST OF SYMBOLS

Symbols		Full meaning
:	=	Ratio
@	=	At the rate of
+	=	Plus
<	=	Less than
>	=	Greater than
°C	=	Degree Celcius
°F	=	Degree Fahrenheit
%	=	Percentage
&	=	And
*	=	5% level of significance
**	=	1% level of significance
/	=	Per

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ABSTRACT

The study was conducted to investigate the productive performance and health status of commercial broiler chicks fed diets containing turmeric oil compared to antibiotic based diet. Experiment was done for a period of 28 days with a total of 150 day-old Cobb 500 broiler chicks were reared in Sher-e-Bangla Agricultural University Poultry Farm, Dhaka. Birds were divided into five dietary treatment groups with 3 replications each having 10 birds per replication. The dietary groups were control (basal diet; no additives), antibiotic (basal diet + antibiotic), turmeric oil (basal diet + 0.125% turmeric oil), turmeric oil (basal diet + 0.25% turmeric oil) and turmeric oil (basal diet + 0.5% turmeric oil). Results showed that the body weight, body weight gain and total FCR were not ($P>0.05$) significantly different among the treatment groups. Abdominal fat, total cholesterol ($P>0.05$) significantly lower in the supplemented groups compare to the control and antibiotic groups. Moreover, turmeric oil to broiler chicks diets found relative weight of liver, heart, gizzard and intestine weight which had no significant ($P>0.05$) differences among the treatments. Although the trends of weights were higher in turmeric oil supplementing group compared to the antibiotic and control. This experiment also reports that there was reduction in the serum glucose concentration in turmeric oil supplemented group when compared to the control and antibiotic group. Cost of production per kg live broiler was lower in antibiotic and control group comparing to the turmeric oil group. With regards to profit, turmeric oil groups showed higher profitability compared to the other groups. As antibiotic free and safe meat, profitability of supplemented groups increased when sale price considered from Tk. 150 to 170 per kg of live birds. Taken together, the results indicated that addition of turmeric oil to broiler diet had positive effect on growth performance, lipid profile and profitability and no negative effect on meat yield, bone development, cost benefit analysis and carcass parameter. Bases on the results of the present study it can be suggested that the 0.25% turmeric oil could be potential feed additives in broiler diet.

KEY WORDS: Broiler; Turmeric oil; Performance; Carcass traits; Cholesterol; Cost benefit analysis.

CHAPTER I

INTRODUCTION

Poultry meat is the first growing meat components of global meat production and it is also one of the most important sectors of agriculture in Bangladesh for maintaining the need of protein and nutrition. In 1995 the poultry industry started in an organized manner in Bangladesh. The demand of livestock products throughout the world is increasing concurrently with the increase of population. Poultry plays an important role in the economic development of the country. Bangladesh provides a very fertile and virgin field for the development of broiler industries. Broiler production has become a profitable and most popular income generating activity at present time for the people of the country. The broiler industry in Bangladesh is developing rapidly and its success depends on how rapidly a bird attains maximum marketable weight. The principle of poultry production is to achieve high level of performance through efficient utilization of feed keeping survivability as maximum as possible. The ultimate consumers of the end products of poultry are human beings and the major concern of all industries is the well being of the mankind. People of modern times are very much conscious about their health and quality of food items that they will consume. Feed additives are products used in animal nutrition for purposes of improving the quality of feed and the quality of food from animal origin, or to improve the animals' performance and health, e.g. providing enhanced digestibility of the feed materials. Feed additives may not be put on the market unless authorisation has been given following a scientific evaluation demonstrating that the additive has no harmful effects, on human and animal health and on the environment (Niemenmaa *et al.,* 2008).

According to the National Office of Animal Health (NOAH, 2001), antibiotic growth promoters are used to "help growing animals digest their food more efficiently, get maximum benefit from it and allow them to develop into strong and healthy individuals".Many synthetic drugs and growth promoters are supplemented to the broilers to have rapid growth, but their use have shown many disadvantages like high cost, adverse side effect on health of birds and long residual properties etc. Growth promoters are chemical and biological substances, which are added to livestock feed with the aim to improve the growth of chickens in fattening, improve the utilization of feed and in this way realize better production and financial results.Their mechanism of action varies. Positive effect can be expressed through better appetite, improved feed

conversion, stimulation of the immune system and increased vitality, regulation of the intestinal micro-flora, etc. A variety of feed additives are being included in poultry diet to derive maximum growth of broiler chickens. Use of in-feed-antibiotics and hormones not only increases the cost of production but also leads to residues in meat and develops antibiotic resistance in microbes

The consumers of today world are much aware of their health and the quality of their food items. Safe food is not luxury for the rich, rather a right for everybody. Unfortunately, farmers are using antibiotics with broiler feed to improve growth and feed efficiency, which adversely effects on human health. Since 1950's farmers have been using antibiotics in animals regularly in feed to attain increased growth rate. With the commercialization, the use of several chemicals, antibiotics, growth promoters at sub-therapeutic levels over extended period is also increased, which have adverse effects in poultry health and its residues in meat can make danger for human health. The use of antibiotics as feed additives is hazardous due to cross-resistance and multiple resistances of pathogens (Schwarz *et al*., 2001). Therefore, European Union has banned the application of most of antibiotics in poultry diets. Thus, during the past decade many studies investigated the use of new and promising feed-additives including probiotics, prebiotics, enzymes, and plant extracts in animal feeding (Demir *et al*., 2003; Sarica *et al*., 2005; Hernandez *et al*., 2004).

World Health Organization (WHO,1997) has recommended antibiotics should be phased out from poultry diet and replaced by alternatives which do not have any adverse effect on the consumer health (Bywater, 2005). Natural medicinal product from herbs and spices has also been introduced as feed additives in poultry diets (Guo, 2003). Feed additives of "natural" origin are establishing their credibility as 2 feasible alternative. In Indian sub-continent, herbal plants or oil are traditionally used for therapeutic treatment for centuries. Since, Bangladesh is very rich in herbal and medicinal plants, inclusion of medicinal plants and oil such as turmeric oil(Curcuma longa) in poultry diet could be a good approach to find out alternatives of antibiotic growth promoters (AGP) and other growth promoters, hormones or enzymes those are commonly used to enhance the growth performance of commercial broilers.

The active ingredients found in Turmeric (Curcuma longa) are curcumin, demethoxy-curcumin, bisdemethoxycurcumin, (Wuthi-Udomler *et al*., 2000) and tetrahydrocur-cuminoids (Osawa et al., 1995). Plant extracts were found to have antifungal, (Wuthi-udomler et al., 2000) and anti- oxidative value (Osawa *et al*., 1995; Iqbal *et al*., 2003). Some pharmacological activities of Turmeric (Curcuma longa) as nematocidal (Kiuchi *et al*., 1993), hypolipidaemic (Ramirez- Tortosa *et al*., 1999) and anti-inflammatory (Ammon *et al*., 1993; Holt et al., 2005) were demonstrated. Curcumin has also been studied extensively as a chemo preventive agent in several cancers (Duvoix *et al*., 2005). Additionally, it has been suggested that curcumin possess hepatoprotective, antitumor, antiviral and anticancer activity (Polasa *et al.,* 1991). It is used in gastrointestinal and respiratory disorders (Anwarul *et al.,* 2006). Moreover Soni *et al*. (1997) proved the protective effects of Turmeric (Curcuma longa) as feed additives on aflatoxin-induced mutagenicity and hepatocarcinogenicity. In our previous study, we demonstrated that the medicinal plant herbs Nigella sativa, guava leaf meal, buckwheat, mulberry leaf and buckwheat supplemented feed improved growth performances and decrease serum cholesterol of poultry birds (Siddiqui *et al*., 2015; Islam *et al.*, 2014; Rahman *et al.*, 2013; Sayed *et al.,* 2013; Islam *et al.*, 2011). So, we are again concentrating on the use of our ancient medicinal system to find beneficial herbs and plants, which can be safely used to increase poultry production. Keeping this view in mind, the research was conducted to investigate the effect of feeding turmeric (Curcuma longa) oil on the growth performances and carcass characteristics of commercial broilers.

Objectives:

a) To determine the effects of turmeric oil on productive performance of broiler.
b) To determine the effect on cholesterol level of broiler.
c) Calculate cost- benefit analysis of turmeric oil fed broiler.

CHAPTER 2

REVIEW OF LITERATURE

Sources of literature

(i) Book and journal in different libraries as mentioned below-

- Sher-E-Bangla Agricultural University (SAU) Library, Dhaka
- Bangladesh National Scientific And Technical Documentation centre (BANSDOC) Library, Agargaon, Dhaka
- Bangladesh Livestock Research Institute (BLRI) library, Savar, Dhaka
- C 2017 Poultry Science Association Inc. Received January 3, 2017. Accepted April 24, 2017. 1Corresponding author: l.j.broom@leeds.ac.uk Present address: Faculty of Biological Sciences, University of Leeds, Leeds LS2 9JT, United Kingdom.
- *Natural antibiotic effect of turmeric in poultry management | Request PDF*. Available from:https://www.researchgate.net/publication/325168727_Natural_antibiotic_effect_of_turmeric_in_poultry_management [accessed Nov 05 2018].

(ii) Abstract searching at BARC, Farmgate, Dhaka, BANSDOC, Agargoan, and Dhaka (iii) Internet browsing

A total about 106 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 15 were full article and 62 abstracts, 16 were only titles and some were miscellaneous. A brief account is given below depending on five main headlines viz, antibiotic impacts on poultry, Antibiotic Growth Promoters (AGPs), Antimicrobial resistance, Alternatives to antibiotic growth promoters and turmeric oil.

Mentioning the references in a traditional way or sequence is avoided. A very critical enquires was made of each article and significant information was collected and arranged according to specific title. It is expected to be pioneering efforts in Bangladesh for higher research review attempts.

Today considering the safety aspect of the products prebiotic, probiotic, enzymes, medicinal plants, several herbs, spice etc. are being used as alternative safe feed additives in poultry diet as well as human health. This summarization of published information assesses to evaluate the effects of using different medicinal plants with special emphasis on garlic. There is an increasing demand for quality in animal products especially broiler meat, as well as concerns about the effects of these products on human health. Therefore, animal production systems will have to focus not only on obtaining high production, but also on their impact on the environment as well as on human and animal health. In Bangladesh some antibiotic has already been banned here too. In light of this situation, scientists, feed manufacturers and the animal growers have been actively searching for safe alternatives.

2. 1 Antibiotic impacts on poultry

The poultry industry uses antibiotics to improve meat production through increased feed conversion, growth rate promotion and disease prevention. Antibiotics can be used successfully at subtherapeutic doses in poultry production to promote growth (Barcelo, 2007; Chattopadhyay, 2014; Engberg *et al*., 2000; Harms *et al*., 1986; Khodambashi Emami *et al.*, 2012; Rosen, 1996) 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 (Dibner and Richards, 2005; Singh *et al.,* 2013; Torok *et al.,* 2011). 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). For example, meta-genome sequencing approaches have demonstrated that diets with salinomycin (60 ppm) has an impact on microbiome dynamics in chicken ceca (Fung *et al.,* 2013). Similarly, the use of virginiamycin (100 ppm) as a growth promoter has been associated with an increased abundance of Lactobacillus species in broiler duodenal loop at proximal ileum. This indicates that virginiamycin alters the composition of chicken gut microbiota (Dumonceaux *et al.,* 2006). In addition, populations of Lactobacillus spp. in the ileum of chickens receiving feed containing tylosin, a bacteriostatic, are significantly lower than those in chickens receiving no tylosin (Lin *et al*., 2013). This decrease in Lactobacilli species following the use of antibiotics has been demonstrated in other studies (Danzeisen *et al.,* 2011; Lee *et al*., 2012; Zhou *et al.,* 2007). For reminder, Lactobacillus are the primary

Commensal bacteria for the production of bile hydrolase salt. The decrease in the Lactobacillus population in antibiotic-treated animals probably reduces the intestinal activity of the bile hydrolase salts, which would increase the relative abundance of conjugated bile salts, thus promotes lipid metabolism and energy harvesting and increases animal weight gain (Lin *et al.*, 2013). A change in the intestinal microbiota of chickens can influence their immunity and their health. However, changes in the intestinal microbiota of chickens can be influenced by several factors. These factors include housing conditions, exposure to pathogens, diet composition and the presence of antibiotics in feed (Lee *et al.,* 2012).

2.2. Antibiotic growth promoters (AGPs):

The discovery of antibiotics was a success in controlling infectious pathologies and increasing feed efficiencies (Engberg *et al.*, 2000). Antibiotics, either of natural or synthetic origin are used to both prevent proliferation and destroy bacteria. Antibiotics are produced by lower fungi or certain bacteria. They are routinely used to treat and prevent infections in humans and animals. However, scientific evidence suggests that the massive use of these compounds has led to increased problem of antibiotic resistance (Diarra *et al.,* 2007, Forgetta *et al.,* 2012, Furtula *et al.*, 2010), and presence of antibiotics residues in feed and environment (Carvalho and Santos, 2016, Gonzalez Ronquillo *et al.*, 2017), compromises human and animal health (Diarra *et al.*, 2010). Hence, there is a growing need to find effective alternatives to control infectious diseases and limit the spread of resistant bacteria, but more importantly, keep antibiotics a useful tool for the future. This literature review synthesizes the current state of antibiotics use, as well as alternative strategies available in broiler chicken production.

Over the past 50 years, the use of antibiotics combined with strict biosecurity and hygiene measures has helped the poultry industry to grow by preventing the negative impacts of many avian diseases (Bermudez, 2003). Even as biosecurity may be sufficient, vaccination can also be used as an additional measure. A vaccine provides assistance to the immune system by preparing it against certain pathogens such as viruses or bacteria to which it may be exposed in the future. Vaccination protocols and the type of vaccine used vary from country to country and from farm to farm. Many factors can influence the choice of vaccination method such as species, place, number of manpower, type of production, and production cycle.

Method also depends on general health status of poultry, maternal immunity, and vaccine costs (Rauw *et al*., 2009). Livestock vaccination against specific diseases is compulsory (e.g., Newcastle disease) in many countries (Belgium, Netherlands, Germany), while in other such as France only long-lived poultry (laying and breeding) are vaccinated (Rauw *et al*., 2009).

Antibiotics are not effective against fungal and viral pathogens. They only treat infectious diseases whose causative agents are bacteria. In general, antibiotics are used in phytosanitary treatments, fish farming, animal feed, and human or veterinary medicine where they can be used as a preventive or curative treatment. Antibiotics are classified according to their chemical family, mode of action and the species of bacteria on which they act. Bactericidal antibiotics kill bacteria and bacteriostatics weaken them by inhibiting their proliferation and facilitating their phagocytosis by the immune system. Thus, mortality rate decreases because animals become more resistant.

In intensive poultry farming, especially in North America, antibiotics such as tetracycline, bacitracin, tylosin, salinomycin, virginiamycin and bambermycin are often used (Diarra and Malouin, 2014). In the United States, tetracyclines represent more than two-thirds of antimicrobials administered to animals (Gonzalez Ronquillo and Angeles Hernandez, 2017), while in European Union (EU) they represent only 37% (Carvalho and Santos, 2016). In 2015, the overall sales of veterinary antimicrobial agent were 8,361 t in EU (ESVAC, 2017). This figure is calculated without counting growth promoters in animal production (Kummerer, 2009). The use of antibiotics as growth factors is not allowed in the European Surveillance of Veterinary Antimicrobial Consumption (ESVAC) participating countries (ESVAC, 2017). In 2014, 1.5 million kg of active antimicrobial ingredients were distributed for use in animals in Canada, up 5% from 2013. For antimicrobials distributed, 99% were for farm animals and less than 1% were for pets. In 2014, 81% of the antimicrobials used in Canada on broiler farms were for prevention purposes. In the feed, 84% of these antimicrobials were used (Fig. 1).

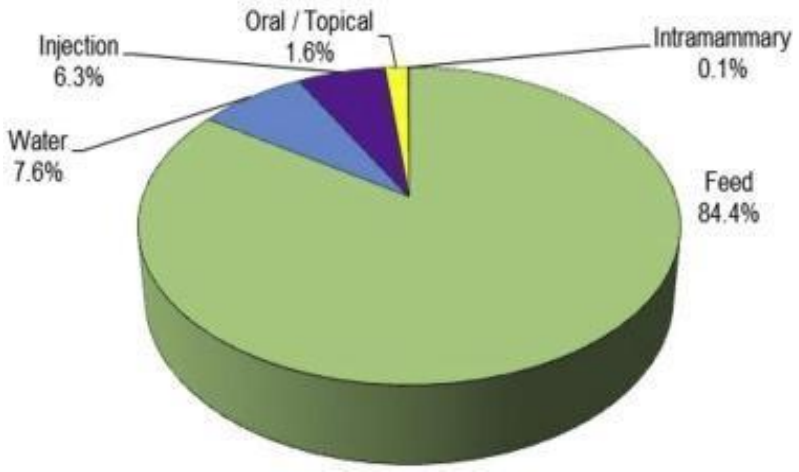

Fig. 1. Quantity of antimicrobials (% of total weight in kg) distributed for veterinary use by route of administration in Canada (CSCRA, 2016).

2.3 Antibiotic and bacterial resistance

Scientific evidence suggests that the use of antimicrobials in livestock production can promote bacterial resistance in treated animals (O'Brien, 2002). Antibiotic resistance is defined as the ability of microorganisms to proliferate in presence of an antibiotic that generally inhibits or kills microorganisms of the same species (RUMA, 2016). Resistance is by mutation or acquisition of genes carried by mobile genetic elements such as transposons, integrons, plasmids or phages (Kempf and Zeitouni, 2012). Chicken harbors large proportion of Enterobacteriaceae resistant to aminosides in its digestive tract and tetracycline in its meat (Guillot *et al*., 1977; Yulistiani et al., 2017). Bacterial resistance to antibiotics has been the subject of several studies in the recent years (Diarra *et al*., 2007; Forgetta *et al.*, 2012; Furtula *et al.*, 2010, 2013; Johnson *et al.*, 2012). In one study on Salmonella enterica isolates collected from poultry farms in British Columbia (Canada), (Diarra *et al*.,2014) showed that more than 43% of the isolates were simultaneously resistant to ampicillin, amoxicillin-clavulanic acid, ceftiofur, cefoxitim and ceftriaxone. Another Canadian study (Diarra and Malouin, 2014) highlights the existence of different stereotypes of Salmonella, isolated from broiler farms, resistant and multi-resistant to antibiotics. In addition, antibiotic resistance in Enterococci (Silbergeld *et al*., 2008), Mycoplasma gallisepticum (Pakpinyo and Sasipreeyajan, 2007) and Salmonella spp. (Manning *et al.,* 2015) isolated in broilers have been reported. A study in Germany (Schwaiger *et al.,* 2012) showed that resistant and multi-resistant isolates are very common in chicken meat.

Another study in Italy (Bacci *et al.*, 2012) reported that 86% of S. enterica isolated from chicken carcasses were resistant to tetracycline, while 30% of isolates showed multipharmacological phenotypic resistance to ampicillin, sulfamethoxazole and tetracycline. In Ecuador, a study by Braykov *et al.* (2016) showed that tetracycline resistance was detected in 78% of production bird (broilers and laying hens). More than half of the isolates were resistant to sulfisoxazole and trimethoprim- sulfamethoxazole (69% and 63%, respectively).

Bacterial resistance to animal antibiotics is a public health issue. In Canada, for example, poultry meat may play a role in human infections (Diarra *et al*., 2010; Manges *et al.,* 2007). In addition, Hur *et al.* (2011) founded that isolates of S. enterica from egg and chicken carcasses were resistant to penicillins, sulfisoxazole, treptomycin, tetracycline and quinolones. S. enterica isolates were resistant to at least 21 antibiotics used by the authors. Most isolates harbored genes associated with SPI-1 and SPI-2 and the spv operon, which are known to be associated with human infections. This represents a threat to human health. This situation is mainly due to the misuse of certain antibiotics such as penicillins, tetracyclines, macrolides and aminoglycosides (Diarra and Malouin, 2014). The abusive use of antibiotics and the associated selection pressure have led to decreased therapeutic efficacy and created populations of antibiotic-resistant microorganisms. Antibiotic resistance may spread over time despite the suspension of antibiotic use. Indeed, strains of E. coli resistant to trimethoprim and streptomycin have been shown to persist for several weeks in a chicken farm without using the antibiotics mentioned above (Chaslus-Dancla *et al.,* 1987). On the other hand, antibiotic resistance is lower in organic farms (Hegde *et al.,* 2016). Thus, it is imperative to determine the exact sources and ecology of resistant bacteria in order to develop strategies to stop their proliferation (Diarra and Malouin, 2014).

2.4 Alternatives to the use of antibiotics

Consumers' pressure and worries towards harmful effects of antibiotic use and the ban of antibiotics in EU have prompted researchers to think about alternatives to antibiotics (Diarra and Malouin, 2014). The aim of these alternatives is to maintain a low mortality rate, a good level of animal yield while preserving environment and consumer health. Much research has been carried

out to look for natural agents with similar beneficial effects of growth promoters. There are indeed a number of non-therapeutic alternatives that can substitute antibiotics use. Among these, the most popular are probiotics, prebiotics, enzymes, organic acids, immunostimulants, bacteriocins, bacteriophages, phytogenic feed additives, phytocides, nanoparticles and essential oils.

2.4.1 Probiotics

Probiotics are defined as "live micro-organisms, when administered in adequate amounts, confer a health benefit to the host" (WHO, 2001). Probiotic feed supplementation improves growth, feed efficiency and intestinal health (Ghasemi *et al.,* 2014; Giannenas *et al.,* 2012; Samli *et al*., 2007). This improvement is achieved by reducing intestinal pH, intestinal bacteria composition and digestive activity. Mechanisms of action of probiotics include stimulation of endogenous enzymes, reduction of metabolic reactions that produce toxic substances, and production of vitamins or antimicrobial substances (Hassanein and Soliman, 2010). Probiotic bacteria produce molecules with antimicrobial activities such as bacteriocins which inhibits toxins' production and pathogens' adhesion (Pan and Yu, 2014). On the other hand, probiotics stimulate the immune response and increase resistance to colonization of bacteria (Hassanein and Soliman, 2010). Administration of Enterococcus faecium in chicken feed had an antibacterial effect on bacterial microflora in the small intestine (Levkut *et al.,* 2012). Similar results were reported with Streptomyces sp. (Latha *et al.,* 2016) and Bacillus subtilis (Zhang *et al.,* 2013). In a study (Zhang *et al*., 2013), comparing B. subtilis with enramycin, widely used as a feed additive for chickens to prevent necrotic enteritis, administration of 105 cfu of B. subtilis UBT-MO2/kg in broiler feed increased body weight by 4.4% and relative weight of the thymus. In addition, the treatment reduced NH3 and H2S concentrations in chicken excretions leading to less odor emissions. Probiotics have positive effects on poultry meat quality (Hassanein and Soliman, 2010; Popova, 2017). They improve pH, color, fatty acid profile, chemical composition, water retention capacity and oxidation stability (Popova, 2017). The probiotics affect the protein and fat contents of meat and thus the meat quality. Abdurrahman et al. (2016) reported that lipid oxidation is one of the main causes of deterioration in feed quality. This hypothesis can be confirmed by other studies that showing the inclusion of Aspergillus awamori and Saccharomyces cerevisiae in

chicken feed reduced blood saturated fatty acids and increased the polyunsaturated (Saleh et al., 2012). Another similar study of Liu *et al.* (2012b) showed that treatment with Bacillus licheniformis significantly increased the protein content and the respective essential and aromatic amino acids (Liu *et al.*, 2012b). Feed containing B. licheniformis improves meat color, juiceness and flavor of broiler chickens (Liu *et al*., 2012b). These factors are very important in terms of consumer appreciation especially the color. Probiotics may also have anticoccidial role. Results of Giannenas et al. (2012) suggest that treatment with probiotics may mitigate the impact of parasitic infection on chickens in the absence of anticoccidial infections. The use of probiotics exerted coccidiostatic effect against Eimeria tenella. This can help to minimize the risk and spread of coccidiosis and maintain intestinal health.

2.4.2 Prebiotics

Prebiotics are non-digestible feed components that are potentially beneficial to host health because of their fermentable properties that stimulate bacteria growth and/or activity in the ileum and caecum (Gibson and Roberfroid, 1995). It generally consists of short chain polysaccharides and oligosaccharides. Several prebiotics are generated from yeast cell walls and fermentation products. Prebiotics are not digestible by the host but commensal intestinal bacteria can metabolize them to produce short chain fatty acids like propionate, acetate and butyrate (Joze fiak *et al*., 2008). These prebiotic components have positive effects on poultry productivity and contribute to a healthy intestinal tract and can be a good alternative to antibiotics (Morales-Lopez *et al.,* 2009; Zhang *et al.,* 2005). When ingested, the prebiotics alter the caecal microbial composition resulting in changes in the proteobacteria and changes in the genus and family of bacteria which causes change in growth (Park *et al*., 2016). The addition of a product rich in mannose and mannoproteins in chicken feed significantly increased the number of intestinal villus cells (Baurhoo *et al.,* 2007). Further, administration of mannanoligosaccharide (0.2%) in the chicken diet conferred intestinal health benefits over antibiotics. These advantages are expressed by a reduction of pathogenic bacteria, a morphological development (height of the villus and number of goblet cells) and an increased colonization by beneficial bacteria (Baurhoo *et al*., 2009).

supplementation in water after hatching. The doses of prebiotics used in ovo are 10 times lower than after hatching.

2.4.3 Organic acids

Organic acids are conservation agents used to protect feed from microbial and fungal proliferation (Kum *et al*., 2010). These acids are mainly carboxylic acids carrying a hydroxyl group on alpha carbon such as malic, lactic and tartaric acids. The organic acids can also be simple monocarboxylic acids such as acetic, formic, butyric and propionic acids. The antimicrobial action of organic acids is due to the fact that non-dissociated acids can diffuse through lipophilic bacteria membrane and disrupt enzymatic reactions and transport system (Cherrington *et al*., 1991). Some studies (Hassan *et al*., 2010; Nava *et al.,* 2009) showed that organic acids addition to broiler feed promotes growth, feed conversion rate and feed utilization. Adding organic acids in drinking water gives young chicks a protective efficacy against Campylobacter infection (Chaveerach *et al*., 2004). These acids also have a protective action against E. coli (Izat *et al*., 1990). Thus, it has been shown (Mohammadagheri *et al.,* 2016) that supplementation with citric acid (2%) can improve cell proliferation epithelial and villi height of gastrointestinal tract. Organic acid blend, formic and propionic acid supplementation (0.0525% in drinking water) generates more homogeneous and distinct populations in the intestinal microbiota and increases the colonization of Lactobacillus spp. in ileum of chicken (Nava *et al.,* 2009). These changes in the intestinal microbiota and the increase in Lactobacillus populations show that organic acid can be used as an alternative to antibiotics (bacitracin in this study) to reduce pathogenic bacteria in the gastrointestinal tract (Nava *et al*., 2009). Some organic acids would play a role in digestion. Indeed, a diet with low digestible protein in chicken leads to more protein reaching the gut, resulting in an increase in protein fermentation. Protein fermentation produces ammonia, branched-chain fatty acids, volatile fatty acids and intermediate products such as lactate and succinate as well as gases (hydrogen, carbon dioxide and methane). Some of these compounds may have adverse effects on growth performance (Bikker *et al*., 2007). Organic acids, such as butyric acid, added as a feed additive can be used to improve the digestibility of ileal proteins from poorly digestible protein sources (Adil *et al.,* 2010). Butyric acid is a saturated carboxylic acid produced in the cecum and colon of animals via the fermentation

carbohydrates such as dietary fiber and unabsorbed starch (Hu and Guo, 2007). Butyric acid is a readily available source of energy for intestinal epithelial cells and stimulates their multiplication and differentiation, as a result improves the feed efficiency in chickens (Adil *et al*., 2010; Joze fiak *et al.,* 2004). Indeed, Hu and Guo (2007) showed that body weight gain in chickens increased linearly during the period from 0 to 21 days as the dietary supplementation of butyrate increased. Further, according to Hu and Guo (2007) dietary supplementation of butyrate influenced feed conversion ratio in a positive quadratic fashion during the period from 0 to 42 days. Qaisrani *et al.* (2015) reported that diet supplemented with butyric acid improved the growth performance of chickens fed proteins of low digestible sources.

2.4.4 Amino acids and enzymes

The feed additive enzymes are produced through fungi and bacteria fermentations. They are used to maximize feed conversion. Enzymes facilitate components degradation such as proteins, phytates and glucans. For example, endo-b-1-4-xylanases and b-1- 3,1-4-glucanases have been used in wheat and barley diets of broilers to improve their digestion (Cowieson *et al.,* 2006). Also, phytase enzyme can increase villus width and decrease crypt depth which can improve ADG (Mohammadagheri *et al.,* 2016). Lysins are bacteriophage endolysins representing an innovative alternative therapeutic option of antibacterial. Lysins are phage-encoded peptidoglycan hydrolases which bring about the bacterial cell lysis when applied exogenously to Gram-positive bacteria (Fenton *et al*., 2010; Rios *et al.,* 2016). According to Volozhantsev *et al*. (2011), administration of a combination of a group of lysins containing peptidases, amidases and lysozymes produces an antimicrobial effect against C. perfringens in poultry. For example, Ply3626 lysine is an enzyme which has been shown lytic activity against several strains of C. perfringens, which is an important cause of food poisoning and leads to economic losses in poultry production (Fenton *et al.,* 2010; Zimmer *et al*., 2002).

2.4.5 Essential oils

Essential oils are the hydrophobic liquid of odoriferous and volatile aromatic compounds of a plant. Essential oils can be natural (vegetable origin) or synthetic. Only a few essential oils have

useful antibacterial properties. The most used are thymol, transcinnamaldhyde, carvacrol and eugenol. Their modes of action lie in their interference with the enzymatic system of the bacteria and the modulation of immune responses and inflammation. Some studies (Khattak *et al*., 2014; Peng *et al.,* 2016; Pirgozliev *et al.,* 2015) showed that essential oils are promising alternatives to growth promoter antibiotics (e.g., avilamycin) in improving chicken production. Essential oils can also play a preventive and curative role in necrotic enteritis in broilers (Jerzsele *et al*., 2012). The use of essential oils has a positive effect on growth, meat and carcass quality as well as chicken health. Peng *et al.* (2016) reported that adding oregano essential oil (Origanum genus) at 300 and 600 mg/ kg in broiler chicken feed increased ADG. According to the authors, this result may be related to increased villus height and decreased crypt depth in the jejunum of broiler chickens. In addition, the administration of 600 mg/kg of feed of oregano essential oil improved the percentage of thigh muscle and decreased abdominal fat percentage in broiler chickens. Nevertheless, peppermint (Mentha piperita) was a good alternative to virginiamycin in broiler chickens (Khodambashi Emami *et al.,* 2012).

2.5 Turmeric Essential Oil

Turmeric (*Curcuma longa*) is a perennial herbaceous plant of the ginger family (*Zingiberaceae*). The turmeric plant grows to a height of about three feet and has yellow flowers. The root is bright orange with a thin brownish skin. Native to southern India and Indonesia, turmeric is cultivated on the mainland and in the islands of the Indian Ocean.

2.5.1 Plant Origin and Chemical Composition

Turmeric essential oil is derived from the plant's tuberous rhizomes, or underground roots. The essential oil is typically obtained from the turmeric root through CO2 or steam distillation using the solvent hexane. Ideally want a turmeric oil that is CO2-extracted. Turmeric essential oil is yellow in color and has an interesting scent that can be described as sweet and woody with notes of spice

2.5.2 Turmeric Essential Oil History and Interesting Facts

The use of turmeric dates back nearly 4,000 years to the Vedic culture in India, where it was used in cooking as well as religious ceremonies. Turmeric most likely reached China by 700 A.D., East Africa by 800 A.D., West Africa by 1,200 A.D. and Jamaica in the 18th century.

In 1280, Marco Polo described turmeric and was impressed that it exhibited qualities very similar to that of saffron. The plant was called Indian saffron during the middle ages because of its orange-yellow color.

According to Sanskrit medical treatises and Ayurvedic and Unani systems, turmeric has a long history of medicinal use in South Asia. Topically speaking, turmeric essential oil is traditionally used as an antiseptic and in natural skin care to discourage acne and facial hair in women. You can also mix a carrier oil like coconut oil with a drop or two of turmeric oil for hair and scalp concerns like dryness and dandruff.

Present day, turmeric is widely cultivated in the tropics and goes by many different names in various cultures and countries. The name turmeric derives from the Latin word *terra merita* ("meritorious earth"), referring to the color of ground turmeric, which resembles a mineral pigment.

2.5.3 Constituents of Turmeric Essential Oil

As already discussed turmeric essential oil contains hundreds of molecules, but its main constituents are:

- Sesquiterpene alcohol – 50%
- Zingeriberene and other Sesquiterpene hydrocarbons – 30%
- d-a-phellandrene – 4%
- Cineol – 3%
- d-sabinene – 2%
- d-borneol – 2.5%
- Valeric acid – 0.1%

The constitution varies based on turmeric used and also method.

2.5.4 Mechanism of action on Turmeric Essential Oil:

Turmeric essential oil is considered a strong relaxant and balancer.

- According to Ayurveda, this energizing herb is meant to support the imbalance of Kapha body type.
- What is turmeric essential oil used for? Truly, so many things:
    - The essential oil of turmeric has been shown to help fight against breast and colon cancer as well as leukemia.
    - Turmeric oil has been shown to stimulate regeneration of cells in the brain, making it effective at improving neurologic diseases like Parkinson's, Alzheimer's, spinal cord injury and stroke.
    - Turmeric essential oil can help you recover from the common cold through the use of aromatherapy (inhalation of the oil).
    - The essential oil of turmeric has shown potential as a natural epilepsy treatment.
    - Studies have shown that curcumin and turmeric essential oil successfully reduce the overall symptoms of depression and also work as an anti-anxiety agent when taken over a period of eight weeks.
    - The liver can greatly benefit from turmeric essential oil's protective and anti-inflammatory abilities.Turmeric essential oil can be used topically to help soothe joint and muscle aches and even arthritis.
- Turmeric essential oil is used both topically and internally. In either case, but especially when used internally, the oil needs to be of very high-quality and used sparingly in small dosages (one drop of essential oil).

Always purchase turmeric oil that is 100 percent pure, USDA-certified organic and therapeutic grade

2.5.5 Antioxidant activity of *C. longa* essential oil

The essential oil antioxidant activity most likely results from a synergy among its components. In general, the major compounds are primarily responsible for the essential oil total antioxidant activity (Singh *et al.*, 2010). Because the *C. longa* essential oil antioxidant capacity results from

different action mechanisms, four methods were used to evaluate the scavenging capacity for different free radicals and the metal-ion-chelating ability of the oil. *C. longa* essential oil exhibited dose-dependent DPPH-radical-scavenging activity, indicating that the oil acts as a hydrogen donor antioxidant. The estimated IC_{50} value was 10.03 mg/ml (Fig. 1), which is satisfactory when compared with the IC_{50} value of 4.5 mg/ml reported by Gounder and Lingamallu (2012). This difference was most likely due to the low percentage of ar-turmerone (12.9%) because reduced ar-turmerone decreases the DPPH-radical-scavenging activity of turmeric oil (Gounder & Lingamallu, 2012).

The assay for ABTS-radical-scavenging activity is based on the capacity of the sample to decrease the amount of $ABTS^{\bullet+}$ cation radical preformed in the solution. This method is considered excellent for the evaluation of the antioxidant activity of several substances and can be applied both to liposoluble and hydrosoluble substances because the method evaluates the scavenging action of lipid or hydrogen peroxyl radicals in an aqueous phase (Gounder & Lingamallu, 2012). The turmeric rhizome essential oil showed dose-dependent ABTS-radical-scavenging action (Fig. 2), with the IC_{50}equalling 0.54 mg/ml. This value was similar to those in previously reported studies of *C. longa* essential oil extracted from fresh rhizomes and leaves, whose IC_{50} values were 3.3 and 1.54 mg/ml, respectively (Gounder and Lingamallu, 2012, Priya et al., 2012). The treatments applied and the part of the plant chosen for extraction influence the chemical composition of the essential oil, which causes its antioxidant action to vary (Gounder and Lingamallu, 2012, Priya *et al*., 2012).

The reducing capacity of substances is an important indicator of their antioxidant capacity because it evaluates the ability of the sample to donate hydrogen atoms and interfere with the free-radical chain reaction (Priya *et al*., 2012). The reducing power of the turmeric oil extracted from fresh rhizomes increased with the oil concentration in a dose-dependent manner (Fig. 3). However, the essential oil reducing capacity was lower than that of 0.02% BHT because the BHT average absorbance at 700 nm was 1.290. Similar results were reported by Gounder and Lingamallu (2012) and Priya *et al.* (2012). The turmeric essential oil did not exhibit ferrous-ion- chelating activity. Similarly, the essential oil from dry *Curcuma zedoaria* rhizomes also exhibited a low capacity to reduce and chelate ferrous ions (Mau *et al.*, 2003).

2.5.6 Traditional Medicine to Modern Medicine

Although modern medicine has been routinely used in treatment of various diseases, it is less than 100 years old. Traditional medicine, in comparison, has served mankind for thousands of years, is quite safe and effective. The mechanism or the scientific basis of traditional medicine, however, is less well understood.

2.5.6.1 Effect of Turmeric against Development of Various Diseases/Disorders.

In various models, turmeric has been reported to exhibit activity against the development of skin cancer (Villaseñlor, Simon, and Villanueva 2002), breast cancer (Deshpande, Ingle, and Maru 1998a), oral cancer (Azuine and Bhide 1992a), and stomach cancer (Azuine and Bhide 1992b). It prevents carcinogenesis at various steps, including inhibiting mutation (Polasa et al. 1991), detoxifying carcinogens (Thapliyal, Deshpande, and Maru 2001), decreasing cell proliferation, and inducing apoptosis of tumor cells (Garg, Ingle, and Maru 2008). Turmeric extract prevents animal tumors induced by Dalton's lymphoma (Kuttan *et al*. 1985). In this study, mice were injected with Dalton's lymphoma cells intraperitoneally and treated with turmeric extract (10–40 mg/animal) for 10 days. After 30 days, the authors found up to 80% decrease in tumor formation in comparison with nontreated mice (Figure 13.2a). They also observed that up to 75% of animals survived after 30 days and 50% after 60 days of treatment (Figure 13.2b). In a 7,12- dimethylbenz(*a*)anthracene (DMBA)-induced hamster buccal pouch model of carcinogenesis, dietary turmeric (1%) decreased tumor burden and multiplicity and enhanced the latency period in parallel. The mechanisms of anticarcinogenesis were mediated through inhibition of DMBA- induced expression of the *ras* oncogene product, induction of p21 and its downstream targets, mitogen-activated protein kinases, and reduction of proliferating cell nuclear antigen and Bcl-2 expression. Turmeric also enhanced apoptosis (increased expression of Bax, caspase-3, and apoptotic index), decreased inflammation (levels of cyclooxygenase [COX]-2, the downstream target of activator protein-1/nuclear factor ^{K}B [NF-^{K}B], and PGE2), and induced aberrant expression of known differentiation markers, that is, cytokeratins (Garg, Ingle, and Maru 2008).

Topical application of turmeric was found to decrease multiplicity and onset of skin tumors (Villaseñor, Simon, and Villanueva 2002). Dietary administration of 1% turmeric per 0.05%

ethanolic turmeric extract was found to inhibit DMBA-induced mammary tumorigenesis in female Sprague–Dawley rats (Deshpande, Ingle, and Maru 1998a). Dietary turmeric inhibited ethyl (acetoxymethyl) nitrosamine-induced oral carcinogenesis in Syrian hamsters. However, the inhibitory effect of a combination of turmeric and betel leaf extract was found to be higher than that of the individual constituents (Azuine and Bhide 1992a). Administration of turmeric extract at a dose of 3 mg/animal 18 hours prior to intraperitoneal (i.p.) injection of benzo[a]pyrene (BaP; 250 mg/kg) significantly inhibited bone marrow micronuclei formation in female Swiss mice. Moreover, the incidence and multiplicity of BaP-induced forestomach tumors in female Swiss mice were significantly inhibited by turmeric extract (Azuine, Kayal, and Bhide 1992). Chandra Mohan, Abraham, and Nagini (2004) also showed that pretreatment with turmeric alone and in combination with tomato and garlic extract significantly lowered the frequencies of DMBA- induced bone marrow micronuclei, as well as the extent of lipid peroxidation. They revealed that these changes may be mediated by the antioxidant-enhancing effects of the dietary agents. Combined treatment of urethane, a well-known mutagen, and turmeric displayed an inhibition of the genotoxic effect of urethane by turmeric (Hamss *et al*., 1999). Decrease in tumorigenesis caused by turmeric is also associated with inhibition of DNA adduct formation. Turmeric inhibited the levels of BaP-induced DNA adducts in the livers of rats. Inclusion of turmeric at 0.1%, 0.5%, and 3.0% in the diet for 4 weeks significantly decreased the level of BaP–DNA adducts, including the major adduct dG-N2-BaP, formed within 24 hours in response to a single
i.p. BaP injection (Mukundan *et al.* 1993). Irrespective of whether turmeric was included in the diet or applied locally, it significantly decreased DMBA-induced DNA adducts at the target site and consequently lowered the number of tumors and tumor burden in the studied animals (Krishnaswamy *et al*. 1998). Turmeric contains several substances capable of inhibiting chemical carcinogenesis. It enhanced the xenobiotic-metabolizing enzymes in the hepatic tissue of rats fed with 0.5–1.0% turmeric in the diet. Detoxifying enzymes such as uridine diphosphate (UDP), glucuronyl transferase, and glutathione-S-transferase significantly increased in turmeric-fed mice as compared with control animals (Goud, Polasa, and Krishnaswamy 1993).

Turmeric enhances lymphocyte viability and blastogenesis, but induces formation of cytoplasmic blebs and plasma membrane disintegration of tumor cells.

apoptosisinducing for tumor cells (Chakravarty and Yasmin 2005). A comparative study of edible plants like C. *longa* and *F. caraica*, and herbaceous plants like *Gossypium barbadense*and *Ricinus communis* extracts for their antitumor activities showed that the edible plant extracts exhibited higher antitumorigenic activities. Thus, edible plants that show in vivo antitumor activities may be recommended as safe sources of antitumor compounds (Amara, El-Masry, and Bogdady 2008).

Turmeric showed antioxidant potential by lowering oxidative stress in animals. A study showed that a diet containing 0.1% turmeric fed for 3 weeks to retinol-deficient rats lowered lipid peroxidation rates by 22.6% in liver, 24.1% in kidney, 18.0% in spleen, and 31.4% in brain (Kaul and Krishnakantha 1997). A study conducted on mice showed that turmeric extract inhibited membrane phospholipid peroxidation and increased liver lipid metabolism, which indicates turmeric extract has the ability to prevent the deposition of triacylglycerols in the liver. Dietary supplementation for one week (1% w/w of diet) with a turmeric extract showed lower phospholipids hydroperoxide level in mice red blood cells (RBC). The liver lipid peroxidizability induced with Fe^{2+}/ascorbic acid was effectively suppressed by dietary supplementation with turmeric (Asai, Nakagawa, and Miyazawa 1999). Oral administration of a nutritional dose of turmeric extract decreased susceptibility to oxidation of erythrocyte and liver microsome membranes in vitro. When turmeric hydroalcoholic extract (1.66 mg/kg of body weight) was given to rabbits fed a high-fat diet, oxidation of erythrocyte membranes was found to be significantly lower than that in membranes of control animals. Levels of hydroperoxides and thiobarbituric acid-reactive substances in liver microsomes were also low (Mesa *et al*. 2003). Turmeric also seems beneficial in preventing diabetes-induced oxidative stress. In diabetic rats, an AIN93 diet containing 0.5% turmeric was found to control oxidative stress by inhibiting increases in thiobarbituric acid-reactive substances and protein carbonyls and reversing altered antioxidant enzyme activities without altering the hyperglycemic state (Arun and Nalini 2002; Suryanarayana *et al*. 2007). This diet also inhibited expression of vascular endothelial growth factor in diabetic rats (Mrudula *et al.* 2007). Further, it suppressed increase in blood glucose level in type 2 diabetic KK-Ay mice. A dose of 0.2 or 1.0 g of ethanol extract, 0.5 g of hexane extract, and 0.5 g of hexane-extraction residue per 100 g of diet in the mice feed suppressed significant increase in blood glucose levels. The ethanol extract of turmeric also stimulated human adipocyte differentiation, and it showed human peroxisome proliferator-

activated receptor-gamma (PPAR-γ) ligand-binding activity (Nishiyama *et al.*, 2005). Further, turmeric appeared to minimize osmotic stress. Most importantly, aggregation and insolubilization of lens proteins due to hyperglycemia was prevented by turmeric, indicating that it prevents or delays the development of cataracts (Suryanarayana *et al.*, 2005).

Turmeric has been reported to be hepatoprotective. Diets containing turmeric extract suppressed increases in lactate dehydrogenase (LDH), alanine aminotransferase (ALT), and aspartate aminotransferase (AST) levels caused by D-galactosamine-induced liver injury in rats (Miyakoshi *et al.*, 2004). A 5% turmeric extract decreased carbon tetrachloride–induced increases in serum levels of bilirubin, cholesterol, AST, ALT, and alkaline phosphatase (ALP) in mice (Deshpande *et al*. 1998b). In female Wistar rats fed a diet containing 0%, 0.2%, 1.0%, or 5.0% turmeric, nitrosodiethylamineinduced hepatocarcinogenesis was inhibited. This effect was detected by measuring the numbers of γ-glutamyl transpeptidase–positive foci, a marker of hepatocarcinogenesis (Thapliyal *et al.*, 2003).

Turmeric is also effective against neuronal, cardiac, and kidney disorders. The effect of turmeric on myocardial apoptosis and cardiac function was examined in an ischemia and reperfusion model of myocardial injury. Turmeric at 100 mg/kg administered for 1 month afforded significant cardioprotection and functional recovery that was attributed to reduction in cell death (Mohanty, Arya, and Gupta 2006).

Turmeric is also useful against depression (Yu, Kong, and Chen 2002; Xia *et al.* 2006; Xia *et al.* 2007). Its ethanolic extract markedly attenuated swim stress–induced decreases in serotonin, 5- hydroxyindoleacetic acid, and noradrenaline and dopamine concentrations, as well as increases in serotonin turnover. Also, this extract significantly reversed swim stress–induced increases in serum corticotropin-releasing factor and cortisol levels and thus regulated neurochemical and neuroendocrine systems in mice (Xia *et al.* 2007). In another study, administration of aqueous extracts of turmeric to mice (140–560 mg/kg for 14 days) reduced immobility in the tail suspension test and the forced swimming test (Yu, Kong, and Chen 2002). The effects of 560- mg/kg turmeric were found to be more potent than those of the antidepressant fluoxetine. The extracts significantly inhibited brain monoamine oxidase (MAO)-A activity at a low dose, but at a higher dose, they inhibited brain MAO-B activity. In comparison, fluoxetine showed only a tendency to inhibit MAO-A and -B activity in animal brains. These results demonstrate that

turmeric has specific antidepressant effects in vivo. However, since curcumin is not water soluble, the agent in aqueous extracts of turmeric responsible for this activity is not clear.

The antiarthritic effects of turmeric include inhibition of joint inflammation and periarticular joint destruction. In vivo treatment with turmeric extract prevented local activation of NF-κB and the subsequent expression of NF-κB-regulated genes mediating joint inflammation and destruction, including chemokines, COX-2, and the receptor activator of NF-κB ligand (RANKL). It also inhibited inflammatory cell influx, joint levels of PGE2, and periarticular osteoclast formation in rats (Funk *et al.* 2006). Turmeric was found to be effective against carrageenan-induced edema in rats (Yegnanarayan, Saraf, and Balwani 1976), and water extracts of turmeric were more active than alcohol extracts in the inhibition of carrageenan-induced edema. Turmeric extract, when given intraperitoneally, was found to be more active than hydrocortisone (Ghatak and Basu 1972). The yellow powder of turmeric is known to have potent vasorelaxant activity and to decrease the atherogenic properties of cholesterol. A study showed that supplementation of turmeric in the diet controlled arterial blood pressure in animals and enhanced vasorelaxant responses to adenosine, acetylcholine, and isoproterenol (Zahid Ashraf, Hussain, and Fahim 2005). Turmeric's antiatherosclerotic effect is associated with inhibition of low-density lipoprotein oxidation, prevention of lipoperoxidation, and reduction in levels of cholesterol (Quiles *et al*. 1998; Ramírez-Tortosa *et al.* 1999). A study showed that feeding an ethanolic extract of turmeric to rats elevated the high-density lipoprotein (HDL)-cholesterol/total cholesterol ratio. The extract also caused a significant decrease in the ratio of total cholesterol/phospholipids. Turmeric extract exhibited better cholesterol and triglyceride lowering (85% and 88%, respectively) as compared to *Nardostachys jatamansi* extract in tritoninduced hyperlipidemic rats (Joshi 1988). Turmeric suppresses Freund's adjuvantinduced arthritis and acute edema in rats, and it has also been reported that oil extract of turmeric is more active than cortisone (Chandra and Gupta 1972).

Another interesting property of turmeric is its wound-healing ability. Gujral, Chowdhury, and Saxena (1953) found that turmeric has the property of healing wounds and ulcers in rats and rabbits. Other studies in rabbits revealed that stimulation of mucin secretion could protect the stomach from ulcer (Mukerji, Zaidi, and Singh 1961).

Besides causing these effects, addition of turmeric to the diet significantly improved weight gain of broiler chicks and reduced their relative liver weight. Turmeric also ameliorated the adverse effects of aflatoxin on some serum chemistry parameters (total protein, albumin, cholesterol, calcium) in broiler chicks and restored antioxidant functions in terms of level of peroxides, superoxide dismutase activity, and total antioxidant concentration in their livers (Gowda *et al.* 2008).

Turmeric oil acts as a digestive stimulant. As a dietary supplement, it favorably enhanced the activities of pancreatic lipase, chymotrypsin, and amylase. Moreover, turmeric mixed with other spices such as coriander, red chili, black pepper, and cumin brought about a pronounced stimulation of bile flow and bile acid secretion (Platel et al. 2002). Mukerji, Zaidi, and Singh (1961) showed that turmeric increases the mucin content of gastric juice in rabbits. Studies conducted by Farnsworth and Bunyapraphatsara (1992) and Prucksunand *et al*. (2001)explain that turmeric has local anesthetic action. After eating turmeric, secretion of gastrin hormone from the antrum of the stomach may be inhibited. Turmeric may possess local membrane-anesthetizing activity at the antrum of the stomach, which then inhibits secretion of gastrin in the same way as oxethazaine, the active ingredient of strocain (Masuda 1973). This is the reason turmeric is administered before meals.

CHAPTER 3

MATERIALS AND METHODS

3.1 Statement of the experiment

The research work was conducted at Sher-e-Bangla Agricultural University Poultry Farm, Dhaka, with 150-day-old straight run (Cobb 500) commercial broilers for a period of 28 days from 9 th july to 6 th August , 2018 to assess the feasibility of using Turmeric oil in commercial broiler diet on growth performance, meat yield characteristics and immune status of broilers. This research helps to make a conclusion about turmeric oil as the alternative of antibiotic

3.2 Collection of experimental broilers

A total of 150 day-old Cobb 500 broiler chicks were collected from Kazi hatchery, Savar, Dhaka.

3.3 Experimental materials

The collected chicks were carried to the university poultry farm early in the morning. They were kept in electric brooders equally for 2 days by maintaining standard brooding protocol. During brooding time only basal diet was given no turmeric oil was used as treatment. After two days 90 chicks were selected from brooders and distributed randomly in three (3) dietary treatments of DSP; another 60 chicks were distributed randomly in one treatment for antibiotic and another treatment for control. Each treatment had three (3) replications with 10 birds per replication. The total numbers of treatments were five (5) and their replications were fifteen (15).

3.4 Experimental treatments

T1: Basal Diets/ Control
T2: Antibiotics
T3: 0.125% of Turmeric
T4: 0.25% of Turmeric
T5: 0.5% of Turmeric

Table 1. Layout of the experiment

Treatment groups	No. of replications			Total
	R_1	R_2	R3	
T1	10	10	10	30
T2	10	10	10	30
T_3	10	10	10	30
T4	10	10	10	30
T5	10	10	10	30
Total	50	50	50	150

3.5 Preparation of experimental house

The experimental room was properly cleaned and washed by using tap water. Ceiling walls 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

Starter and grower commercial Kazi broiler feed were purchased from the market. Starter diet was enriched with minimum:-

Table 2. Name and minimum percentage of ingredients present in Starter and Grower ration.

Name of ingredients in Starter ration	**Minimum percentage Present**
Protein	21.0 %
Fat	6.0%
Fiber	5.0%
Ash	8.0%
Lysine	1.20%
Methionine	0.49%
Cysteine	0.40%
Tryptophan	0.19%
Threonine	0.79%
Arginine	1.26%
Name of ingredients in Grower ration	**Minimum percentage Present**
Protein	19.0 %
Fat	6.0%
Fiber	5.0%
Ash	8.0%
Lysine	1.10%
Methionine	0.47%
Cystine	0.39%
Tryptophan	0.18%
Threonine	0.75%
Arginine	1.18%

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

3.6.1 Collection of Turmeric oil

Turmeric oil was used in commercial basal diets**.** This turmeric oil was sponsored by Avon Animal Health Company, Dhaka, Bangladesh for conducting the research work.

Table 3. Nutritional composition of Turmeric oil:

Nutritional analysis	Turmeric oil (curcumol)
CHO	Not detected (detection limit 0.1 %)
Energy	8987.4 kcal/kg
Protein	Not detected (detection limit 0.1 %)
Fat	99.86%
Sesquiterpene alcohol	50%
Zingeriberene and other Sesquiterpene hydrocarbons	30%
d-a-phellandrene	4%
Cineol	3%
d-sabinene	2%
d-borneol	2.5%
Valeric acid	0.1%

3.7 Management procedures

Body weight and feed intake 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 experiment period.

3.7.1 Brooding of baby chicks

The experiment was conducted during 9 th july to 6 th August, 2018. The average temperature was 31.5^0C and the RH was 80% in the poultry house. Common brooding was done for one week. After one week the chicks were distributed in the pen randomly. There were 10 chicks in each pen and the pen space was 1m2. Due to hot climate brooding temperature was maintained as per requirement. Brooding temperature was adjusted (below 35^0C) with house temperature. So when the environmental temperature was above the recommendation, then no extra heat was provided. At day time only an electric bulb was used to stimulate the chicks to eat and drink. In brooding extra heat was not provided at day time except mid night to morning. Electric fans were used as per necessity to save the birds from the heat stress.

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. Averages of room temperature and percent relative humidity for the experimental period were recorded and presented in Appendix 3 & 4**.**

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 feeder and one round drinker were provided in each pen for 4 birds. Feeders were cleaned at the end of each week and drinkers were washed daily. All mash dry feed was fed to all birds ad libitum throughout the experimental period.

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 22 hours light and 2 hours dark was scheduled up to 28 days.

3.7.6 Bio security measures

To keep disease away from the broiler farm recommended vaccination, sanitation program was undertaken in the farm and its premises. All groups of broiler chicks were supplied Vitamin B-Complex, Vitamin-ADEK, Vitamin-C, Ca and Vitamin-D enriched medicine and electrolytes.

3.7.7 Vaccination

The vaccines collected from medicine shop (Ceva Company) and applied to the experimental birds according to the vaccination schedule. The vaccination schedule is shown in Table 4.

Table 4. Vaccination schedule

Age of birds	Name of Disease	Name of vaccine	Route of administration
3 days	IB + ND	MA-5 + Clone-30	One drop in each eye
9 days	Gumboro	G-228E (inactivated)	Drinking Water
17days	Gumboro	G-228E (inactivated) booster dose	Drinking Water
21 days	IB + ND	MA-5 + Clone-30	Drinking Water

3.7. 8 Ventilation

The 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.

3.7.9 Sanitation

Strict sanitary measures were taken during the experimental period. Disinfectant (Virkon) was used to disinfect the feeders and waterers and the house also.

3.8 Study Parameters

3.8.1 Recorded parameters

Weekly lives 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, hear and bursa were measured from each broiler chicken. 30 Dressing yield was calculated for each replication to find out dressing percentage.cholesterol level was analysis from each replication to measure.

3.9 Data collection

3.9.1 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.

3.9.2 Dressing yield:

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

3.9. 3 Feed consumption:

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

3.9. 4 Mortality of chicks:

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

3.9. 5 Dressing procedures of broiler chicken:

Two birds were picked up at random from each replicate at the 28th day of age and sacrificed to estimate dressing percent of broiler chicken. All birds to be slaughtered were weighed and fasted f by halal method or 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 (1982). 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 proventiculus 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 Cholesterol sample analysis

Blood samples (1 ml/bird) were collected into ethylenediethyletetraacitic acid (EDTA) tubes from the wing veins. Samples was calculated by tube touch and tube mate cholesterol meter.

3.10.1 Live weight gain

The average body weight gain of each replication was calculated by deducting initial body weight from the final body weight of the birds. Body weight gain = Final weight – Initial weight

3.10.2 Feed intake

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

Feed intake (g/bird) = No. of birds in a replication / Feed intake in a replication

3.10.3 Feed conversion ratio

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

FCR= Weight gain (kg) / Feed intake (kg)

3.10.4 Statistical analysis

The data was subjected to statistical analysis by applying one way ANOVA using statistical package for social sciences (SPSS) version 16. Differences between means were tested using Duncan's multiple comparison test, LSD and significance was set at $P<0.05$.

CHAPTER 4
RESULT AND DISCUSSION

4.1. Introduction

Experimental treatments significant effect on daily feed intake and body weight gain of broilers at different periods. Although final body weight of broilers fed diet supplemented with turmeric oil was numerically higher than in control group. Supplementation of 0.125%, 0.25% and 0.5% turmeric oil improved feed efficiency compared with control group ($P<0.05$). No birds were died during the experimental died.

The results of feeding broilers on diet containing turmeric oil are presented in the following sub- headings:

4.1.1 Production performance of broiler chicken

Table 5: Production performance of broiler chicken with control, antibiotic and turmeric oil

Treatment	Live weight (g/bird)	Feed consumption (g/bird)	FCR (g/bird)	Survivability (%)
T_1	1527.67 ± 6.333^{c}	2167.67 ± 27.425	$1.42 \pm .024$	100 ± 00
T_2	1564.17 ± 16.604^{b}	2160.33 ± 10.477	$1.38 \pm .017$	100 ± 00
T_3	1601.50 ± 6.764^{a}	2198.50 ± 5.393	$1.37 \pm .009$	100 ± 00
T_4	1612.33 ± 13.815^{a}	2179.00 ± 30.730	$1.35 \pm .029$	100 ± 00
T_5	1561.83 ± 6.547^{bc}	2203.67 ± 22.669	$1.41 \pm .014$	100 ± 00
Mean ± SE	1573.50 ± 9.108	2181.83 ± 9.353	$1.39 \pm .010$	100 ± 00
Level of significance	*	NS	NS	NS

T_1 = Control, T_2= Antibiotic, T_3= .125% Turmeric oil, T_4= .25% Turmeric oil, T_5= .5% Turmeric oil, Values are Mean ± S.E (n=15) one way ANOVA (SPSS, Duncan method).

- Mean with different superscripts at the same column are significantly different ($P<0.05$)
- Mean within same superscripts don't differ ($P>0.05$) significantly
- SE= Standard Error
- *means significant at 5% level of significance ($p<0.05$)
- NS= Non significant

4.1.2 Live weight:

Table 5 represents the productive performance of broiler receiving feed supplemented with antibiotic and turmeric oil. Incase of live weight (g/bird) there were significant (P<0.05) difference in different group. Significantly (P<0.05) highest live weight was found in T_3 (1601.50 ± 6.764) and T_4 (1612.33 ± 13.815) group tan the control T_1 (1527.67 ± 6.333) and antibiotic T_2 (1564.17 ± 16.604) group. Significantly (P<0.05) lowest live weight was found in T1 (1527.67 ± 6.333).

The present result was supported (Durrani *et al*., 2006; Raghdadand Al-Jaleel, 2012; Osawa *et al.,* 1995; Samarasinghe *et al*., 2003; Wuthi-Udomleret *et al.,* 2000) who reported that The significant effect of turmeric oil on body weight.

4.1.3 Feed Consumption:

The result present in table 5 showed that, the effect of different treatment on FC (g/bird) were insignificant (P>0.05).The FC of different dietary groups T1, T2, T3, T4 & T5 were 2167.67 ± 27.425, 2160.33 ± 10.477, 2198.50 ± 5.393, 2179.00 ± 30.730 and 2203.67 ± 22.669 respectively.Numerically highest feed intake was found in T5 (2203.67 ± 22.669) group and lowest FC in T2 (2160.33 ± 10.477) group but this difference was insignificant (P>0.05).

4.1.4 FCR:

The result present in table 5 showed that, the effect of different treatment on FCr were insignificant (P>0.05).The FCr of different dietary groups T1, T2, T3, T4 & T5 were1.42 ± .024, 1.38 ± .017, 1.37 ± .009, 1.35 ± .029 and 1.41 ± .014 respectively.Numerically better FCR was found in T4 (1.35 ± .029) group than the other groups but this difference was insignificant (P>0.05).

4.1.5 Survivability (%):

Table 5 was showed that, survivability percentage of different dietary groups were insignificant (P>0.05). All treatment groups showed 100% survivability and was not related to different percentage of turmeric oil.

4.1.6 Weekly Body weight gain (BWG):

Table 6: Weekly Body weight gain (BWG) (0-4 week)

Treatment	1st week (g/bird)	2nd week (g/bird)	3rd week (g/bird)	4th week (g/bird)
T_1	176.67 ±4.410	363.00 ±16.503	545.33 ±7.860^{b}	442.67 ±6.741^{b}
T_2	171.67 ±3.756	383.33 ±8.988	552.17 ±4.187^{b}	457.00 ±12.490^{ab}
T_3	175.00 ±3.884	392.83 ±6.431	558.17 ±6.723^{ab}	475.50 ±10.259^{a}
T_4	180.00 ±2.930	385.00 ±7.911	574.83 ±3.245^{a}	472.50 ±5.204^{a}
T_5	174.67 ±.333	360.00 ±7.638	564.67 ±6.353^{ab}	462.50 ±4.359^{ab}
Mean ± SE	175.60 ±1.473	376.83 ±5.169	559.03 ±3.521	462.03 ±4.467
Level of significance	NS	NS	*	*

*Mean with different superscripts at the same Column are significantly different (P<0.05)

Body weight gain was differed by the addition of turmeric (P<0.05) oil in diet. In 3rd week, T_4 (0.25% turmeric oil) (574.83 ±3.245) group showed significantly (P<0.05) higher body weight gain compare to the antibiotic T_2 (552.17 ±4.187) group and control T_1 (545.33 ±7.860) group. The control showed the lowest value (545.33 ±7.860g/d) while 0.25 turmeric oil group showed highest value (574.83 ±3.245g/d) of body weight gain.In case of 4th week BWG different treatment group showed significant (P<0.05) difference.Signficantly (P<0.05) highest BWG (g/bird) showed T3 (475.50 ±10.259) and T_4 (472.50 ±5.204) group compared to control T_1 (442.67 ±6.741) group.Asghari et al. (2009) reported that the curcumin content of turmeric oil at different stage (0.25 to 2.7%), in addition and Reema et al. (2006) showed that the curcumin contents of the selected brands of turmeric from different regions and countries could vary from 0.58 to 3.14%.

The significant effect of turmeric oil on body weight was in agreement with the findings of some previous reports (Durrani *et al.*,2006; Raghdadand Al-Jaleel,2012;Osawa et al., 1995; Samarasinghe *et al*.,2003; Wuthi-Udomleret *et al.*,2000). They had found that inclusion of turmeric at the rate of 0.25% significantly increase body weight of broiler. But these findings contradict with 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.

4.1.7 Weekly Feed Consumption:

Table 7: Feed consumption of the broiler supplemented with turmeric oil (0-4 week)

Treatment	1st week	2nd week	3rd week	4th week
T_1	180.00 ±2.887	423.33 ±20.883	592.00 ±18.903	972.33 ±32.845
T_2	185.33 ±1.453	422.67 ±10.269	581.67 ±18.782	970.67 ±2.603
T_3	186.67 ±1.667	423.33 ±8.819	596.17 ±8.738	992.33 ±3.941
T_4	186.33 ±.882	433.33 ±3.333	598.33 ±1.667	961.00 ±30.567
T_5	185.17 ±2.489	430.00 ±5.774	608.00 ±11.184	980.50 ±9.751
Mean ± SE	184.70 ±.997	426.53 ±4.506	595.23 ±5.602	975.37 ±8.292
Level of significance	NS	NS	NS	NS

NS= Non significant

Table 7 showed that, Effect o different treatments on FC (g/bird) were insignificant (P>0.05) in different week.At the end of 4th week, FC of different dietary groups were T1, T2, T3, T4 & T5 972.33 ±32.845, 970.67 ±2.603, 992.33 ±3.941, 961.00 ±30.567 and 980.50 ±9.751 respectively. Numerically higher feed intake found in T3 (992.33 ±3.941) group and lower in T4 (961.00 ±30.567) group.The above results were partially agreement with some earlier studies (Nouzarianet *al.*, 2001; Wuthi-Udomler, *et al*., 2000). Similar observations were made by Emadi and Kermanshahi (2006) and Durrani *et al.* (2006) in chickens; the authors reported that at .05% level turmeric significantly decreased feed consumption of chickens, whereas feed intake of birds supplemented with 0.2, 0.5 and 1.0 % levels turmeric oil was similar to that of control group.

4.1.8 Weekly Feed Conversion ratio (FCR)

Table 8: Weekly FCR of the broiler supplemented with turmeric oil (0-4 week)

Treatment	1st week	2nd week	3rd week	4th week
T_1	1.02 ±.020	1.17 ±.101	1.09 ±.038	2.20 ±.069
T_2	1.08 ±.030	1.10 ±.020	1.05 ±.042	2.13 ±.065
T_3	1.07 ±.027	1.08 ±.016	1.07 ±.028	2.09 ±.038
T_4	1.04 ±.013	1.13 ±.029	1.04 ±.004	2.03 ±.065
T_5	1.06 ±.012	1.20 ±.027	1.08 ±.009	2.12 ±.025
Mean ± SE	1.05 ±.010	1.14 ±.022	1.07 ±.012	2.11 ±.025
Level of significance	NS	NS	NS	NS

Table 8 represents the FCR of broiler receiving feed supplemented with antibiotic or turmeric oil. In respect to FCR up to 28 days, there was no significant difference (P>0.05) among the dietary groups. At the end of 4th week of age, the better FCR (2.03 ±.065) was found in broilers fed on 0.25% turmeric oil. May be increased body weight gain is due to the antioxidant activity of turmeric (According to Osawa *et al*.,1995) antioxidant of turmeric stimulates the protein synthesis bird through the enzymatic system.

4.1.9 Cholesterol

Table 9: Cholesterol level (mg/dl) of birds in different age

Treatment	Cholesterol level (mg/dl)
T_1	167.6^{a}±6.0
T_2	164.3^{ab} ±3.9
T_3	147.0^{bc}±8.6
T_4	128.6^{c}±4.9
T_5	148.3^{abc}±5.3
Mean ± SE	151.2±4.3
LSD (0.05)	8.5**

a values superscripts in the same significant (P<0.05), b values superscripts comparatively lower than a in the same significant (P<0.05), ab values with different superscripts in the same row differ significantly (P<0.05),bc values with different superscripts in the same row differ significantly lower than ab and abc values with different superscripts in the same row differ significantly.

The data represented in the table 9 indicates that total cholesterol was significantly (P<0.05) lower in the 0.25% turmeric oil group compare to the control and antibiotic groups. The turmeric group 0.25% showed the lowest (128.6mg/dl) and control group showed the highest (167.6mg/dl) total cholesterol value. Asai and Miyazawa (2001) examined the effect of curcumin on lipid metabolism in rats fed a moderately high-fat diet. Cholesterol level decreases as we increases the turmeric oil upto 0.25%. However, its increases further additing of the turmeric oil.

This study is in accordance with that of Dono [38] who reports that the addition of turmeric at 0.25% level can increase HDL content and reduce total cholesterol, triglycerides, and LDL in broiler serum because turmeric oil is able to stimulate the activity of lipase-sensitive hormone.

4.1.10. Different dressing parameter of broiler

Table 10: Carcass characters of the broiler supplemented with turmeric oil

Treatment	T1	T2	T3	T4	T5	Mean ± SE	LSD (0.05)	Age (28 days)
Live wt.	1727[b] ± 41.2	1772[b] ± 27.5	1814[ab] ± 29.1	1781[b] ± 41.2	1897[a] ± 6.1	1798 ± 19.2	44.9*	
Dressed wt.	1334 ± 33.3	1276 ± 47.5	1363 ± 27.5	1355 ± 47.2	1350 ± 6.8	1336 ± 15.9	50.6	
Eviserated wt.	1088[ab] ± 30.9	1025[b] ± 33.0	1155[a] ± 17.6	1125[ab] ± 46.6	1120[ab] ± 20.6	1102 ± 16.8	44.5*	
Liver wt.	37.6 ± 2.7	36.0 ± 2.3	38.8 ± 2.2	38.1 ± 1.7	40.3 ± 1.0	38.2 ± 0.8	2.9	
Spleen wt.	1.8 ± 0.7	2.0 ± 0.5	2.6 ± 0.7	2.0 ± 0.5	2.0 ± 0.5	2.1 ± 0.6	0.5	
Heart wt.	8.3[b] ± 0.7	8.8[b] ± 0.2	9.6[b] ± 0.7	9.0b ± 0.5	11.3[a] ± 1.5	9.4 ± 1.3	0.7**	
Intestine wt.	106.8[b] ± 6.6	113.0[b] ± 1.7	129.2[a] ± 2.9	108.8[b] ± 4.2	110.5[b] ± 4.0	113.6 ± 2.6	5.9*	
Gizzard wt.	32.8[b] ± 2.1	37.0[b] ± 3.2	46.8[a] ± 3.5	38.0[b] ± 1.5	46.5[a] ± 1.2	40.2 ± 1.7	3.5**	
Bursa wt.	2.3[ab] ± 0.4	2.0[b] ± 0.2	1.8[b] ± 0.2	3.1[a] ± 0.2	2.5[ab] ± 0.5	2.3 ± 0.2	0.4*	
Abdominal fat wt.	23.0 ± 3.1	21.0 ± 1.3	26.6 ± 1.1	27.3 ± 1.3	26.0 ± 2.8	24.8 ± 1.0	3.0	

Table 10 indicates that turmeric oil had significant (P<0.05) effect in live, Eviserated, heart, intestine, gizzard and bursa weight comparing to the control and antibiotic group. However, the treatments had no significant effect (P>0.05) on dressed, liver, spleen, liver, spleen, abdominal fat weight in relation to body weight. Similar to our findings on carcass yield, Mehala and Moorthy (2008) failed to observe any significant impact of turmeric on carcass percentage of broiler chickens reared to six weeks of age. On the contrary, Durrani et al. (2006) reported higher dressing percentage, breast, thigh and giblet weight in broilers fed diet containing 0.75% turmeric.

Considering the results obtained in the current study it could be concluded that dietary inclusion of 0.25% turmeric oil may increase feed consumption and body weight gain in broiler chickens, but has the potential to improve feed effeciency. In addition, turmeric oil had a favourable impact on carcass fat deposition and cholesterol at slaughter age.

4.1.11 Cost-effectiveness of production

Table 11: Cost benefit analysis of broiler in different dietary treatment

Treatment	T_1 (Control)	T_2 (Antibiotic)	T_3 (0.15%)	T_4 (0.25%)	T_5 (0.5%)	Mean ±SE
Benefit cost Ratio/m2	1.22^{c} ±.013	1.25^{abc} ±.014	1.26^{ab} ±.007	1.28^{a} ±.018	1.23^{bc} ±.007	1.25*±.008

Benefit cost Ratio/m2 of the present research work is shown in the table 11. The benefit cost ration showed that , turmeric 0.25% group was higher (1.28) comparing the turmeric 0.15% (1.26), turmeric 0.5% (1.23), antibiotic (1.25) and control (1.22) group. There was significant difference (P>0.05) among the dietary groups

CHAPTER 6

SUMMARY AND CONCLUSION

The use of turmeric oil has been associated with many beneficial effects in poultry production. An experiment was conducted with 150 one-day-old straight run Cobb 500 broiler chicks for a period of 28 days of age at Sher-e-bangla Agricultural University (SAU) Poultry Farm, Dhaka to study the effect of turmeric oil as an alternative to antibiotic growth promoter in broiler diet. The broiler chicks were divided into five groups each of 30, replicated to three sub-groups each of 10 birds. The first, second and third group of chicks was considered as turmeric oil in different ratio .The fourth group of chicks received control (without additives), the fifth group of chicks received antibiotic growth promoter. Live weight, feed intake, feed conversion ratio, livability, internal organ and bone development, meat yield, cholesterol parameters of broiler on different treatments were recorded and statistically analyzed. The body weight and body weight gain of broilers in the 2nd and 3rd week body weight showed significant difference ($P<0.05$) among the dietary groups. Turmeric oil 0.25% group showed significant lower data compare to the control and antibiotic group in 2nd week and 3rd week. Highest body weight was in turmeric oil 0.25% (1612.33), followed by, turmeric oil 0.125% (1601.50), turmeric oil 0.5% (1561.63), control group (1527.67) and antibiotic (1564.17)

However, 1st week, 3rd week, 4th week and final body weight were not ($P>0.05$) different among the treatment groups. Body weight gain was not differed by the addition of turmeric oil in diet. In 2nd week, control group showed higher body weight gain compare to the turmeric oil 0.25% and 0.5% group while, antibiotic group was higher than the turmeric oil 0.125% group. The control group showed the lowest value (1527.67) while turmeric oil 0.25% showed highest value (1612.33) of body weight gain at the end of the experiment. In case of the total feed intake there was significant difference among control, antibiotic, and turmeric group.

However, there were insignificant effect (P>0.05) on 1st, 2nd, 3rd, 4th and up to 28 days of feed intake of broiler in different treatments. In case of total FCR value, antibiotic and turmeric oil groups (0.125% and 0.25%) showed better FCR comparing to the control and higher level (0.5%) of turmeric group. Turmeric group showed significantly (P<0.05) low abdominal fat weight comparing to the control and antibiotic group. However, the treatments had no significant effect (P>0.05) on skin, head, shank, liver, spleen, kidney, heart, gizzard weight in relation to body weight. The cholesterol was significantly (P<0.05) lower in the turmeric group compare to the control and antibiotic groups. The Turmeric group 0.5% showed the lowest (147.0) and control group showed the (128.6) total cholesterol value.

With regards to profit, antibiotic and control group showed higher profitability compared to turmeric groups. However, considering the health safety concern of supplemented groups if we increase the sell price up to 150 tk/kg then we will get higher profit from turmeric oil supplemented groups compare to the control and antibiotic groups.

So, finally it can be concluded that addition of turmeric oil in the broiler diet positively affects growth parameters. Moreover, upon supplementation of turmeric oil abdominal fat, cholesterol level positively improved. Considering these results it is clearly noticeable that if we will extensively use turmeric oil in our country as potential feed additives in poultry diet we can produce antibiotic free poultry meat and eggs, which will be safe food for human and develops related industries in Bangladesh. More research is needed in this context.

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APPENDICES

Appendix 1. Recommended level of nutrients for broiler

Components	Starter	Grower
ME (kcal/kg)	3000	3100
% CP	22	20
% Ca	1.0	0.85
% P (Available)	0.5	0.4
% Lysine	1.2	1.0
% Methionine	0.5	0.45
% Tryptophane	0.21	0.18

Source: Cobb500 Broiler Management Guide, 2016

Appendix 2. Nutrient composition of the ingredients used to formulate experimental diets

Ingredients	DM (%)	ME (K. Cal/kg)	CP (%)	CF (%)	Ca (%)	P (%)	Lys (%)	Meth (%)	Tryp (%)
Soybean meal	90	2710	44.50	7.5	0.26	0.23	2.57	0.76	0.57
Maize	89.5	3309	9.2	2.4	0.25	0.40	0.18	0.15	0.09
DCP					22	17.21			
Soybean oil	100	8800							
Protein concentrate (Jeso-prot)	91.64	2860	63.30	8.1	6.37	3.24	3.87	1.78	.53
Meat and Bone meal	95.5	1044	14.6	2.5	7.0	12.11	.66	0.24	0.12

Source: Cobb500 Broiler Management Guide, 2016

Appendix 3. Recorded temperature (°C) and humidity during experiment

		Morning 6 (am)	Morning 6 (am)	Noon 2 (pm)	Noon 2 (pm)
Serial	**Date**	**Temperature**	**Humidity**	**Temperature**	**Humidity**
0	**9.7.2018**	**30.3**	**81**	**35**	**64**
1	**10.7.2018**	**30.5**	**82**	**33.6**	**70**
2	**11.7.2018**	**33.4**	**74**	**32.3**	**84**
3	**12.7.2018**	**31.6**	**82**	**32.1**	**72**
4	**13.7.2018**	**30.2**	**80**	**31.4**	**65**
5	**14.7.2018**	**28.4**	**88**	**31.6**	**64**
6	**15.7.2018**	**30.0**	**81**	**33.7**	**67**
7	**16.7.2018**	**30.0**	**82**	**33**	**68**
8	**17.7.2018**	**29**	**92**	**30**	**66**
9	**18.7.2018**	**29.3**	**93**	**32**	**65**
10	**19.7.2018**	**28**	**92**	**30.7**	**66**
11	**20.7.2018**	**29**	**86**	**32.3**	**69**
12	**21.7.2018**	**27**	**94**	**31**	**70**
13	**22.7.2018**	**28.3**	**90**	**30**	**79**
14	**23.7.2018**	**28.7**	**92**	**30.3**	**70**
15	**24.7.2018**	**27**	**93**	**29**	**82**
16	**25.7.2018**	**27.3**	**92**	**29**	**90**
17	**26.7.2018**	**27.0**	**86**	**29**	**87**
18	**27.7.2018**	**26.9**	**94**	**28.8**	**86**
19	**28.7.2018**	**27.1**	**91**	**30**	**80.4**
20	**29.7.2018**	**27.0**	**89**	**29**	**78**
21	**30.7.2018**	**27.0**	**88**	**29.8**	**79**
22	**31.7.2018**	**27.3**	**88**	**34**	**68**
23	**1.8.2018**	**27.8**	**79**	**32**	**67**
24	**2.8.2018**	**27.3**	**79**	**32.2**	**68**
25	**3.8.2018**	**27**	**79**	**31**	**69**
26	**4.8.2018**	**27**	**79**	**31.8**	**68**
27	**5.8.2018**	**28.3**	**78**	**31**	**69**
28	**6.8.2018**	**28**	**79**	**32**	**68**

Appendix 4. Average Live weight, Eviscerated Weight and Dressing Percentage of different replication of broiler chicken under different treatment.

Sl. no.	Treatment	Replication	Sample no.	Live wt.	Dressed weight	Eviserated wt.	Liver wt.	Spleen wt.	Heart wt.	Intestine wt.	Gizzard wt.	Bursa wt.	Adominal fat wt.
01.	T_1	T_1R_1	1	1720	1427	1068	37	2	9	106	28	2	15
			2	1650	1274	1095	29	2	8	82	38	3	22
		T_1R_2	1	1505	1093	888	39	3	8	104	36	4	29
			2	1870	1448	1188	46	2	10	128	22	2	29
		T_1R_3	1	1730	1320	1073	35	1	6	105	39	1	18
			2	1890	1445	1216	40	1	9	116	34	2	25
02.	T_2	T_2R_1	1	1705	1150	929	34	2	9	120	30	2	21
			2	1730	1257	1007	40	3	9	103	42	2	20
		T_2R_2	1	1760	1335	1060	37	1	8	118	47	1	27
			2	1840	1396	1105	42	2	10	104	39	2	20
		T_2R_3	1	1480	1213	935	30	2	8	140	33	3	16
			2	1700	1305	1115	33	2	9	93	31	2	22
03	T_3	T_3R_1	1	1780	1303	1125	38	2	9	115	35	2	29
			2	1960	1519	1248	46	2	12	136	48	2	28
		T_3R_2	1	1821	1364	1141	35	3	10	134	45	1	29
			2	1780	1365	1110	34	2	8	136	46	2	20
		T_3R_3	1	1814	1288	1145	39	4	8	118	55	1	24
			2	1730	1343	1165	41	3	11	136	52	3	30
04.	T_4	T_4R_1	1	1790	1250	1069	41	1	9	115	55	2	22
			2	1618	1296	1019	36	2	8	119	27	4	28
		T_4R_2	1	1920	1473	1241	30	2	8	120	35	3	36
			2	1770	1400	1170	40	3	11	93	38	3	23
		T_4R_3	1	1640	1233	1026	42	2	8	97	35	2	20
			2	1950	1482	1228	40	2	10	109	38	5	35
		T_5R_1	1	1920	1380	1136	40	1	13	111	40	3	35
05	T_5		2	1890	1342	1182	39	2	9	108	51	1	28
		T_5R_2	1	1920	1300	1100	41	2	15	121	52	2	22
			2	1850	1375	1126	44	2	11	115	46	2	27
		T_5R_1	1	1902	1356	1110	41	3	12	115	52	4	22
			2	1900	1350	1067	37	2	8	93	38	3	22

Appendix 5. Cholestrol data in different treatment groups.

Treatment	Value(mg/dl)
T_1R_1	170
T_1R_2	155
T_1R_3	224
T_2R_1	192
T_2R_2	142
T_2R_3	188
T_3R_1	132
T_3R_2	190
T_3R_3	203
T_4R_1	222
T_4R_2	215
T_4R_3	127
T_5R_1	205
T_5R_2	271
T_5R_3	142

Appendix 6. Feed consumption (g/bird) of 1st, 2nd, 3rd and 4th week under Different treatments.

Treatments	Replications	1st wk FC (g/bird)	2nd wk FC (g/bird)	3rd wk FC (g/bird)	4th wk FC (g/bird)
T1	R1	175	400	556	1037
	R2	180	465	620	950
	R3	185	405	600	930
T2	R1	185	415	615	966
	R2	188	410	580	975
	R3	183	443	550	971
T3	R1	185	440	580	985
	R2	190	410	610	998.5
	R3	185	420	598.5	993.5
T4	R1	188	430	600	900
	R2	186	440	595	995
	R3	185	430	600	988
T5	R1	180.5	440	630	998.5
	R2	189	420	593.5	978
	R3	186	430	600.5	965

Appendix 7. Body weight (g/bird) of 1st, 2nd, 3rd and 4th week under different treatments.

Treatments	Replications	1st week BWG (g/bird)	2nd week BWG (g/bird)	3rd week BWG (g/bird)	4th week BWG (g/bird)
T1	R1	175	354	550	445
	R2	170	340	556	453
	R3	185	395	530	430
T2	R1	178	367	545	475
	R2	165	385	552	433
	R3	172	398	559.5	463
T3	R1	182.5	398.5	571.5	455
	R2	173	380	550	485
	R3	169.5	400	553	486.5
T4	R1	185.5	400.5	573.5	470
	R2	175.5	374.5	570	465
	R3	179	380	581	482.5
T5	R1	174	355	575.5	461.5
	R2	175	350	553.5	470.5
	R3	175	375	565	455.5

Appendix 8. Average production cost (Tk.) of broilers at different treatments

Treatment	Replication	Feed Intake gm/bird	Feed Cost Tk/bird 45 Tk/kg×amount feed	Total production cost Tk/bird (Feed cost+common cost 95 Tk/bird)	No. of live birds	Total production cost/m^2
T_1	R_1	2168	97.56	192.56	10	1925.6
	R_2	2215	99.675	194.675	10	1946.75
	R_3	2120	95.4	190.4	10	1904
T_2	R_1	2181	98.145	193.145	10	1931.45
	R_2	2153	96.885	191.885	10	1918.85
	R_3	2147	96.615	191.615	10	1916.15
T_3	R_1	2190	98.55	193.55	10	1935.5
	R_2	2208.5	99.3825	194.3825	10	1943.825
	R_3	2197	98.865	193.865	10	1938.65
T_4	R_1	2118	95.31	190.31	10	1903.1
	R_2	2216	99.72	194.72	10	1947.2
	R_3	2203	99.135	194.135	10	1941.35
T_5	R_1	2249	101.205	196.205	10	1962.05
	R_2	2180.5	98.1225	193.1225	10	1931.225
	R_3	2181.5	98.1675	193.1675	10	1931.675

Appendix 9. Average total income (TK.) and benefit cost ratio (BCR)/m^2 of broilers at different treatment

Treatment	Replication	Live wt gm/bird	Sale value Tk/bird (150 Tk/kg Live wt)	Total income Tk/bird (Sale value+other 5Tk/bird)	No. of live birds	Total income /m^2	Total production cost/m^2	Net profit Tk/m^2	Benefit cost Ratio/ m^2
T_1	R_1	1524	228.6	233.6	10	2336	1925.6	410.4	1.213128
	R_2	1519	227.85	232.85	10	2328.5	1946.75	381.75	1.196096
	R_3	1540	231	236	10	2360	1904	456	1.239496
T_2	R_1	1565	234.75	239.75	10	2397.5	1931.45	466.05	1.241295
	R_2	1535	230.25	235.25	10	2352.5	1918.85	433.65	1.225995
	R_3	1592.5	238.875	243.875	10	2438.75	1916.15	522.6	1.272734
T_3	R_1	1607.5	241.125	246.125	10	2461.25	1935.5	525.75	1.271635
	R_2	1588	238.2	243.2	10	2432	1943.825	488.175	1.251141
	R_3	1609	241.35	246.35	10	2463.5	1938.65	524.85	1.27073
T_4	R_1	1629.5	244.425	249.425	10	2494.25	1903.1	591.15	1.310625
	R_2	1585	237.75	242.75	10	2427.5	1947.2	480.3	1.246662
	R_3	1622.5	243.375	248.375	10	2483.75	1941.35	542.4	1.279393
T_5	R_1	1566	234.9	239.9	10	2399	1962.05	436.95	1.222701
	R_2	1549	232.35	237.35	10	2373.5	1931.225	442.275	1.229013
	R_3	1570.5	235.575	240.575	10	2405.75	1931.675	474.075	1.245422



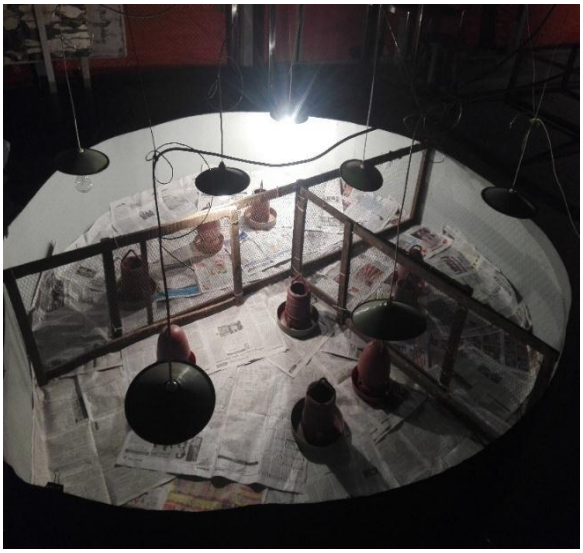




Fig: Brooder house preparation and chicks receving

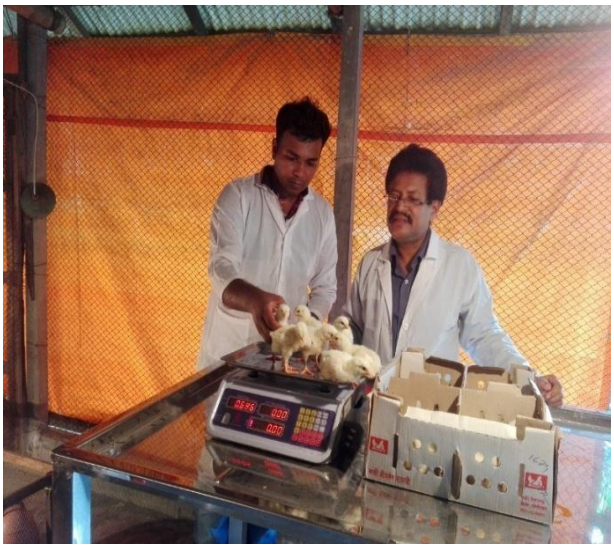
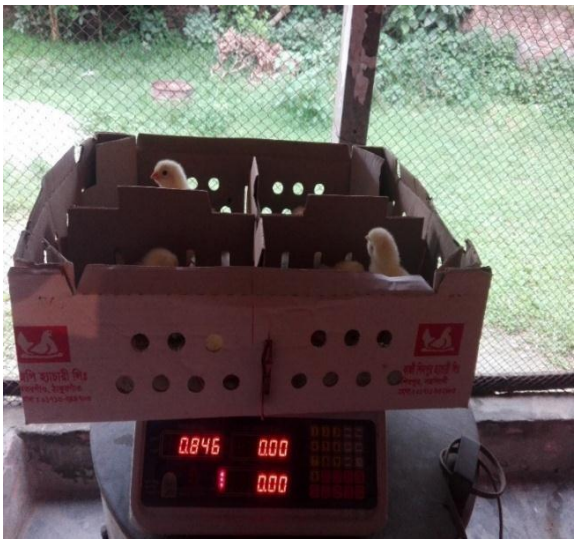
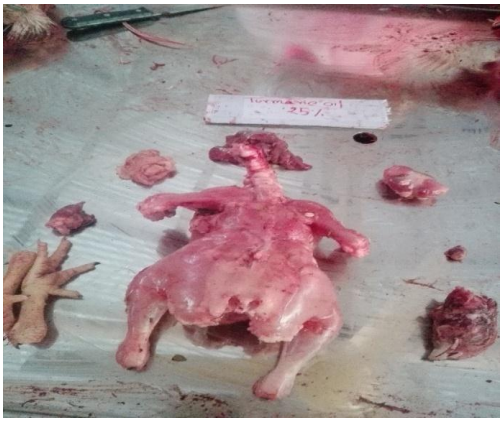
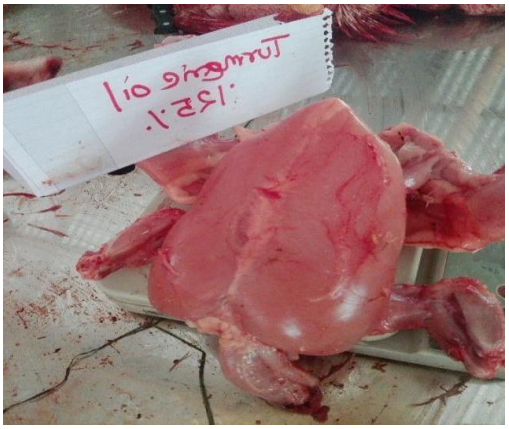



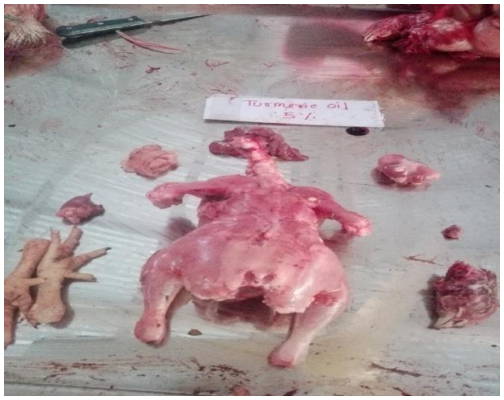


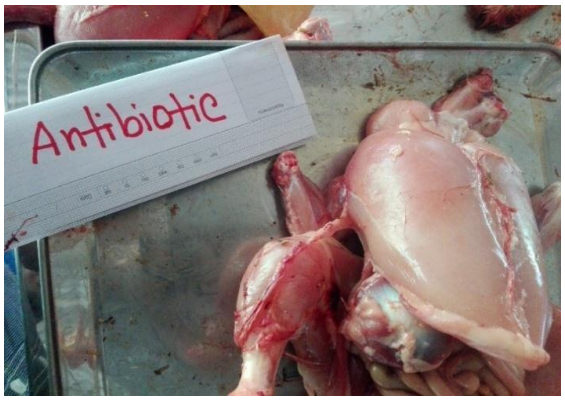

Fig: Baby chick weighning and farm house work

Fig: Bird weighing and differentiation treatment bird

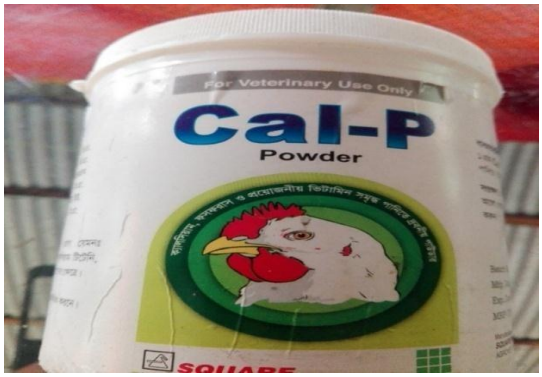








Fig; Carcass weight and body parts of bird



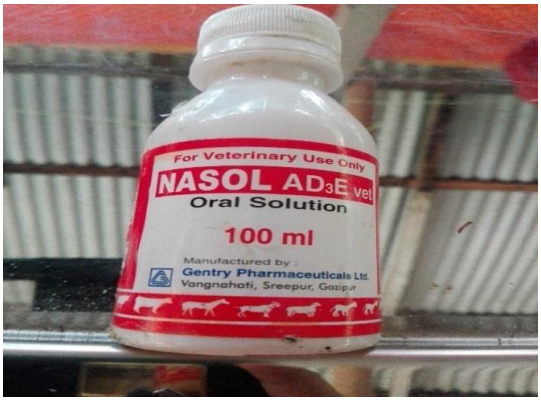


Fig: Vitamin, Antibiotic, Glucose