Chapter-I

Introduction

One of the world's largest food sectors is the chicken sector (Chowdhury and Morey, 2019). It is expected that production will increase by 121% from 2005 to 2050. (Alexandratos and Bruinsma, 2012). There is ongoing development and industrialization throughout the world (FAO, 2022). With regard to worldwide meat consumption and corporate profit, broiler production in particular has demonstrated exponential development and will increase in the following century (Van et al., 2015, Mekonnen et al., 2019). This might be a result of its comparative advantages, such as its excellent nutritional value, delicious flavor, low fat content, rapid economic growth, quick production time, minimum production cost, and affordable value even for poorer strata of community (Najeeb et al., 2014, Petracci et al., 2015).

From 1961 to 2019, the production of chicken increased from 9 to 132 million tons (FAO, 2022). In third place behind China and Brazil in terms of global poultry meat production is the United States (US), generates 17% of global output (FAO, 2022). The amount of meat consumed per person has increased over the world, with 70% of that meat being poultry and every year, more than 66 billion broilers are killed worldwide (Faostat, 2019). Nearly 110 million tons of poultry are produced annually from these quantities of killed birds. The consumption of broiler meat per person is higher in developed nations (FAO, 2018). In 2017, the average amount of broiler meat eaten by each person in the US, Brazil, and China was 48, 44.2, and 8.3 kg/head/year (AVEC, 2018). An indication to expand production is the exponential rise in demand for poultry meat.

A substantial component of Bangladesh's agricultural industry and economy is poultry. It is one of the promising and developing agribusinesses that essentially began in the 1980s. Among all other areas of chicken production, the broiler industry is currently undergoing tremendous growth, and numerous farms are being created across the entire nation. Many rural residents, especially small and marginal farmers, are employed by this lucrative industry. The latest numbers show that there are about 289.28 million chickens and 57.75 million ducks in our country, for a total of 347.03 million poultry (DLS, 2018-19). Between 1970 and 1980, the chicken population grew by 0.7% per year, but between 1990 and 2005, it grew by 4% per year (Begum, 2008). The Department of Livestock Service had 81425 poultry farms on file as of August 2019 (DLS). There were 54411 farms with broiler chickens, 18954 farms with egg layers, 7829 farms with ducks, and 231 farms with other kinds of animals.

In Bangladesh, the average amount of meat and eggs available per person is 124.99 g/day and 103.89 eggs/year (DLS, 2018-19). However, the average amount of meat and eggs needed per person is 120 g/day and 104 eggs/year (DLS, 2018-19). The amount of meat each person eats can meet their needs, but the amount of eggs they eat is still too low. In order to keep making the same amount of meat and eggs as before, poultry can be very important. The industry has become high quality because of intensive farming methods, thorough and balanced feeding, automation equipment, and other modern technology. Chicken meat is a very important source of protein. The broiler industry makes up most of the poultry industry because it is easy to sell and gives farmers a quick return on their investment. But workplace illnesses are a worry, especially as bacteria become more resistant to antibiotics. Less immunity makes it more likely that a disease will spread to the farm. So, it has become a top priority in research to find safe, effective, and environmentally friendly ways to boost the immune systems of broilers.

Poultry is the least expensive type of animal protein, which considerably aids in supplying the expanding demand for animal food products worldwide (Farrell, 2013). The absence of consistently high-quality, stable-priced feed is the biggest issue facing commercial poultry farming. Antibiotics are widely used in the poultry business to prevent disease and infections in order to increase the production of meat and eggs. Using antibiotics in food led to bacteria that could no longer be killed by drugs (Sorum and Sunde, 2001), drug residues in birds (Burgat, 1991), and an imbalance in the normal microbiota (Andremont, 2000). Antibiotic resistance (AR) is the ability of a living thing to fight off the deadly effects of an antibiotic that it used to be weak to (Madigan et al., 2006). Since all microbes have the innate ability to resist some antibiotics, this microbial resistance is not a recent occurrence (Hugo and Russel, 1998). However, the main reason for worry is the rapid increase in the creation and distribution of AR (Marshall and Levy, 2011). Animals' antimicrobial resistance to antibiotics, which contributes to the total burden of antimicrobial resistance, has been linked with excessive use of antibiotics in recent years, according to sufficient evidence (Laxminarayan et al., 2015). Most developing countries are improving their farming methods, which mean that over the next few years, they are likely to consume a lot more (Mathew et al., 2009). Antibiotics are primarily used in food-producing animals for the purposes of infection control, infection treatment, growth enhancement, and increased productivity (Castanon, 2007).

Antibiotic residues left in poultry products (meat and eggs) from their use as growth promoters have been found to produce bacterial resistance as well as adverse effects on humans who consume the products (Donoghue, 2003). This led to the ban on using antibiotics for growth promotion outside of their intended purpose. The EU has banned antibiotic growth promoters as animal nutrition additives due to worries about resistant bacteria spreading across the food channel (Cardozo et al., 2004). Natural Growth Promoters are things like acidifiers, probiotics, prebiotics, phytobiotics, feed enzymes, immune stimulants, and antioxidants (NGP). Plants were used to make medicines in ancient times (Dragland et al., 2003). Bioactive plant components include alkaloids, bitters, flavonoids, glycosides, mucilage, saponins, tannins, phenols, phenolic acids, guinones, coumarins, terpenoids, essential oils, lectins, and polypeptides (Vandergrift, 1998, Cowan, 1999). Using plant supplements may improve poultry health and production.

A type of organic growth promoters or non-antibiotic growth promoters that are added to feed and are made from various herbs, seasonings, and other plants are referred to as "phytogenic feed additives." AGP alternatives include healing plants and herbs. A complicated mixture of chemical substances with immune-boosting, antibacterial, antipyretic, and anti-inflammatory properties can be found in herbs. (Guo et al., 2003).Plant-based chemicals are employed to treat digestive problems, stop diarrhea, lessen inflammation, eradicate parasites, and increase human and animal hunger. In order to prevent infections from occurring, phytogenic feed additives (PFA) mainly regulate the gut flora. PFAs, or phytogenic feed enhancers, are made up of bioactive organic substances derived from plants. The efficacy of each of the four major categories of phytogenic compounds-essential oils, saponins, tannins, and flavonoids as a defense against illness in chicken is significantly affected by the plant from which it was derived. Essential oils, tannins, and saponins are commonly used in the production of poultry. Studies on broilers have proven PFA's antibacterial efficacy against dangerous pathogens like Escherichia coli and Clostridium perfringens (Jamroz et al., 2005; Mitsch et al., 2004).

For many ages, several indigenous medical systems and traditional remedies have effectively used medicinal plants to treat illnesses (Prasad et al., 2011). Botanicals, also known as photobiotics, are plant elements including roots, leaves, and bark that are utilized to create pharmaceuticals for use in medicine. Essential oils refer to a wide variety of plant-based volatile oils that are typically used in the cosmetics, flavors, and medicine industries because to their aromatic and otherwise unique properties (Suganya et al., 2016).In chicken production, oregano, thyme, garlic, horseradish, chile, cayenne, pepper, peppermint, cinnamon, anise, clove, citrus, sage, and rosemary are common phytofeed additives (Madhupriya et al., 2018, Mountzouris, 2016). There are also medicinal plants used, such as turmeric, eucalyptus, and capsicum. So, since these supplements have a lot of active chemicals, they may be a better defense against bacteria than synthetic antimicrobials. (Madrid et al., 2003; Alcicek et al., 2004; Zhang et al., 2005). Herbs, spices, and other plant extracts have been shown to not only improve digestion but also to be delicious. These compounds also have antibacterial properties, increasing the population of good bacteria in the poultry digestive system while decreasing the number and activity of harmful bacteria. (Wenk, 2000). An alternative to antibiotic growth promoters is the inclusion of plant material in the diet that is rich in active compounds with immune-boosting effects.

Animal nutrition that contains herbal extracts or active ingredients can have a number of beneficial effects, including a stimulation of the immune system, an improvement in the manner in which the body produces digestive enzymes, an increase in appetite and feed intake, and the elimination of pathogens such as bacteria, viruses, free radicals, and worms, to name just a few (Tipu et al., 2006).Most plant extracts don't cause resistance problems, and most people liked broilers fed herbal feed additives (Hernandez et al., 2004).PFAs improve broiler performance and health, the studies reveal (Mohamed et al., 2022, Ashour et al., 2021, Toghyani et al., 2011, Mpofu et al., 2016, Kirubakaran et al., 2016, Huyghebaert et al., 2011).

As a result, it is regarded crucial to conduct this research on broiler chicken with herbal phytogenic essential oil, as it can aid in raising consumer knowledge of the importance of consuming nutritious, secure, and sound food. It is possible that giving herbal supplements to broiler chickens will increase production while drastically reducing expenditures. By lowering the quantity of harmful microorganisms present in the intestine of the birds, poultry feed enriched with herbal phytogenic essential oil (Digemax EE^{R}) may promote nutrient utilization. The use of herbal essential oil to broiler chicken may be cost-effective and increase profitability by lowering feed costs. Additionally, it might improve the bird's access to nutrients, raising broiler chicken productivity. The lack of information about herbal phytogenic essential oil may prompt future research and, to some extent, increase broiler production.

The current tendency of reducing antibiotic growth promoters (AGP) in poultry diets has placed tremendous pressure on the industry to find feasible alternatives. The potential use of phytogenic feed additives in animal nutrition has been started rapidly when the usage of antibiotic as growth promoting agent in poultry has been banned by EU in 2006. However, the additives have a potential to be used as sensory, technological additives or other substances which could affect the quality of animal products positively. The additives can be used in the form of extracts, basically indispensable oils. Despite their uses in a number of animal species earlier, we see that there is still not available scientific data, true findings on the safety, efficacy of their use, or on their impact on the quality of animal products (Karskova et al., 2015). Since enough information on herbal goods is still lacking, the current study was undertaken to investigate the performance, meat quality and its cost effectiveness of broiler chicken fed on herbal phytogenic essential oil (Digemax EE^{R}).

Objectives of the Study

Supplementing chicken diets with phytogenic essential oils may be cost-effective or perhaps have the potential to increase productivity by lowering the cost of raising broilers. Given the aforementioned, the current study was carried out to accomplish the following objectives:

- To investigate the overall performance of broiler chickens given a diet comprising herbal supplements in terms of feed consumption, live weight, weight gain, feed conversion ratio (FCR) and viability
- To assess the carcass yield traits and gastro-intestinal development of broiler fed on supplemented diet
- To assess the water intake of broiler fed supplemented herbal product
- To evaluate the cost-benefit ratio of growing broiler chickens on a test diet

Chapter-II

Review of literature

Poultry farming has a constant struggle to maximize birds' efficiency and food safety. Antimicrobials have traditionally been used to improve chicken health and growth performance. However, public awareness about the potential of pathogen cross resistance has led to the progressive elimination of antibiotics for therapeutic and preventative purposes in food animals (Ricke et al., 2020). The transition away from antibiotic supplementation has increased study on alternative control measures, management, and dietary changes to improve animal health, welfare, and production. Essential oils and related compounds from botanical sources to organic acids (Ricke et al., 2020, Zhai et al., 2018), probiotics and prebiotics (Al-Khalaifah, 2018), aldehydes (Ricke et al., 2019), bacteriophages (Li et al., 2020), zinc oxide (Swain et al., 2016), exogenous enzymes (Torres et al., 2019), Phytogenic feed additives (PFAs), often called phytobiotics or botanicals, are gaining popularity as cost-effective feed additives with demonstrated good impacts on broiler chickens' intestinal health. The literature describes antioxidative, immunomodulatory, and growth-promoting properties. The current review provides a summary of the most important findings from a few recent studies that evaluated the effect of supplementing birds' diets with PFAs on the major aspects of bird gastrointestinal health and functionality. Particular attention was paid to the digestibility of nutrients; the gut microbiota, the immune system, the oxidative status, and the growth performance of broilers. Phytobiotics comprise therapeutic herbs and spices, plant extracts, and essential oils with diverse biological effects (Giannenas et al., 2018, Puvaca et al., 2015). The medicinal and useful properties of essential oils in broiler chicken diets are reflected in improved production characteristics (Brenes et al., 2010) and the ability to increase the body's immune response (Ezzat et al., 2016), which maximizes genetic potential, reduces mortality, and increases profitability.

Phytobiotics and essential oils block the most important enzymes involved in cholesterol and lipid production, which decreases cholesterol in the blood and edible tissues and belly fat in broiler chickens (Puvaca et al., 2015). This finding supports phytobiotics and makes them an important complement to diet and food production for particular consumer groups. Essential oils enhance broiler chicken carcasses and meat by increasing digestibility and nutrient utilization.

What is phytogenic feed additives??

Plant secondary metabolites and essential oils also known as phytogenics are biologically active compounds that have recently attracted increased interest as feed additives in poultry production. I have number of advantages - ability to promote feed efficiency by enhancing the production of digestive secretions and nutrient absorption, reduce pathogenic load in the gut, exert antioxidant properties and decrease the microbial burden on the animal's immune status (Abdelli et al., 2021).

Phytogenic additives present a plausible alternative as they enhance a number of important processes in the animal body. Phytogenic feed additives may be included among supplements that are aimed to positively affect feed quality, health of animals as well as animal products by means of their specifically efficacious substances. They can be classified into several groups: sensory additives (feed additives affecting the sensoric properties of animal products), technological additives (antioxidants, substances decreasing mycotoxin contamination of feeds etc.), zootechnical additives (immunomodulators,digestive stimulants, growth promoters of non-microbial origin, substances increasing performance or quality of animal products, etc.), and nutritional additives (vitamins, minerals, plant enzymes, etc.).

Phytogenic feed additives comprise a wide variety of herbs, spices, and products derived thereof, and are mainly essential oils. The assumption that phytogenic compounds might improve the palatability of feed has not yet been confirmed by choice-feeding studies.

2.1: Herbal feed additives in poultry:

In addition to feed enzymes, prebiotics (oligosaccharides), probiotics (mostly lactobacilli for monogastric animals), organic acids, and herbs and botanicals can be utilized as feed additives. From Webster's Encyclopedic Unabridged Dictionary of the English Language (1989), the following definition may be drawn:

Herb: A flowering plant whose stem above ground does not become woody and persistent. A plant when valued for its medical properties, flavor, scent, or the like.

Spices: Any of a class of pungent or aromatic substances of vegetable origin, as pepper, cinnamon, cloves, and the like, used as seasoning, preservatives, etc.

Botanical: A drug made from part of a plant, as from roots, leaves, bark etc. Essential oils are any of a class of volatile oils obtained from plants, possessing the odor and other characteristic properties of the plant, used chiefly in the manufacture of perfumes, flavors and pharmaceuticals (Extracts after hydro - distillation).

Table 1: Different herbal feed additives, its active components and functions

Plant	Used parts	Active component	Function
Nutmeg (Myristica fragrans)	Seed	Sabinene	Digestion stimulant, antidiarrhoeic
Nutmeg (Myristica fragrans)	Seed	Sabinene	Digestion stimulant, antidiarrhoeic
Cinnamon (Cinnamomum zeylanicum)	Bark	Cimetaldehyde	Appetite and digestion stimulant, antiseptic
Cloves (Syzygium aromaticum)	Cloves	Eugenol	Appetite and digestion stimulant, antiseptic
Cardmom (Amomum subulatum)	Seed	Cineol	Appetite and digestion stimulant
Coriander (Coriandrum sativum)	Leaves and seed	Linalol	Digestion stimulant
Cumin (Cuminum cyminum)	Seed	Cuminaldehyde	Digestive, carminative, galactogogue
Anise (Pimpinella anisum)	Fruit	Anethol	Digestion stimulant, galactogogue
Celery (Apium graveolens)	Fruit, leaves	Phtalides	Appetite and digestion stimulant
Parsley (Petroselinum crispum)	Leaves	Apiol	Appetite and digestion stimulant, antiseptic
Fenugreek (Trigonella foenum graecum)	Seed	Trigonelline	Appetite stimulant
Capscicum (Capsicum annuum)	Fruit	Capsaicin	Digestion stimulant
Pepper (Piper nigrum)	Fruit	Piperine	Digestion stimulant
Horsradish (Armoracia rusticana)	Root	Allyl izotiocianat	Appetite stimulant
Mustard (Brassica Nigra)	Seed	Allyl izotiocianat	Digestion stimulant
Ginger (Zingiber officinale)	Rizom	Zingerone	Gastric stimulant

Garlic (Allium sativum)	Bulb	Alkin	Digestion stimulant, antiseptic
Rosemary Rosmarinus officinalis	Leaves	Cineol	Digestion stimulant, antiseptic
Thyme (Thymus vulgaris)	Whole plant	Thymol	Digestion, stimulant, antiseptic antioxidant
Mint (Mentha piperita)	leaves	Menthol	Appetite and digestion stimulant, antiseptic
Shatavari (Asparagus racemosus)	Root	Sapogenins, flavonoids and saponin	Prevention and treatment of gastric ulcers,dyspepsia and as agalactogogue
Jivanti (Leptadenia reticulata)	Leaves and twigs	Stigmasterol, ß - itosterol, flavonoids, pregnane glycosides	Galactogogue, antimicrobial and anti-inflammatory
Shatavari (Asparagus racemosus)	Root	Shatavarin-I-IV, qucertin, rutin, hyperoside	Galactogogue

(**Source:** Mirzaei-Aghsaghali, 2012)

2.1.1: Herbal feed additives as antimicrobial supplements:

Against both Gram- and Gram+ bacteria, a number of investigations demonstrated that certain plant extracts have potent antibacterial activity. Plants are able to rapidly produce chemicals that serve as their defensive mechanism against herbivores, insect herbivores, and microbes. In addition, they may produce secondary antimicrobial metabolites as part of their regular growth and development or in response to stress. Numerous studies have been conducted on the antimicrobial properties of oriental herbs, including Allium sativum, Angelica dahurica, Anguisorba officinalls, Artemisia argyi, Coptis chinensis, Dictamnus dasycarpus, Fraxinus rhynchophyllus, Geranium thunbergii, Hydrastis canadensis, and Phellodenron canadens These plants contain significant flavonoid components, including baicalin, baicalein, limonene, cinnamaldehyde, carvacrol, and eugenol, which, combined with other supportive herbs, have an antibacterial effect.

These herbs are antibacterial against Salmonella, E. coli, Staphylococcus, and Streptococcus. Herbal feed additives decrease fatty acid content, which increases microbe hydrophobicity. Herbs and spices work as antibacterial agents by altering cell membranes and generating ion leakage, making microorganisms less virulent. Phytobiotics have antibacterial, anti-inflammatory, anti-oxidative, and anti-parasitic properties. Due to biological variables (plant species, growing region, and harvest circumstances), manufacturing (extraction/distillation and stabilization), and storage conditions, phytobiotic content varies greatly (light, temperature, oxygen tension, and time); (Huyghebaert et al., 2011).

2.1.2 Herbal feed additives as anti-inflammatory:

The extracts of these spices exhibited the anti-inflammatory activities of curcuma, red pepper, black pepper, cumin, cloves, nutmeg, cinnamon, mint, and ginger. The most significant anti-inflammatory substances include phenols, terpenoids, and flavonoids. These compounds prevent the production of inflammatory prostaglandins by inhibiting their metabolism. Anti-inflammatory properties have been attributed to phenolic compounds, which are benzoic acid and cinnamic acid derivatives that have been hydroxylated. Phenolic compounds are found in plants. It has been known for a long time that flavonoids contain properties that are anti-inflammatory, anti-allergic, anti-viral, and anti-proliferative (Muanda et al., 2011).

Anis, liquorice, chamomile, and marigold are the most well-known of the medicinal plants and spices that have the ability to reduce inflammation (Frankic et al., 2009). The families of plants known as Labiatae, which include mint, have garnered a lot of attention recently. The phenolic terpenes that they contain are responsible for their anti-oxidative actions (Cuppett and Hall, 1998). Oregano and thyme both contain significant levels of the monoterpenes thymol and carvacrol (Rahim et al., 2011). In addition to black pepper (Piper nigrum), chili peppers (Capsicum fretuscene) and red peppers (Capsicum annuum L), chili peppers include a number of anti-oxidant chemicals (Nakatani, 1997). However, the sections of many of these plants that contain the active chemicals have a strong odor and/or taste, which lead to limitations on their usage as animal feed. This is the case for several species. Aloevera's antibacterial, antiviral, antifungal, antitumor, anti-inflammatory, immunomodulatory, wound-healing, antioxidant, and anti-diabetic effects in chickens were recently evaluated (Babak and Nahashon, 2014).

2.1.3 Herbal feed additives as antioxidants:

Antioxidants have a tendency to reduce rancidity, stop the production of dangerous oxidation products, and assist maintain the nutritious value of food when added to it. When added to food, antioxidants, which are substances that assist delay and prevent lipid oxidation, tend to reduce rancidity (Muanda et al., 2011).It is believed that the antioxidants that come from plants have a positive influence on health because of the protective benefits they have by neutralizing the effects of reactive oxygen species.

Numerous researches have shown that eating these plants lowers the risk of getting cancer, cardiovascular disease, hypertension, and stroke. These studies also show that plants strong in antioxidants perform a preventative function in health and against diseases. The content of phenolic components, including flavonoids, hydrolyzable tannins, proanthocianidins, phenolic acids, and phenolic terpenes, as well as certain vitamins, may be related to the antioxidant potential of medicinal plants (E, C and A).It has been revealed that the sulfur-containing active principle in garlic and onions has the ability to reduce cholesterol levels and block the oxidation of low-density lipoproteins. The biological action products of garlic and onions are attributed to this sulfur-containing active principle (Ahmed and Bassuony, 2009). Rosemary, thyme, oregano, sage, green tea, chamomile, ginko, dandelion, and marigold are some of the most often used herbs that are high in phenolic content. Adding herbs and spices to feed can help prevent the feed from becoming rancid due to oxidation while it is being stored.

2.1.4 Herbal feed additives as immune-stimulant:

The immune system has been found to benefit from foods rich in flavonoids, vitamin C, and carotenoids, such as herbs and spices. Cat's claw, echinacea, liquorice, and garlic are a few examples of plants that include compounds that might boost the immune system. These plants have the ability to enhance the function of lymphocytes, macrophages, and natural killer (NK) cells; specifically, they boost phagocytosis and induce interferon generation (Frankic et al., 2009). Essential oils produced from medicinal plants have been demonstrated to boost the immunological response and also have the ability to create changes in the duodenal mucosa that have favorable consequences for the animal (Lavinia et al., 2009).

2.1.5 Herbal feed additives as coccidiostat:

There is evidence that the extraction of some plants can be effective against certain chicken parasites, particularly the coccidian. The production of sugar beets results in the production of a byproduct called betaine, which has recently been shown to have a beneficial effect in the battle against coccidiosis. It guards against the osmotic stress that is linked with dehydration and makes it possible for cells to maintain normal metabolic function. However, the protective effects of betaine on the cells of the intestinal parasite are likewise exerted on those cells of the intestinal parasite. Curcumin, a phenolic chemical that is derived from the rhizome of Curcuma longa, is the component that is responsible for the anticoccidial effects. This effect is achieved by curcumin's ability to function as an antioxidant on the immune system. The use of extracts from Nectaroscordum tripedale and Gallarhois as a treatment for coccidial infections has shown some encouraging results.

2.2 Body growth responses of broiler on herbal diet:

Everyone knows that broilers are the type of poultry chickens that are expanding the quickest worldwide. Many nations have already banned the use of drug growth promoters when handling broilers. As a result, natural growth promoters, or botanical products, are becoming immensely popular all over the world because they are thought of as health boosting agents that have no negative side effects or aftereffects on the general public's health. Broiler production has been the subject of numerous studies, but most of the experts have discovered both positive and bad effects on the growth rate of broilers. When broiler chickens were given diets containing thymol and cinnamaldehyde, researchers discovered that the growth efficiency, micronutrient digestibility, or plasma lipids of the females were comparable. (Lee et al., 2003). However, when broilers were given a diet that included cinnamon, a different researcher noticed a rise in body weight.

According to the results of (Muhl and Liebert, 2007), neither of the two commercial PFAs containing 5% carvacol, 3% cinnamaldehyde, and 2% capsicum oleoresin, nor the alkaloids sanguinarin and chelerythrin, had any noticeable impact on the growth performance of broiler chicks. Researchers (Chang et al., 2008) and (Park, 2008) found that supplementing with cinnamon extract increased daily development and decreased the feed-to-gain ratio. According to research by (Al-Kassie, 2009), cinnamon and ground thyme had a positive impact on the health and development of broiler chickens' live weight. This was in addition to the positive impacts they had on other performance factors like feed consumption and feed conversion ratio. (Al-Kassie, 2009) found that chicks fed with 200 ppm essential oil (EO) derived from thyme and cinnamon had substantially greater body weight increase than chicks fed with 100 ppm EO derived from thyme and cinnamon, and that control group chicks had the least body weight gain of all the groups. According to the findings of (Koochaksaraie et al., 2011), the inclusion of cinnamon in the food at doses ranging from 500 to 2000 mg/kg had no impact on the development of broiler chickens. (Toghyani et al., 2011) found that include cinnamon in the diet at a rate of 2 grams per kilogram led to a considerable increase in body weight. They also recommended that cinnamon might serve as an alternative to the use of antibiotic growth promoters in broilers. According to the findings of (Ebrahimi and colleagues, 2013), the group that supplemented their meals with cinnamon had considerably greater body weight than the control group. According to research done by (Sang-Oh et al., 2013), the growth performance of birds and the quality of their meat greatly increased when their meals were supplemented with 3, 5, or 7 percent cinnamon powder. This was in comparison to the birds that served as the control.

When compared to the group that was fed the control diet, there was a discernible difference in the amount of weight growth that occurred between 21 and 42 days of age (containing no antibiotics or prebiotics). In addition, (Fotea et al., 2010) investigated the effects of oregano oil on broilers at three different concentrations: 0.3, 0.7, and 1% of the diet. According to the findings, the supplementation with oregano oil at a concentration of one percent led to the greatest weight increase. According to the findings of (Roofchaee et al., 2011), the incorporation of oregano essential oil at a dose of 600 mg/kg into the grower feed of broilers led to a substantial increase in the animals' overall body weight growth as compared to birds that were given the control basal diet. (Ghazi et al., 2015) found that feeding broilers a diet with oregano essential oil (250 mg/kg) resulted in higher body weight and growth when compared to the control diet which did not include any antibacterial or anti-coccidial additives.

Capsicum frutescens powder can promote growth at 2.2% inclusion level, like tannins from Quebracho (Marzoni et al., 2020) and coriander (Abou-Elkhair et al., 2014), Positive growth benefits have also been found for numerous phytogenic feed additives at lower levels, such as 0.2, 0.25, 0.5, 0.75% for chicory, Myristica fragrans, turmeric, and red pepper extract correspondingly (Khoobani et al., 2019; Adu et al., 2020; Abou-Elkhair et al., 2014; Islam et al., 2018). Local chicken growers might explore using C. frutescens powder to boost broiler chicken development.

2.3 Feed consumption and feed conversion ratio of broiler chicken fed on herbal supplemented diet:

Feed intake and feed efficiency are the key indicators which help to assess the overall performance efficiency of the broiler chickens. A research done by (Jamroz and Kamel, 2002) reported that broilers exhibited increased weight growth and improved feed efficiency when they were fed on a mixture of essential oils (capsaicin, carvacrol, and cinnamaldehyde). (Hernandez et al., 2004) found identical feed intake and FCR when the broiler was given 200 mg/kg of diet with essential oils isolated from oregano, cinnamon, and pepper, and or 5000 mg/kg of diet with a labiates extract from sage, thyme, and rosemary were identical. The addition of plant extracts containing capsaicin, cinnamaldehyde, and carvacrol to feed mixtures improved feed conversion by 4.1% when the diet consisted of maize and by 2.0% when it consisted of wheat and barley. However, the BW was not impacted by the addition of the plant extracts (Jamroz et al., 2005).

According to (Garcia et al., 2007) findings, dietary supplementation with a mixture of oregano, cinnamon, and pepper essential oil at a concentration of 200 ppm led to an increase in FCR (0-42 days). In a research conducted by (Al-Kassie., 2009), it was discovered that adding 200 ppm of an oil extract that was obtained from thyme and cinnamon to broiler diets led to a considerable improvement in both the live weight increase and the feed conversion ratio over the course of a growing period of six weeks. According to the findings of (Toghyani et al., 2011), the addition of cinnamon powder into broiler diets did not result in any differences in feed intake or FCR. (Sampath and Atapattu, 2013) found that supplementation of dietary Cinnamon powder had no effect on final live weight, weight gain, visceral organ weight, and gizzard, cloaca, and total fat contents or serum cholesterol level, but it did have a tendency to increase feed intake and feed conversion ratio (FCR). Supplementation with one percent each of cinnamon, black cumin, and chili powder resulted in considerably greater FCR and body development, according to (Hossain et al., 2014)'s findings. (Shirzadegan, 2014) found that the administration of cinnamon powder (CP) had significant effects on the final body weight, body weight gain, feed intake, feed conversion ratio (FCR), liver weight, glucose level, thiobarbituric acid (TBA), and breast fat percentage of broiler chicks. Cinnamon is a spice that has been used for culinary and medicinal purposes for thousands of years.

The amount of feed that a broiler chicken consumes is a highly important and crucial factor in the determination of its performance. Therefore, it is of the utmost importance to evaluate the influence that feed components have on the amount of feed that an animal consumes. The results of published investigations on the effect of turmeric on the amount of feed consumed by broilers vary widely from one trial to the next. According to (Emadi and Kermanshashi., 2006), the addition of 0.25-0.75 percent turmeric powder had no effect on the amount of feed consumed by Ross broilers. This finding is consistent with the findings of (Mehala and Moorthy., 2008), who found that feeding Vencobb broilers 0.1-0.2% turmeric powder did not affect their feed consumption. Additionally, the research done by (Ahlawat et al., 2018) did not uncover any significant effects of consuming 0.25-1% turmeric powder in diet. On the other hand, (Daramola, 2020) discovered that the consumption of feed by broiler chickens (Arbor-acre) decreased when 0.5% turmeric powder was used.

On addition, (Qasem et al., 2015) revealed that there were unfavorable impacts of turmeric powder in feed intake at a higher level (1-2% into the diet of Ross 308 broiler chicken). When broiler chickens are placed in stressful environments, the consumption of feed may be improved by using turmeric powder. According to the findings of (Akhavan-Salamat and Ghasemi, 2016), heat-stressed Ross 308 broilers that were given a diet with 0.2% turmeric powder showed an increase in their ability to consume feed. (Baghban et al., 2016) and (Sadeghi and Moghaddam, 2018) came to a similar conclusion when they tested turmeric powder at a concentration of 0.5%. The Cobb-500 broilers that were reared in a humid subtropical region had a superior feed intake when fed a diet containing 0.75 percent turmeric powder. Turmeric can help relieve the negative effect of harmful pollutants in the diet. According to the findings of (Alagawany et al., 2015), the feed intake of Hubbard broiler chickens exposed to endosulfan at a concentration of 30 ppm was enhanced when they were fed a diet with 0.5-1% turmeric powder. Additionally, when administered turmeric powder at a concentration of 0.5%, Cobb x Cobb broilers that had been exposed to 1 ppm of aflatoxin showed a small improvement in both their performance and their feed intake (Gowda et al., 2008). According to research done by (Gholami-Ahangaran et al., 2016), the harmful effect that aflatoxin has on the liver can be reduced by using turmeric powder. In addition, it was discovered by (Yarru et al., 2009) that the powdered form of turmeric alters the expression of certain genes in the liver of chickens that have been given aflatoxin. These genes are involved in antioxidant, biotransformation, and immune system processes.

An illness such as coccidiosis can have a negative impact on the amount of feed consumed by broiler chickens (Christaki et al., 2004). On the other hand, the Eimeria tenella-infected chickens that were given a meal containing 3% turmeric powder continued to consume the same quantity of non-infected chicken (Abbas et al., 2010). According to research done by (Nascimento et al., 2019), adding 3% turmeric powder to the meal had a negative impact on the amount of feed that the chicken took in, even if the animal had been infected with Salmonella typhimurium. According to the results of the study, an inclusion of 1% was the most effective dose without having a detrimental effect on the amount of feed consumed.

2.4 Carcass traits and gastro-intestinal organ development of broilers in response to herbal diets:

When cinnamaldehyde was added to the diet of broiler chickens, (Lee et al., 2003) found no evidence of any major alterations in the hens' internal organs (100 ppm). Although (Hernandez et al., 2004) came to the conclusion that the Labiatae extract and the mixture of carvacrol, cinnamaldehyde, and capsaicin enhanced the digestibility of the meals, they found that there were no impacts on the weight of the organs. According to (Garcia et al., 2007), the combination of oregano, cinnamon, and pepper oil at a concentration of 200 parts per million had no effect on the carcass weight of broilers. On the other hand, breast weight as a percentage of the total carcass appeared to rise following the addition of a plant extract that was derived from a combination of clove and cinnamon oil (100 ppm). According to (Byung-Sung, 2008), the sensory assessment of the flavor and savour in fried and boiled chicken meat were better from broiler chicken fed with diets containing cinnamon powder. This was the conclusion reached after evaluating the taste and savour of fried and boiled chicken meat. Researchers (Isabel and Santos, 2009) showed that dietary supplementation with a plant extract based on a mixture of clove and cinnamon oil had no impact (100 ppm). Cinnamon did not seem to have any effect, according to (Stefan et al., 2009)'s findings, on the amount of MDA found in the tissues of the liver and kidneys. According to the findings of (Koochaksaraie et al., 2011), supplementing broiler diets with cinnamon powder at doses ranging from 250 to 2000 mg/kg did not have any effect on the carcass metrics. (Toghyani et al., 2011) found that the diets of broilers supplemented with 2 and 4 g/kg of cinnamon powder had no effect on the parameters measured in the carcasses of the animals. In addition, he discovered that the sensory assessment did not reveal any difference in the flavor, aroma, or attractiveness of the meat after the dietary supplements was administered.

According to (Sampath and Atapattu's, 2013) research, the addition of cinnamon to one's diet at concentrations of 0.1 and 0.4 percent led to an increase in the amount of belly fat compared to the control group. It was determined that the dietary cinnamon utilized with broiler chickens did not have any benefits that promoted growth or reduced fat levels. According to the findings of (Sang-Oh et al., 2013), supplementing broilers' diets with cinnamon powder at a level of 5 percent increase the quality of chicken meat in terms of its color, flavor, texture, and general acceptability as well as its shelf life. According to (Safa-Eltazi, 2014), feeding cinnamon to broiler chickens resulted in substantial reductions in the levels of cholesterol, triglyceride, low density lipoproteins (LDL), abdominal fat, and gizzard and heart weights, as well as an increase in the percentage of breast protein. In their study, (Najafi and Taherpour, 2014) found that the consumption of cinnamon did not have a significant effect on the proportional weights of the spleen, bursa of Fabricius, or thymus.

FAO (2014) defined meat quality based on composition, palatability, and nutrition. Turmeric in broiler chicken diets affects meat quality. Supplementing broiler chicken with turmeric powder increases crude protein and reduces triglycerides and saturated fatty acids (Daneshyar et al., 2011). 0.2-0.4% turmeric powder in the diet boosted breast Docosahexaenoic acid (DHA), while 0.6-0.8% lowered thigh and breast saturated fatty acids (Urusan and Bolukbasi, 2020). Heat-stressed Ross 308 improved meat pH and color (Kanani et al., 2017). Broilers fed 1% acidified turmeric powder had lighter meat than the control (Sugiharto et al., 2020). Slightly yellow complexion and little abdomen fat were detected. (Partovi et al., 2018) related meat lightness to phospholipid oxidation, which reduced pH. Curcuminoids, natural antioxidants in turmeric, are deposited in the skin and tissue when supplemented in the diet, generating minor yellow coloring of the flesh (Johanna et al., 2018). Curcuminoid boosts meat's oxidation protection (Zhang et al., 2018; Partovi et al., 2018).

Some oregano-supplemented feeding studies failed. (Bozkurt et al., 2009) compared an unsupplemented control diet to one containing 1.0 g/kg oregano oil and found no difference in carcass parameters (slaughter weight, carcass yield, and liver %). Oregano essential oil (0.0 and 300 mg/kg) did not alter broiler weight or carcass output at 42 days (Alp et al., 2012). Oregano oil in broiler chicken diets affected liver weight (Corduk et al., 2013). (Kirkpinar et al., 2014) studied the effects of oregano oil at 150 and 300 mg/kg diet on broiler carcass yield and weight.

2.5 Meat quality and herbal diet:

The amount of fat content in the broiler meat determines its quality. Extra fat accumulation in broiler carcass is generally considered as an unfavourable characteristic in the poultry industry (Remignon and Le Bihan-Duval, 2003). Lower the fat content gives rise to higher lean meat carcass yield. Generally people prefer lean meat or fatless meat. So lean meat implies quality meat, as it assures higher protein % than fat content in the carcass. According to (Al-Kassie and G.A. 2009), varying concentrations of oil extract obtained from thyme and cinnamon had substantial impacts on the percentage of dressing, the percentage of abdominal fat, and the percentage of internal organs (liver, heart and gizzard). A report stated that supplementing one's diet with cinnamon oil at a dose of either 500 or 1000 ppm was found to reduce the levels of cholesterol in blood and in chicken meat (Ciftci et al., 2009). But they also suggested that dietary cinnamon supplementation would improve the nutritional quality of chicken meat because cinnamon oil plays an important role as an endogenous antioxidant and could be applicable as a protective agent against tissue damage. This was due to the fact that cinnamon oil could be applied as a protective agent against tissue damage.

2.6 Responses of herbal supplemented diet on the viability of broiler:

The essential oil combination of peppermint and eucalyptus was shown to have an immune-stimulant impact on the humoral and cell mediated immune response against Newcastle disease in hens, which resulted in a lower death rate (Awaad et al., 2009a). Their utility in modulating the immune response of immunocompromised birds after infection with infectious bursal disease virus (IBDV) and/or vaccination against IBDV was also evident when compared with untreated control groups. This was demonstrated by the fact that they were able to suppress the immune response of immune-compromised birds after IBDV infection (Awaad et al., 2009b).The curcumin in turmeric played a part in the immune system's production of an immune boosting factor, which in turn led to a lower mortality rate in chicken (Al-Kassie et al., 2011). In contrast to what has been seen here, (Abd Al-Jaleel, 2012) discovered that death rates in broiler chickens fed control diets and diets containing turmeric varied significantly.

2.7 Economical analyses of broiler fed on herbal diet:

Farm animal populations are undergoing continuous selection to improve the economic efficiency of animal production (Svitakova et al., 2014). Animal production itself is affected by a number of both external and internal factors that unequivocally include nutrition. Apart from nutrition, the farm profitability could be influenced by many other factors say, feed price, feed form, feed composition, labour cost, housing, marketing of live birds or dressed carcass, price of feed stuffs, price of day-old chicks, vaccination, medication and so on.

2.8 Water consumption of broiler and herbal diet:

The water content in broiler meat is higher (>70%) than that of other poultry. So it goes to saying that the higher the purchasing of broiler meat the greater the water we achieve. Anyway, the water of meat is mainly comes from the ingestion of food and water as or when supplied to the bird. Normally the birds consume water twice of the feed it ingests; sometimes it goes double or triples depending on the climatic or heat stress condition. The water intake of bird goes higher when the environmental temperature goes up. Apart from this, many other factors such as flavor, odour, taste appeal, level of water retention capacity, level of thirstiness, bird’s health condition, temperature, heat stress etc., might be responsible for the variation of water consumption by the broiler chicken fed herbal extract or photogenic essential oil (Lee et al., 2003; Sang-Oh et al., 2013). It can be surmised that the, sensory flavours, higher water retention capacity and lower thirstiness of broiler chicken can induce lower water consumption by birds. This is also supported by (Sang-Oh et al., 2013) who reported that broiler had increased water retaining capacity when they fed diet supplemented with herbal products (cinnamon). Further, water consumption is reduced dramatically when broiler fed herbal products (cinnamaldehyde) reported by another researcher (Lee et al., 2003).

2.9 Importance of the current study:

Consumers are eager to try out fresh products in today's fast-paced culture, and products manufactured with herbal substances are at the top of the list. The reason is that, unlike antibiotics, it poses no threat to human health and has no negative consequences. In addition, experts throughout the world are working to outlaw the use of antibiotics in animal agriculture because of the harm that these drugs may do to people even after they have been removed from the food chain. Therefore, it is reasonable to expect that studies of broilers fed herbal phytogenic essential oils might be very useful in raising people's consciousness about the need of eating healthily. Producing broiler meat using herbal items has the potential to improve consumer demand, leading to a steady expansion of the chicken industry and a rise in poultry farmers' incomes. In addition, there is a lack of sufficient data on herbal products, making it necessary for more research to be undertaken in order to shed light on the existing findings.

The study's findings may serve as guidance for future poultry farmers and researchers, allowing them to create more effective food formulations that enable poultry integrators to boost broiler meat output with more efficiency. The research would also help chicken farmers and raisers become economically independent through increased income, new job opportunities, and reduced unemployment.

Conclusion:

Based on the literature available, it might be concluded that administering herbal supplements to broiler chicks could result in an increase in broiler output while simultaneously resulting in considerable cost savings. In this regard, poultry feed that is added with herbal phytogenic essential oil (Digemax EE^{R}) may promote the utilization of nutrients by lowering the amount of harmful microorganisms that are detected in the guts of birds. The use of herbal phytogenic essential oil as a supplement on broiler chickens may be cost-effective, as it has the potential to both lower feed costs and increase profitability. In addition, it could improve the availability of nutrients in birds, which would lead to an improvement in the productivity of broiler chickens. There is a paucity of data on herbal phytogenic essential oils; hence, the topic may merit more research if the goal is to significantly increase broiler output.

Chapter-III

Materials and Methods

3.1 Statement of the experiment:

The experiment was conducted to determine the effectiveness of herbal phytogenic essential oil on the growth performance of broiler chickens fed on supplemented diet under the Department of Dairy and Poultry Science (DDPS), Chattogram Veterinary and Animal Sciences University (CVASU), Chattogram, Bangladesh. The feeding trial was conducted at the CVASU's Research and Farm-based campus, located at the Hathazari, Chattograam from the August to September, 2022. Laboratory analyses, feed sampling and processing were carried out in the Poultry Research and Training Centre (PRTC) and DDPS of CVASU, Khushi, Chattogram.

3.2 Preparation of the experimental shed:

The experimental chicken shed was cleaned with a broom to get rid of dust and dirt. The whisk was also used to wash and clean the cage. Then, both the shed and the cages were washed and cleaned properly with soapy tap water. Then, the ceiling, walls, floor, and cages were sprayed with a disinfectant made of FAM 30^{R} (5ml/1L water) to clean them. During the whole time of the experiment, strict bio-security was kept. At the entrance to the chicken shed, a footbath with potassium permanganate was kept and changed every day. Feeders were also cleaned and washed with soap and clean water once a week before they were used again. The cage was split into 16 equal-sized pens for broiler chicken. Before letting the chicks in, stickers were put in the right places on each tube feeder, drinker, and pen (bearing cage no. and treatment). The chicks were kept warm with a 60-watt electric bulb that was hung from the roof of each pen. In the cage, each bird had 0.8 square feet of floor space. Each pan had a medium-thick piece of paper on the bottom to keep the temperature warm and keep the legs from getting hurt. Outside the shed, all of the tools were cleaned and sanitized as needed.

3.3 Collection of day-old broiler chicks and experimental design:

A total of 112 day-old broiler chicks of either sex (Cobb 500) were collected from a local hatchery (Kazi Farms Ltd.) to conduct the biological trial from hatch to 32 days in a battery cage system. Basically, the chicks were purchased from the local agent of Kazi Hatchery named Alif Agro Complex, Hathazari, Chattogram. After procurement, the chicks were weighed initially, then randomly distributed into four treatments (T_1, T_2, T_3, and T_4), each treatment replicated with four times with 7 birds per replicate cage in a completely randomized design(CRD), as shown in Table 2. The following Table shows how the experimental birds are allotted into the sixteen experimental pens of similar size.

Table 2: Experimental design

Treatments	Number of replicate				No. of chicks per treatment
	R_1	R_2	R_3	R_4	
T_1	7	7	7	7	28
T_2	7	7	7	7	28
T_3	7	7	7	7	28
T_4	7	7	7	7	28
Total	28	28	28	28	Grand Total=112

[T_1 refers to control diet while T_2, T_3 and T_4 refer to treatments which were supplemented with 0.5 %, 1.0 % and 1.5 %, phytogenic essential oil, respectively, R_1, R_2, R_3 and R_4 refer to replicates 1, 2 and 3, 4, respectively]

3.4 Collection of the experimental feed and test ingredient:

Broiler pre-starter, starter and grower ready-made compound feeds were collected by purchasing from the local market of Nourish Feed mill Ltd., and used these diets were used for the birds for *ad libitum* feeding from d1-32 days . Pre-starter, starter and grower diets were provided the chicks in both crumble and pellet forms from d1-10, 11-20d and 21-32days, respectively, throughout the trial period. The chemical composition of the ready-made diets was shown in Table 3 and Table 4, respectively. Test ingredient named phytogenic essential oil (Digemax EE^R) was collected from the renowned pharmaceutical company Renata Limited. The phytogenic additives predominantly essential oil (Digemax EE^R) was supplied the bird by treating with water at the rate of 0.5, 1.0 and 1.5%, respectively, from d1 to 32 days. A brief description of [1]**Digemax EE^R** was given below.

[1]Digemax EE^{R} (Herbal phytogenic essential oil):

Composition: Phytogenic blend, containing mainly Capsicum, Cinnamon, Oregano, Turmeric, Eucalyptus, Rosemary

Properties: (Acts as growth promoter)

- Immunomodulation
- Antibacterial properties
- Increase feed conversion ratio
- Prevent –
    i. Dysbacteriosis
    ii. Necrotic Enteritis
    iii. Indigestion
    iv. Wet litter and Coccidiosis

Fig. Digemax EE^{R}

Function:

Phytogenic essential oils bind to the cell membranes of harmful bacteria

↓

Increases the permeability of the membrane by causing ion leakage

↓

Bacterial cell balance is disturbed

↓

Bacterial cell division stops

Note: Phytogenic essential oils contain Cinnamaldehyde, inhibits of the GTPase enzyme and preventing the accumulation of FtsZ protein in Z-ring of bacteria (harmful bacteria), required for cell division.

Table 3: Chemical composition of starter diet

Nutrients	Analytical values (%)	Reporting values (%)
Moisture	7.80	12.00
DM	92.20	88.00
CP	21.53	20.00
CF	2.84	5.00
EE	5.75	-
Ash	5.12	-

Table 4: Chemical composition of grower diet

Nutrients	Analytical values (%)	Reporting values (%)
Moisture	7.29	12.00
DM	92.71	88.00
CP	20.40	20.00
CF	2.78	5.00
EE	7.65	-
Ash	4.82	-

3.5 Management:

The following management procedures were utilized during the whole trial period in an effort to preserve homogeneity (same feeding, lighting, and environmental conditions) in the management practices.

3.5.1 Brooding:

The chicks were brooded with a brooding temperature by an electric bulb set at the middle of each pen of replicate cage. To regulate brooding temperature, a 60 watt electric light was hung at a height of 45 cm in the top center of each pen roof. For the first two days, the birds were exposed to a temperature of 35 °C. After the chicks arrived at 10 days old, the temperature progressively decreased by 1 or 2 °C every one or two days. Later, the room temperature was held at 25°C for the entire trial period.

3.5.2 Floor space:

Birds were raised in a cage with 16 pens of the equal size. Seven birds were put in each pen, which was 5.7 square feet. So, each bird had a floor space of 0.8 square feet.

3.5.3 Feeding and watering:

Feed and fresh clean drinking water were supplied *ad-libitum* to the birds throughout the experimental period. Pre-starter feed was supplied to birds up to 10d, starter feed given up to 20 days and grower fed was given the bird from 21 to rest of the trial period,. Paper along with tube feeder and drinkers were used for feeding and watering the chicks during the early stages soon after coming from the hatchery. The diets were given to the experimental birds normally times daily, where once in the morning at 6 AM and another in the afternoon at 6 PM. Fresh, clean and cool drinking water treated with herbal supplements was supplied the birds three times a day *i.e.* at 6 AM, 12 AM, and 6PM. Each pen was furnished with a feeder and a drinker to have a free access of broiler to feeding and drinking. Drinkers are washed and dried with detergent water every three to five days.

3.5.4 Lighting:

The birds were exposed to a continuous lighting (23 h: 1h) in each 24 hrs. of photoperiod.

3.5.5 Immunization and medication:

According to the schedule listed in Table 5, birds were immunized against New Castle Disease and Gumboro disease. Both the live vaccines for New Castle Disease (Ranivax plus^{R}) and Gumboro (Cevac IBD-L^{R}) were purchased from a nearby veterinary pharmacy. At the scheduled immunization day, each individual vaccine was collected in an airtight container with ice. Within two hours after vaccine collection, each bird received the vaccination by eye. On the designated immunization date, each shot was given in the evening. Vitamin-C was given after each vaccination to help the body recover from the stress of the shot and the cold shock. The day old chicks in the experiment were given glucose in their water on the first day. Then specific dosages of phytogenic essential oil were applied.

Table 5: Vaccination schedule

Age(Days)	Name and type of the Vaccine	Name of diseases	Route of administration
5	Ranivax plus^{R}, Live	Newcastle disease	Eye drop
12	Cevac IBD-L^{R}, Live	Gumboro	Eye drop
17	Cevac IBD-L^{R}, Live	Gumboro	Drinking water
21	Ranivax plus^{R}, Live	Newcastle disease	Drinking water

3.5.6 Data and sample collection:

Prior to delivering birds, starter and grower feed samples were taken to evaluate the nutritional content of each diet. To determine body weight increase and the feed conversion ratio, body weight, feed intake, and residual feeds were recorded on a weekly basis on a record sheet. Additionally, two healthy birds were randomly chosen from each replication and then killed in a halal manner to collect data. The following meat yield characteristics were noted: carcass weight, dressing %, breast, thigh, drumstick, shank, head, neck, back, and wing weights. To determine the growth of the birds' gastrointestinal systems, the amount of abdominal fat and the weight of the specific gastrointestinal organs (liver, heart, and gizzard) were also recorded. At the conclusion of the trial period, a cost-benefit analysis was measured.

3.5.7 Sample processing and analyses:

3.5.8 Feed sample:

Eight feed samples (2 samples for each diet) were collected from ready-made or test diets prior to feeding the birds. The samples were processed by grinding with the help of mortar and pestle and then mixed thoroughly for lab analyses. About 500gm of each diet of finisher as well as starter diet were taken and sent to the PRTC lab for proximate analysis. Each analysis was done three times for each sample to minimize technical errors. The samples were tested for proximate analysis of dry matter (DM %), moisture %, crude protein (CP %), crude fiber (CF %), ether extract (EE %) and ash using standard laboratory procedures. Dry matter estimation was done by oven dry method. Crude protein estimation was accomplished by Kjeldahl Method. Ether Extract estimation was done by Soxhlet apparatus. Ash was measured by igniting the pre-asking sample on a Muffle furnace at a temperature of 600°C for four to six hours.

3.5.9 Method of broiler processing:

At the last day of the experimental period, two broilers were chosen at random, weighed, and humanely killed from each replication pen to evaluate the meat characteristics of the body carcass yield (dressing %, breast weight, thigh, drumstick, back, wing, head, shank, neck), the abdominal fat contents, and the weight of the visceral organs (liver, heart, proventiculus with gizzard). Three hours prior to slaughter, feed and water were removed from the enclosures to allow for appropriate bleeding and skinning. Following the killing procedure, the carcasses of the birds were processed by being stripped of their feathers, skin, heads, shanks, viscera, oil glands, hearts, kidneys, livers, lungs, and small and large intestines. By carefully cutting and fractioning the heart and liver free from the gastro-intestinal system, they were removed. The liver's gallbladder was removed. By cutting the gizzard and proventriculus free in front of the duodenum and behind the final portion of the esophagus, the gastro-intestinal tract was separated.

3.5.10 Record keeping:

The following parameters were observed and recorded during the entirety of the trial period.

3.5.11 Mortality:

Mortality was measured or recoded as when it occurred.

3.5.12 Body weight:

Broilers' weekly live weights for each condition were calculated using repetition. The average live weight of the broilers was also noted by the weighing scale at the beginning of the trial and at the finish of each weekend.

3.5.13 Feed intake:

The amount of feed consumed was calculated by subtracting the amount of leftover feed from the total amount of feed provided to birds on each weekend.

3.5.14 Water intake:

The amount of water consumed was calculated by subtracting the amount of leftover water from the total amount of water provided to birds on each weekend.

3.6 Calculation of data:

3.6.1 Body weight gain (BWG):

The weight increase was estimated by deducting the initial body weight from the end or final body weight. BWG=Final body weight (g) –Initial body weight (g).

3.6.2 Feed conversion ratio (FCR):

FCR refers to the amount of feed needed per unit of production (meat or egg). Feed efficiency is the efficiency of converting feed to meat or egg or other products. The formula used to compute FCR was as follows:

$$\text{FCR} = \frac{\text{Feed intake}}{\text{Body weight gain}}$$

3.6.3 Mortality and livability:

The number of deceased birds during the experimental period divided by the total number of housed birds at the beginning of the experiment served as the foundation for the calculation of bird mortality. The mortality of the birds in each replicate cage was used to calculate livability. This formula was used to determine the fatality percentage.

$$\text{Mortality (\%)} = \frac{\text{Number of broiler died}}{\text{Toutal number of broiler housed}} \times 100$$

3.6.4 Dressing percentage:

The following is how the dressing % for the birds was calculated:

$$\text{Dressing (\%)} = \frac{\text{Dressed Weight}}{\text{Live Weight}} \times 100$$

3.6.5 Evaluation of meat yield parameters:

On day 32, two broilers were humanely killed, and various meat yield parameters, such as carcass weight, dressed weight, and abdominal fat content, as well as the weights of different meat cuts (neck, thigh, wings, breast, back, shank, drumstick), and giblets (heart, liver, proventriculus with gizzard), were precisely recorded.

3.7 Production cost:

When determining the cost of production, we took into account the money spent on chicks, feed, vaccines, and other related items. The price of the chick was determined by the total cost of the purchase. The cost of the feed was calculated based on the sale price of the feed that was offered by the corporation to the dealers.

3.8 Statistical analyses:

All collected data were subjected to analysis by one way ANOVA procedure using Minitab software (Minitab, Minitab Version, 16, 2000). The significance of differences between means was tested using the Duncan‘s multiple range tests (DMRT). Statistical significance was considered at $P \leq 0.05$.

Photo gallery of some activities during experiment

Figure: Cleaning and Washing of shed and cages

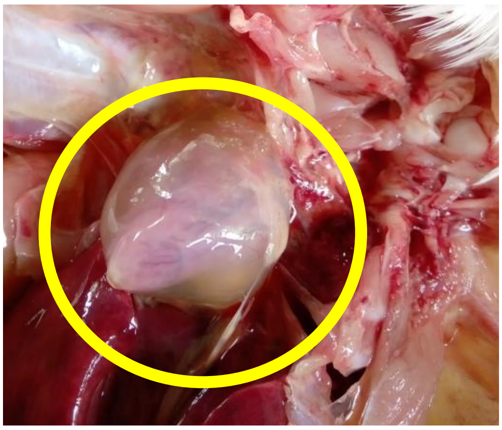
Figure: Cage brooding and Vaccination of chicks

Figure: Distribute of feed and water

Photo gallery of some activities during experiment

Figure: Feeding of birds and weighting

Figure: Cutting and evaluating of meat yield traits



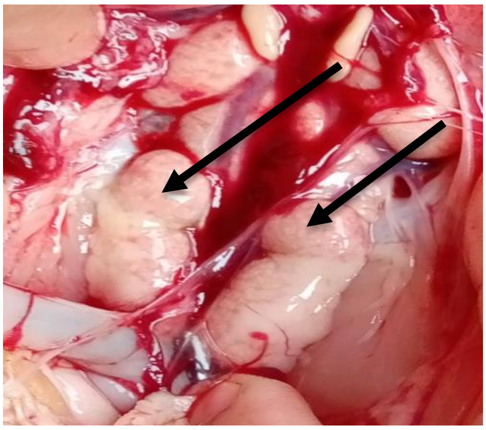


Figure: Inclusion Body Hepatitis (IBH) and Gout in Broiler

Chapter-IV

Results

4. Responses of broiler chickens given herbal extract (phytogenic essential oil): The gross responses of broilers in terms of feed intake, live weight, body weight gain, FCR and viability are stated below in a tubular form. Apart from this, meat quality, carcass traits, gastro-intestinal organ weights, water consumption and profitability of broiler data also represented below in this section.

4.1 Live weight of broilers fed herbal extract or phytogenic essential oil:

The live weight (LW) of broiler chicken is shown below in Table 6. It is clear from the LW data that there was no significant (P>0.05) difference found among treatment from1- 4d, 1-11d, 1-18d, 1-25d and 1-32d, respectively, in this study. The LW of broiler fed on supplemented diets tend to be significant (P<0.072) during d1-32 days of age. The birds fed on T_2 group attained the highest LW (P<0.072) compared to others dietary group.

Table 6: Live weight (LW) of broiler chickens fed herbal extract

Traits	Days	Treatment				SEM	P-value
		T_1	T_2	T_3	T_4		
LW (g/b)	1 - 4	56.86	58.21	56.87	56.43	0.419	0.487
	1 - 11	242.00	246.00	238.12	239.00	2.188	0.615
	1 - 18	641.17	651.00	626.00	635.36	4.298	0.201
	1 - 25	1192.00	1221.00	1151.40	1192.00	14.725	0.488
	1 - 32	1767.30	1832.60	1793.00	1817.00	17.800	0.072

[Data refer to mean values of seven birds per replicate from d4-32 days; T_1 refers to control diet with no supplemental agents, whereas T_2, T_3 and T_4 diets are supplemented with 0.5, 1.0, and 1.5 % herbal products treated with water, respectively; SEM-Standard error mean]

4.2 Live weight gain (LWG) of broiler chicken on day 32 fed herbal extract:

The LWG of broiler was shown graphically (Fig. 1), which indicate insignificant difference (P>0.05) as well between treatment on 32 days. Numerically higher LWG was found in the birds fed T_2 diet group than that of others in this study.

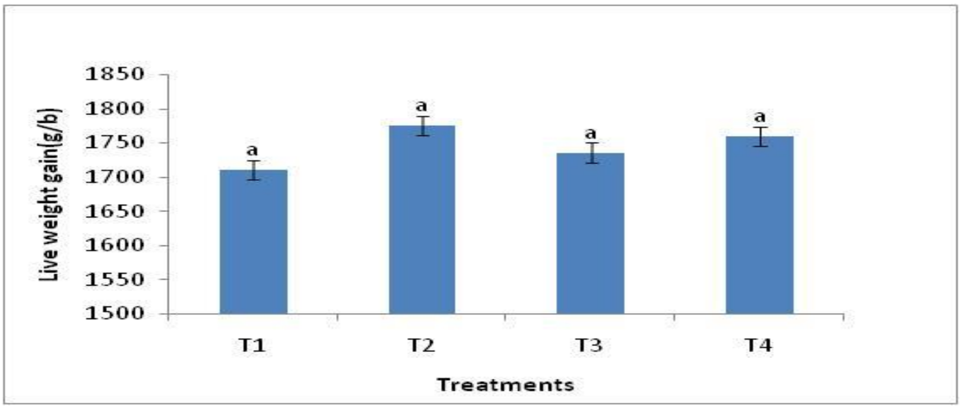


Fig.1: Live weight gain (mean ±SE; g/b) of broiler fed diets supplemented with herbal diet on day32; Bar with similar superscripts has no significant difference (P>0.05) between treatment

4.3 Feed intake (FI) of broiler chicken fed herbal products:

Table 7 shows the results of broiler chicken FI. The findings demonstrated that there were no significant (P>0.05) variations found in the FI of broilers between treatment groups from day 1 to 32 days. The FI of broiler fed on supplemented diets tend to be significant (P<.098) during day 1-32 days of age.

Table 7: Feed intake (FI) of broiler chicken fed herbal extract

Traits	Days	**Treatment**				SEM	P-value
		T_1	T_2	T_3	T_4		
FI (g/b)	1 - 4	229.00	231.00	225.00	222.00	2.165	0.533
	1 - 18	785.05	772.17	772.00	740.00	5.740	0.082
	1 - 25	1760.40	1740.00	1731.00	1732.00	5.875	0.293
	1 - 32	2797.00	2849.30	2847.30	2860.00	9.425	0.098

[Data refer to mean values of seven birds per replicate from d4-32 days; T_1 refers to control diet with no supplemental agents, whereas T_2, T_3 and T_4 diets are supplemented with 0.5, 1.0, and 1.5 % herbal products treated with water, respectively]

4.4 Feed conversion ratio (FCR) of broilers fed herbal extract:

The results of FCR were shown in the Table 8. Though FCR of broiler was insignificant (P>0.05) between treatment, but numerically improved FCR (1.60) was observed in the birds of T_2 group on day 32.

Table 8: Feed conversion ratio (FCR) of broiler chicken

Traits	Days	Treatment				SEM	P-value
		T_1	T_2	T_3	T_4		
FCR	1 - 4	1.23	1.22	1.24	1.22	0.019	0.80
	1 - 18	1.34	1.30	1.36	1.28	0.0509	0.171
	1 - 25	1.54	1.50	1.52	1.53	0.014	0.548
	1 - 32	1.64	1.60	1.64	1.63	0.0169	0.886

[Data refer to mean values of seven birds per replicate from d4-32 days; T_1 refers to control diet with no supplemental agents, whereas T_2, T_3 and T_4 diets are supplemented with 0.5, 1.0, and 1.5 % herbal products treated with water, respectively]

4.5 Livability of broiler fed herbal extract:

The response of broiler in terms of livability fed with herbal supplemented diets on 32 days was not found significant (P>0.05) among treatments as shown below in Figure 2. The results show that the numerically (P>0.05) highest survivability (100%) was found in the bird of T_2 group followed by T_4 (93 %), T_3 (90%), and T_1 (87.0%) group, respectively.

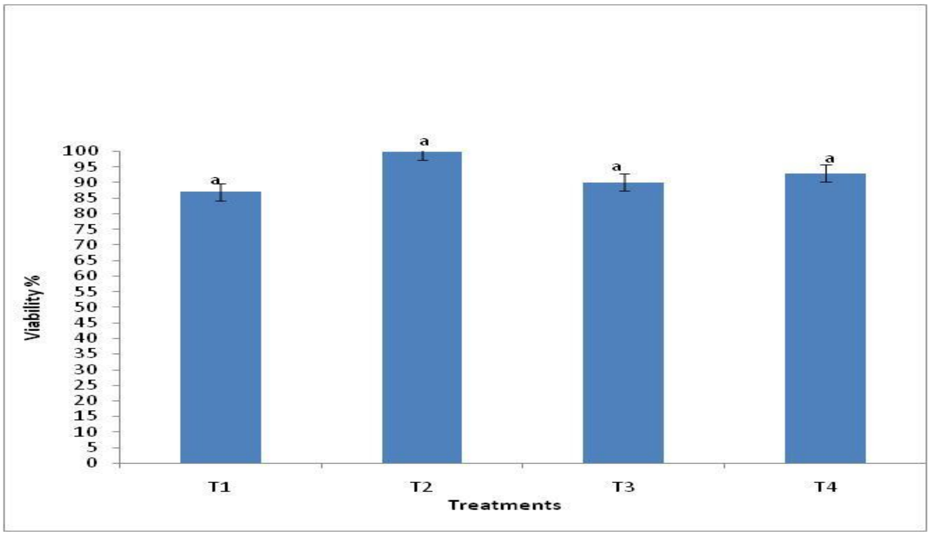


Fig. 2: Survivability (%; mean ±SE) of broiler chicks fed herbal diet; Bar with similar superscripts has no significant difference (P>0.05) between treatment

4.6 Meat yield traits of broilers fed herbal extract:

Results of meat yield parameters shown in Table 9 demonstrated that the weights of dressing %, breast weight, drumstick weight, thigh weight, wing weight, shank weight, back weight, neck weight and head weight % etc., were not significantly different (P>0.05) between treatments by the dietary treatment. Numerically (P>0.05) the highest dressing (%) and breast weight % were found in the birds fed on the T_2 diet group compared to others.

Table 9: Carcass yield traits (%) of broiler chicken fed herbal extract on day 32

Traits	Treatments				SEM	P-value
	T_1	T_2	T_3	T_4		
Dressing %	62.64	65.87	60.76	61.33	0.463	0.225
Breast weight	22.00	24.57	22.62	23.25	0.530	0.453
Drumstick weight	8.45	9.14	8.80	8.82	0.169	0.603
Thigh weight	8.46	9.35	8.85	8.78	0.174	0.439
Shank weight	4.16	4.27	4.0	4.13	0.038	0.247
Wing weight	6.09	6.10	5.91	5.88	0.136	0.905
Back weight	11.80	11.85	10.31	10.75	0.18	0.087
Neck weight	6.09	6.10	5.91	5.88	0.136	0.095
Head weight	2.51	2.75	2.37	2.61	0.1201	0.735

[Data refer to mean values of two birds per replicate on 32 days; T_1 refers to control diet with no supplemental agents, whereas T_2, T_3 and T_4 diets are supplemented with 0.5, 1.0, and 1.5 % herbal products treated with water, respectively]

4.7 Gastro-intestinal development of broilers fed herbal extract:

The relative weight of visceral organs of broiler chicken fed on the supplemented diet is shown in Table 10. The data show that the weights of proventriculus, gizzard, liver, and heart weight of birds were identical (P>0.05) between treatments.

Table 10: Gastro-intestinal organ weight (g/b) of broiler chicken fed herbal diet on day 32

Traits	Treatments				SEM	P-value
	T_1	T_2	T_3	T_4		
Gizzard plus proventriculus	46	48	44	45	1.643	0.703
Heart weight	12	11	13	13	0.968	0.862
Liver weight	60.5	55	52	49	2.347	0.251

[Data refer to mean values of two birds per replicate on 32 days;]

4.8 Meat quality of broilers fed herbal extract or essential oil:

To evaluate the meat quality of broiler chickens, data on the abdominal fat accumulation of broiler was recorded at 32 days. The result demonstrated that there was no discernible variation (P>0.05) in the abdominal fat content of broiler chickens between treatment. The results show that the numerically (P>0.05) lowest fat content (11g/b) was found in the bird of T_2 group followed by T_3 (16g/b), T_4 (17g/b) and T_1 (18g/b) group, respectively.

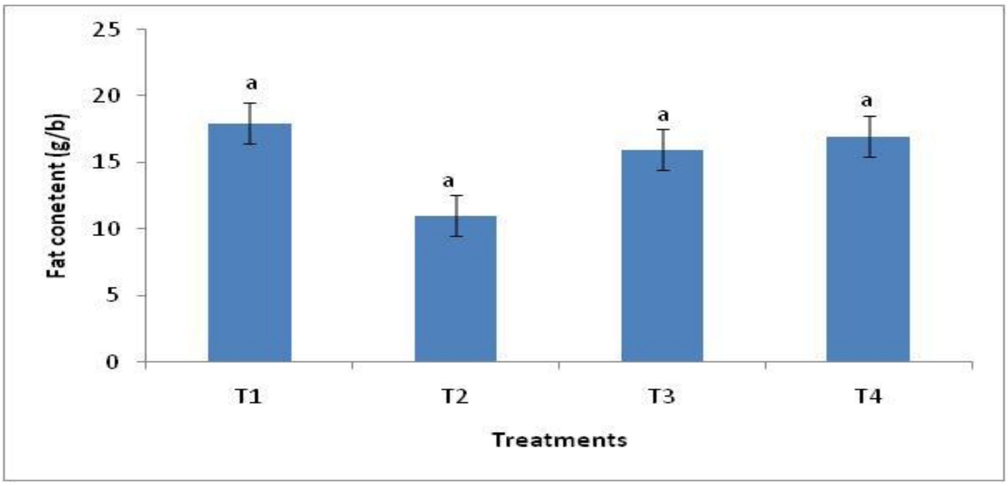


Fig.3: Fat contents (g/b; mean ±SE) of broiler chicks fed herbal diet; Bar with similar superscripts has no significant difference (P>0.05) between treatment

4.9 Water consumption of broiler fed with the herbal extract:

The water intake (WI) (ml/b) data of broiler was shown in the following graph (Fig-4) during day 25 to 32 days of rearing period. The result of WI was influenced significantly (P<0.05) by the treatment group. The data indicate that the highest WI found in the birds of T_3 (3102.5 ml/b) group, followed by T_1 (3018.4 ml/b), T_4 (2674.0 ml/b) and T_2 (2587.20 ml/b) group, respectively, as shown in the graph (Fig-10).

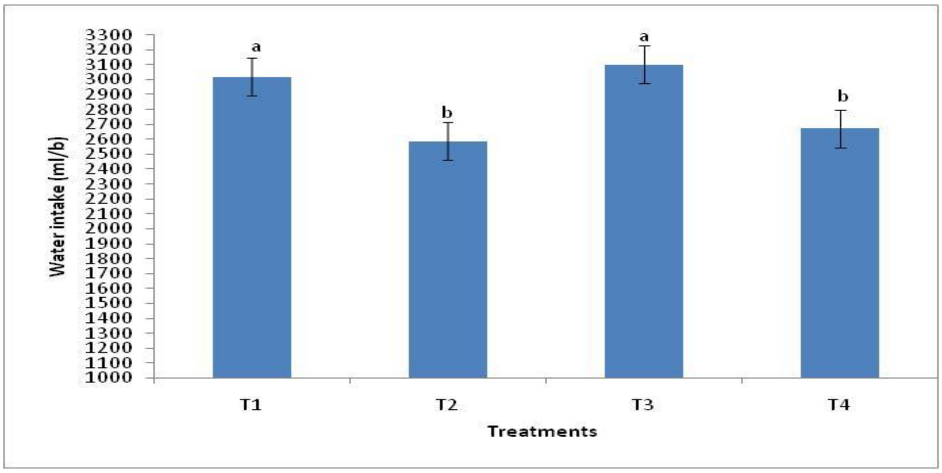


Fig.4: Water intake (ml/b; mean ±SE ;) of broiler chicks fed herbal products from day 25 to 32 days; Bar with dissimilar superscripts has a significant difference (P<0.05) between treatment]

4.10. Cost benefit analyses of broiler fed herbal extract:

Data of cost-benefit evaluations of broiler were given in Table 11. The results demonstrated that the significantly greater profit (P<0.05) was found in the broiler of T_2 (15.0 Tk/Kg) dietary group followed by T_4 (14.92 Tk), T_3 (9.90 Tk) and T_1 (9.69 Tk) dietary groups, respectively. The highest profit margin was observed in the broiler of T_2 group while T_1 group being the lowest in profit.

Table 11: Cost of production and profit of broiler chicken fed herbal diet

Traits	Treatment				SEM	P-value
	T_1	T_2	T_3	T_4		
Live weight (g/b)	1770.30	1833.0	1790.80	1816.0	16.800	0.071
Viability (%)	87.0	100.0	90.03	93.0	1.325	0.08
Total production cost (TK/kg live weight)	130.31	125.0	130.11	125.08	-	-
Selling price (TK/kg live bird)	140.0	140.0	140.0	140.0	-	-
Profit (Tk/kg live bird)	9.69^b	15.0^a	9.90^b	14.92^a	0.379	0.05
Cost: benefit ratio	13.45	8.33	13.14	8.38	-	-

[Values bearing different superscripts in a row differ significantly between treatment at *P<0.05; Detailed cost of production shown in the Appendix Table 1]

Chapter-V

Discussion

5.1 Gross responses of broiler chickens:

5.1.1Growth performance of broiler chicken fed the supplementing water treated with herbal phytogenic essential oil (Digemax EE^{R}):

Currently herbal extract or products are being used popularly for both man and animal across the globe. Several issues such as no residual effect or side effect, health-promoting agent, natural growth promoter, and ban of using antibiotics by EU etc., are considered as the valid reasons for the increased popularity of using these products unequivocally in animal kingdom globally. So phytogenic feed additives in animal nutrition are being used rapidly as natural growth stimulant instead of using antibiotic in animal production. Phytogenic feed additives are basically the herbal extracts, predominantly phytogenic essential oil, which is derived from phytogenic blend that is composed of mainly many plants or herbs (e.g. capsicum, cinnamon, oregano, turmeric, eucalyptus, and rosemary) together.

The main or most important performance indicators or parameters used to evaluate the performance of broiler chickens are body weight and weight growth. According to the present research, broilers given water treated with herbal phytogenic essential oil had no discernible impact on the live weight or weight increase of the poultry from day 4 to day 32. The identical growth responses of broiler to herbal essential oil possibly due to similar action of the supplemental products added in potable water. Our results are agreed with the findings of the previous investigators (Namagirilakshmi, 2005, Sarica et al., 2009), who found similar growth responses when broiler chicken and quail fed diet supplemented with herbal extracts particularly, turmeric and cinnamon essential oil, respectively.

Our present research shows that, on day 32 of the experimental period, live weight and body weight growth fed on phytogenic essential oils or herbal extracts are only slightly raised (P=0.07). Particularly in the T_2 and T_4treatment groups, broiler chickens discovered to have taken supplemental herbal extracts showed a slight rise in body weight growth. The increased weight gain or body weight is assumed to be an outcome of supplementing herbal extracts in the drinking water. The growth promoting properties of herbal phytogenic essential oil or extracts might accelerate the growth rate of the broiler chicken. The results are also consistent with the findings of the earlier researchers (Toghyani et al., 2011, Raghdad and Al-Jaleel, 2012, Shirzadegan, 2014, Devi et al., 2018), who found increased body weight gain of broiler when the birds fed diet supplemented with turmeric, cinnamon powder and cinnamon essential oil, respectively.

5.1.2Feed intake (FI) of broiler fed herbal extract or phytogenic essential oil:

In the present study, we observed no significant changes in feed consumption of broiler chicken fed water treated with herbal extracts up to 25 days of rearing period. It implies that phytogenic essential oil mixed with water did not alter or affect the taste preference of the birds which could affect the feed consumption of broiler chicken. The same ration of similar makeup, shape, texture, color, and flavor (ready-made compound) may have been fed to the broilers throughout the trial time, which may have contributed to their identical FI in this research. The uniform broiler chicken development pattern discovered in this research may also account for the birds' identical feed intake. Our results are agreed with the findings of the previous studies conducted by several researchers (Sarica et al., 2009, Wuthi-Udomler et al., 2000, Nouzarian et al., 2011, Mehdipour et al., 2013, Symeon et al., 2014), when broiler or quail fed cinnamon oil or powder diet.

However, the FI is found to be slightly increased (P=0.08) in the broiler of T_4 and T_2 treatment groups, respectively, as the birds fed phytogenic essential oil on 32 days only. The increased FI of the birds could be a resultant of heavier body weight obtained by the particular group of broiler chicken, as is seen in this study. It is clear that feed intake of individual chicken could vary due to the differences in body weight of the each animals’ feed requirement. The result is coincided with the report of (Raghdad and Al-Jaleel, 2012), who found substantial differences in feed intake of broiler when fed herbal extract.

5.1.3 Feed conversion ratio (FCR) of broiler fed herbal extract or essential oil:

The broiler FCR outcome in this research did not significantly change over the course of the trial. Despite non-significant variations, the T_2 group's FCR (1.60) appears to be slightly more effective than the others at converting feed into meat than the other groups in this research. Our findings are in agreement with those of earlier researchers

(Lee et al., 2003; Hernandez et al., 2004; Sarica et al., 2009; Yaghobfar et al., 2011; Symeon et al., 2014), who discovered no differences in FCR of broiler when they gave extracts of cinnamon, turmeric, pepper, and oregano. The marginally increased body weight of the broiler chickens in this treatment group (T_2) might be a result of the broiler chickens' effective feed usage and feed efficiency. The findings are supported by the previous researchers (Al-Sultan et al., 2003, Wuthi-Udomler et al., 2000, Durrani et al., 2006, Raghdad and Al-Jaleel, 2012). (Lee et al., 2003) observed that adding cinnamaldehyde to feed did not significantly affect the FI and FCR of female broilers.

5.1.4 Survivability of broilers fed herbal extract or essential oil:

The data on survivability of broiler show that adding herbal extract had no significant effect on the livability or death of birds. It is interesting to note that birds of T_2 treatment group got the 100 % viability amongst others in this study, which implies that the herbal extracts or oils are not detrimental for the broiler chicken at these doses. Though the livability did not differ significantly, but the mortality was comparatively a bit increased in the rest of the treatment group, died mainly due to gout and inclusion body hepatitis disease. Our finding is agreed with previous researchers who showed similar result when broiler fed various types and doses of spices, turmeric powder or cinnamon oil in broiler ration (Abou Egla et al., 1995, Abaza, 2001,Ciftci, et al., 2009, Daneshyar et al., 2012, Symeon et al., 2014) .

5.1.5 Impact of herbal extract or essential oil on the carcass yield traits and gastro-intestinal development of broiler:

The results of carcass yield of broiler traits clearly show that the dressing%, breast weight, thigh weight, neck, wing, and drumstick weight% of broiler chicken in this investigation did not differ significantly from one another. The gastro-intestinal organ weights (gizzard, liver and heart) were also not influenced by dietary group. The regular or uniform growth pattern and development of the broiler chicken might result in similar growth performance of the various organs in the broiler carcass. The result is consistent with the report of (Lal et al., 1999) and (Al-Sultan et al., 2003), who found no difference in the size of the liver and heart when broiler fed on herbal extracts (turmeric powder). Our result also agrees with the report of (Sampath and Atapattu, 2013), who stated that the meat yield and fat content were unaffected when broiler fed herbal extract (cinnamon powder). (Isabel and Santos, 2009) also stated that the cinnamon oil-fed group's broiler breast meat part increased and abdominal fat decreased.

5.1.6 Effect of herbal extract or essential oil on the meat quality of broiler chicken:

The amount of fat content in the meat determines its quality. Extra fat accumulation in broiler carcass is generally considered as an unfavorable characteristic in the poultry industry (Remignon and Le Bihan-Duval, 2003). This study showed that abdominal fat content of broiler was also unaffected between treatments. Broiler chickens fed on herbal extracts supplemented diet deposited similar fat content in their carcasses. It implies that supplemental diet had no influence on the abdominal fat deposition in broiler, though increasing trend of depositing fat (%) content was observed in the other supplemented group except for T_2 group. The probable reason for the increase in abdominal fat on the diets might be due to more rapid growth, leading to earlier transition from muscle to fat deposition (Hossain et al., 2013). Feed nutrients appear to be metabolized at different rates when supplied in diets to the birds. This influences deposition of fat deposition. As one phase nearly completes, the rate of the next phase increases, so that birds that grow rapidly tend to enter the fat deposition phase earlier than those that grow slowly (Hossain et al., 2013).

Numerically lower fat content (11g/b) was observed in the T_2 treatment group in this study, and it can support the findings of (Nouzarian et al. 2011), who found that broilers fed a diet containing 0.5% turmeric powder had less fat%. Another researcher suggests that essential oils might enhance meat yield/output by reducing abdominal fat deposition in broiler carcasses (Cross et al., 2011). It is reported that cinnamon oil decreased the amount of abdominal fat in broiler meat (Isabel and Santos, 2009, Al-Kassie, 2009). Lower the fat content gives rise to higher lean meat carcass yield. Generally, people prefer lean meat or fatless meat. So lean meat implies quality meat because it assures higher protein % than fat content in the carcass.

Dietary manipulation is an important way to improve meat quality in poultry. (Sampath and Atapattu, 2013) revealed that cinnamon powder had no noticeable effect on belly fat and meat output. However, some research suggests that the quality of chicken meat can be improved by using cinnamon powder, cinnamaldehyde, or their essential oils alone or in combination with other oils. (Isabel and Santos, 2009)

They also stated that the cinnamon oil-fed group's broiler breast meat part increased and abdominal fat decreased. Another research found that turmeric includes curcuminoids, which are naturally occurring antioxidants that are deposited in the skin and tissue when added to the diet and result in a mild yellowing of the flesh (Johannah et al., 2018, Pashtetsky et al., 2019). The level of curcuminoid increases the meat's ability to resist oxidation (Zhang et al., 2018; Partovi et al., 2020).

5.1.7 Effect of herbal extract or essential oil on the water intake (WI) of broiler:

The result of WI of broiler fed herbal extract differed significantly between treatments on 32 days. The data revealed that the greater WI was found in the T_3 and T_1 treatment groups, respectively, and lowest WI being in the T_2 and T_4 group. Many factors such as flavor, odour, taste appeal, level of water retention capacity, level of thirstiness, bird's health condition, temperature, heat stress etc., might be responsible for the variation of water consumption by the broiler chicken fed herbal extract or photogenic essential oil (Lee et al., 2003; Sang-Oh et al., 2013). It can be surmised that the, sensory flavours, higher water retention capacity and lower thirstiness of broiler chicken fed herbal extract might induce lower water consumption by T_2 and T_4 treatment groups of birds, respectively. This is also supported by (Sang-Oh et al., 2013) who reported that broiler had increased water retaining capacity when they fed diet supplemented with herbal products (cinnamon). Further, water consumption is reduced dramatically when broiler fed herbal products (cinnamaldehyde) reported by another researcher (Lee et al., 2003).

5.1.8 Effect of herbal extract or essential oil on the farm profitability of broiler:

Higher profit margin was found in herbal treated group (T_2 and T_4). The increased profit might be due to increased body weight gain and reduced production cost per treatment group. Our result is agreed with the findings of previous investigator (Singh et al., 2009; Alam et al., 2021), who found similar result in profitability when broiler raised with herbal diet.

However, the current feed costs and market meat prices, as well as the criteria by which the cost and benefit and performance of birds are evaluated (live weight, carcass yield, or cut-up part value, total production cost of per kg live weight), might affect feed cost or production cost in relation to its economic returns (Corzo et al., 2010; 2005). It is necessary, in order to maximize profits from broiler production, to continually reevaluate the relationship between feed costs and subsequent chick cost as well as processing yield. This is necessary because feed prices, meat prices, and other costs required for broiler production are constantly changing. This fluctuation is mostly attributable to differences in the cost of feed, the amount of feed consumed, the amount of weight gained, and the mortality rate. Herbal supplementation in diet gave better economic returns. Additionally, a farm's revenue may change depending on how its completed products are sold in the market, such as live birds, dressed birds, cooked meat, deboned meat, different meat portions, etc. (Akter et al., 2020).

Chapter-VI

Conclusion & Recommendations

From an overview of the result obtained in the study revealed that broiler chickens fed diet supplemented with herbal extracts (Digemax EE^R) responded positively for the live weight and body weight gain marginally without influencing feed consumption, viability and FCR. This implies that addition of the herbal supplement to the diet of broiler chickens might improve their ability of chicken to produce more meat and higher profitability. However, significant variation was observed in water intake by the broiler chickens. No significant differences were observed in the carcass yield traits, gastro-intestinal organ weight and abdominal fat accumulation of broiler chickens in this study. Herbal extracts (Digemax EE^R) @ 0.5ml/liter of water could work more effectively for broilers' growth performance and economics of broiler production without having a negative impact on the health of the broilers. The current findings indicate that phytogenic essential oil or Digemax EE^R can be used as potential feed additives to be used in broiler diet for lucrative broiler production under farming condition.

Limitations of the study:

- Fewer researches were conducted on this topic
- Limited sample size and fund availability
- Evaluation of meat quality (Proximate analysis, pH, cook loss, drip loss, amino acid and fatty acid profile) not done
- Study of the broiler's immune condition (Titer level) and blood lipid profile not done in this study

Chapter-VII

References

Abaza, I. M. K. (2001). The use of some medicinal plants as feed additives in broiler diets. Ph.D Thesis, Graduate School, Faculty of Agriculture, Alexandria University, Egypt. www.abazacenter.8m.net.

Abbas, R. Z., Iqbal, Z., Khan, M. N., Zafar, M. A., & Zia, M. A. (2010). Anticoccidial activity of Curcuma longa L. in broilers. *Brazilian Archives of Biology and Technology, 53, 63-67*

Abd Al-Jaleel, R. A. (2012). Use of turmeric (Curcuma longa) on the performance and some physiological traits on the broiler diets. *The Iraqi Journal of Veterinary Medicine, 36(1), 51-57*

Abdelli, N., Solà-Oriol, D., & Pérez, J. F. (2021). Phytogenic feed additives in poultry: Achievements, prospective and challenges. *Animals*, *11*(12), 3471

Abou–Egla, El-Samra H, Attia YA, El-Deek AA, Mafret Saleh El-Din.(1995). Growth promoting influence of some herbs on performance and carcass quality of broilers and ducklings. *Journal of Agriculture Sciences. Mansoura University*

Abou-Elkhair, R., Ahmed, H. A., & Selim, S. (2014). Effects of black pepper (Piper nigrum), turmeric powder (Curcuma longa) and coriander seeds (Coriandrum sativum) and their combinations as feed additives on growth performance, carcass traits, some blood parameters and humoral immune response of broiler chickens. *Asian-Australasian Journal of Animal Sciences, 27(6), 847*

Adu, O. A., Gbore, F. A., Oloruntola, O. D., Falowo, A. B., & Olarotimi, O. J. (2020). The effects of Myristica fragrans seed meal and Syzygium aromaticum leaf meal dietary supplementation on growth performance and oxidative status of broiler chicken. *Bulletin of the National Research Centre, 44(1), 1-10*

Ahlawat, P. K., Dalal, R., Sonu, T. B., Panwar, V. S., & Sheoran, N. (2018).Antimicrobial effect of dietary supplementation of turmeric powder in intestine of broilers. *International Journal of Current Microbiology and Applied Sciences, 7, 2244-2251*

Ahmed, A. A., Bassuony, N. I., El-Habiab, S. A., Awad, S., Aiad, A. M., & Mohamed, S. A. (2009). Adding Natural Juice of Vegetables and Fruitage to Ruminant Diets (B) Nutrients Utilization, Microbial Safety and Immunity, Effect of Diets Suplemented with Lemon, Onion and Garlic Juice Fed to Growing Buffalo Calves. *World Journal of Agricultural Sciences, 5(4), 456-465*

Akhavan-Salamat, H., & Ghasemi, H. A. (2016). Alleviation of chronic heat stress in broilers by dietary supplementation of betaine and turmeric rhizome powder: dynamics of performance, leukocyte profile, humoral immunity, and antioxidant status. *Tropical Animal Health and Production, 48(1), 181-188*

Akter, N., Islam, M, S., Zaman, S., Jahan, Hossain, M. A. (2020). The impact of different levels of L-methionine (L-Met) on carcass yield traits, serum etabolites, tibial characters and profitability of broilers fed conventional diet. *Journal of Advance Veterinary and Animal. Research, 7 (2): 253–259*

Alagawany, M. M., Farag, M. R., & Kuldeep, D. (2015). Nutritional and biological effects of turmeric (Curcuma longa) supplementation on performance, serum biochemical parameters and oxidative status of broiler chicks exposed to endosulfan in the diets. *Asian Journal of Animal and Veterinary Advances, 10(2), 86-96*

Alam, M.M., Hossain, M. A., Ghosh, S. and Zaman, S. (2021). Ascertaining the productivity and economic profitability of broiler chicken fed compound diet supplemented with herbal product. *Bangladesh Journal of Veterinary and Animal Sciences, 9(2):15-22*

Alcicek, A. H. M. E. T., Bozkurt, M., & Çabuk, M. (2004).The effect of a mixture of herbal essential oils, an organic acid or a probiotic on broiler performance. *South African Journal of Animal Science, 34(4), 217-222*

Alexandratos, N., & Bruinsma, J. (2012). World agriculture towards 2030/2050: the 2012 revision

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

AL-Kassie, G. A., Mohseen, A. M., & Abd-AL-Jaleel, R. A. (2011).Modification of productive performance and physiological aspects of broilers on the addition of a mixture of cumin and turmeric to the diet. *Research Opinions in Animal and Veterinary Sciences*

Al-Khalaifah, H. S. (2018). Benefits of probiotics and/or prebiotics for antibiotic-reduced poultry. *Poultry Science, 97(11), 3807-3815*

Alp, M. Ü. J. D. A. T., Midilli, M., Kocabağlı, N., Yılmaz, H., Turan, N. U. R. İ., Gargılı, A., & Acar, N. Ü. K. E. T. (2012). The effects of dietary oregano essential oil on live performance, carcass yield, serum immunoglobulin G level, and oocyst count in broilers. *Journal of Applied Poultry Research, 21(3), 630-636*

Al-Sultan, S. I. (2003). The effect of Curcuma longa (turmeric) on overall performance of broiler chickens. *International Journal of Poultry Science, 2(5), 351-353*

Andremont, A. (2000, May). Consequences of antibiotic therapy to the intestinal ecosystem.*In Annales Francaises d'anesthesie et de Reanimation (Vol. 19, No. 5, pp. 395-402)*

Ashour, E. A., Farsi, R. M., Alaidaroos, B. A., Abdel-Moneim, A. M. E., El-Saadony, M. T., Osman, A. O., ... & Abd El-Hack, M. E. (2021). Impacts of dietary supplementation of pyocyanin powder on growth performance, carcase traits, blood chemistry, meat quality and gut microbial activity of broilers. *Italian Journal of Animal Science, 20(1), 1357-1372*

AVEC annual report (2018). *EU28 Poultry Meat Export Trade, Main Tariff Lines. EU28 Poultry Meat ExportAssociation of Poultry Processors and Poultry Trade in the EU Countries ASBL*

Awaad, M. H. H., Abdel-Alim, G. A., Sayed, K., Ahmed, K., & Nada, A. (2009). The immunostimulant effects of peppermint and eucalyptus essential oils in chickens. *Pakistan Veterinary Journal, 36, 61-66*

Awaad, M. H. H., Abdel-Alim, G. A., Shaaban, K. S., Kawkab, A. A., Nada, A. A., & Metwalli, A. S. Z. (2009). Modulating effect of peppermint and eucalyptus oils in infectious bursal disease immunocompromised chickens. *Veterinary Medical Journal Giza, 57(3), 357-375*

Babak, D., & Nahashon, S. N. (2014).A review on effects of Aloe vera as a feed additive in broiler chicken diets. *Annals of Animal Science, 14(3), 491-500*

Baghban, P., Daneshyar, M., and Najafi, R., (2016). Effects of Cinnamon (Cinnamomum zeylanicum) and Turmeric (Curcuma longa) Powders on Performance, Enzyme Activity, and Blood Parameters of Broiler Chickens under Heat Stress. *Poultry Science Journal 2016, 4 (1): 47-53*

Begum, I. A. (2008). Prospects and potentialities of vertically integrated contract farming in Bangladesh poultry sector development. *(Doctoral dissertation)*

Bozkurt, M., Alçiçek, A. H. M. E. T., Cabuk, M., Küçükyilmaz, K., & Çatli, A. U. (2009).Effect of an herbal essential oil mixture on growth, laying traits, and egg hatching characteristics of broiler breeders. *Poultry Science, 88(11), 2368-2374*

Brenes, A., & Roura, E. (2010). Essential oils in poultry nutrition: Main effects and modes of action. *Animal Feed Science and Technology, 158(1-2), 1-14*

Burgat, V. (1991).Residues of drugs of veterinary use in food. *Livestock Practiciens, 41(11), 985-990*

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

Cardozo, P. W., Calsamiglia, S., Ferret, A., & Kamel, C. (2004).Effects of natural plant extracts on ruminal protein degradation and fermentation profiles in continuous culture. *Journal of Animal Science, 82(11), 3230-3236*

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

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

Chowdhury, E. U., & Morey, A. (2019).Intelligent packaging for poultry industry. *Journal of Applied Poultry Research, 28(4), 791-800*

Christaki, E., Florou-Paneri, P., Giannenas, I., Papazahariadou, M., Botsoglou, N. A., & Spais, A. B. (2004). Effect of a mixture of herbal extracts on broiler chickens infected with Eimeria tenella. *Animal Research, 53(2), 137-144*

Ciftci, M., Dalkilic, B., Cerci, I. H., Guler, T., Ertas, O. N., & Arslan, O. (2009). Influence of dietary cinnamon oil supplementation on performance and carcass characteristics in broilers. *Journal of Applied Animal Research, 36(1), 125-128*

Corduk, M., Sarica, S., & Yarim, G. F. (2013). Effects of oregano or red pepper essential oil supplementation to diets for broiler chicks with delayed feeding after hatching. 1. Performance and microbial population. *Journal of Applied Poultry Research, 22(4), 738-749*

Corzo, A., Kidd, M. T., Burnham, D. J., Miller, E. R., Branton, S. L., & Gonzalez-Esquerra, R. (2005). Dietary amino acid density effects on growth and carcass of broilers differing in strain cross and sex. *Journal of Applied Poultry Research, 14(1), 1-9*

Corzo, A., Schilling, M. W., Loar II, R. E., Mejia, L., Barbosa, L. C. G. S., & Kidd, M. T. (2010). Responses of Cobb× Cobb 500 broilers to dietary amino acid density regimens. *Journal of Applied Poultry Research, 19(3), 227-236*

Cowan, M. M. (1999). Plant products as antimicrobial agents. *Clinical Microbiology Reviews, 12(4), 564-582*

Cross, D. E., McDevitt, R. M., & Acamovic, T. (2011). Herbs, thyme essential oil and condensed tannin extracts as dietary supplements for broilers, and their effects on performance, digestibility, volatile fatty acids and organoleptic properties. *British Poultry Science, 52(2), 227-237*

Cuppett, S. L., & Hall, C. A. (1998).Antioxidant activity of the Labiatae. *Advances in Food and Nutrition Research, 42, 245-272*

Daneshyar, M., Ghandkanlo, M. A., Bayeghra, F. S., Farhangpajhoh, F., & Aghaei, M. (2011). Effects of dietary turmeric supplementation on plasma lipoproteins, meat quality and fatty acid composition in broilers. *South African Journal of Animal Science, 41(4), 420-428*

Daneshyar, M., Kermanshahi, H., & Golian, A. (2012). The effects of turmeric supplementation on antioxidant status, blood gas indices and mortality in broiler chickens with T3-induced ascites. *British Poultry Science, 53(3), 379-385*

Daramola, O. T. (2020). Growth performance and serum metabolites of broiler chickens fed turmeric (Curcuma longa) powder supplemented diets. *Livestock References, 32, 12*

Devi, P. C., Samanta, A. K., Das, B., Kalita, G., Behera, P. S., & Barman, S. (2018). Effect of plant extracts and essential oil blend as alternatives to antibiotic growth promoters on growth performance, nutrient utilization and carcass characteristics of broiler chicken. *Indian Journal Animal Nutrition, 35, 421-427*

DLS (2019).Annual report on livestock 2018-19.*Division of Livestock Statistics, Ministry of Fisheries and Livestock, Farmgate, Dhaka, Bangladesh*

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

Dragland, S., Senoo, H., Wake, K., Holte, K., & Blomhoff, R. (2003). Several culinary and medicinal herbs are important sources of dietary antioxidants. *The Journal of Nutrition, 133(5), 1286-1290*

Durrani, F. R., Ismail, M., Sultan, A., Suhail, S. M., Chand, N., & Durrani, Z. (2006). Effect of different levels of feed added turmeric (Curcuma longa) on the performance of broiler chicks. *Journal of Agricultural and Biological Science, 1(2), 9-11*

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

Emadi M., Kermanshahi H., 2006. Effect of turmeric rhizome powder on performance and carcass characteristics of broiler chickens.*International Journal Poultry Science 5, 1069-1072*

Ezzat Abd El-Hack, M., Alagawany, M., Ragab Farag, M., Tiwari, R., Karthik, K., Dhama, K., & Adel, M. (2016). Beneficial impacts of thymol essential oil on health and production of animals, fish and poultry: a review. *Journal of Essential Oil Research, 28(5), 365-382*

Faostat, (2019). Food and Agriculture Organization of the United Nations, 2019. *Production: Crops*

Farrell, D. (2013). The role of poultry in human nutrition. *Poultry Development Review. Rome: Food and Agriculture Organization, 2-9*

Food and Agriculture Organization (2014).Meat Quality.*Retrieved from: Tinyurl.com January 14, 2021*

Fotea, L., Costăchescu, E., Hoha, G., & Leonte, D. (2010).The effect of oregano essential oil (Origanum vulgare L.) on broiler performance. *Lucrări Ştiinţifice Seria Zootehnie, 53, 253-256*

Frankic, T., Voljc, M., Salobir, J., & Rezar, V. (2009). Use of herbs and spices and their extracts in animal nutrition. *Agricultural Science, 94(2), 95-102*

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

Ghazi, S., Amjadian, T., & Norouzi, S. (2015). Single and combined effects of vitamin C and oregano essential oil in diet, on growth performance, and blood parameters of broiler chicks reared under heat stress condition. *International Journal of Biometeorology, 59(8), 1019-1024*

Gholami-Ahangaran, M., Rangsaz, N., & Azizi, S. (2016). Evaluation of turmeric (Curcuma longa) effect on biochemical and pathological parameters of liver and kidney in chicken aflatoxicosis. *Pharmaceutical biology, 54(5), 780-787*

Giannenas, I., Bonos, E., Skoufos, I., Tzora, A., Stylianaki, I., Lazari, D., & Florou-Paneri, P. (2018).Effect of herbal feed additives on performance parameters, intestinal microbiota, intestinal morphology and meat lipid oxidation of broiler chickens. *British Poultry Science, 59(5), 545-553*

Gowda, N. K. S., Ledoux, D. R., Rottinghaus, G. E., Bermudez, A. J., & Chen, Y. C. (2008). Efficacy of turmeric (Curcuma longa), containing a known level of curcumin, and a hydrated sodium calcium aluminosilicate to ameliorate the adverse effects of aflatoxin in broiler chicks. *Poultry Science, 87(6), 1125-1130*

Guo, F. C., Williams, B. A., Kwakkel, R. P., & Verstegen, M. W. (2003).In vitro fermentation characteristics of two mushroom species, an herb, and their polysaccharide fractions, using chicken cecal contents as inoculum. *Poultry Science, 82(10), 1608-1615*

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

Hossain, M. A., Islam, A. F., & Iji, P. A. (2013). Growth responses, excreta quality, nutrient digestibility, bone development and meat yield traits of broiler chickens fed vegetable or animal protein diets. *South African Journal of Animal Science*, *43*(2), 208-218

Hossain, M. M., Howlader, A. J., Islam, M. N., & Beg, M. A. H. (2014). Evaluation of locally available herbs and spices on physical, biochemical and economical parameters on broiler production. *International Journal of Plant, Animal and Environmental Sciences, 4(1), 317-323*

Hugo, W. B. (1998). Mode of action of non-antibiotic antibacterial agents,"Hugo WB, Russell AD (eds). *Pharmaceutical Microbiology, 6. Baskı" Kitabında s. 256-62*

Huyghebaert, G., Ducatelle, R., & Van Immerseel, F. (2011).An update on alternatives to antimicrobial growth promoters for broilers. *The Veterinary Journal, 187(2), 182-188*

Isabel, B. A. S. Y., & Santos, Y. (2009). Effects of dietary organic acids and essential oils on growth performance and carcass characteristics of broiler chickens. *Journal of Applied Poultry Research, 18(3), 472-476*

Islam, M. A., Haque, M. E., Shikhauu, M. S. A., Uddin, M. J., Uddin, M. N., Islam, M. T., & Islam, M. S. (2018). Effect of red chili and garlic nutrition as feed additives on growth performance of broiler chicken. *International Journal of Natural and Social Sciences, 5(3), 16-24*

Jamroz, D., & Kamel, C. (2002). Plant extracts enhance broiler performance. In non-ruminant nutrition: Antimicrobial agents and plant extracts on immunity, health and performance

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

Johannah NM, Ashil J, Balu MB, Krishnakumar IM (2018). Dietary addition of a standardized extract of turmeric (TurmaFEEDTM) improves growth performance and carcass quality of broilers. *Journal of Animal Science and Technology., 60: 1-9*

Kanani, P. B., Daneshyar, M., Aliakbarlu, J., & Hamian, F. (2017).Effect of dietary turmeric and cinnamon powders on meat quality and lipid peroxidation of broiler chicken under heat stress condition.*In Veterinary Research Forum (Vol. 8, No. 2, p. 163). Faculty of Veterinary Medicine, Urmia University, Urmia, Iran*

Karaskova, K., Suchy, P.and, Strakova, E. (2015). Current use of phytogenic feed additives in animalnutrition: a review. *Czech Journal of Animal Science, 60 (12): 521-530*

Khoobani, M., Hasheminezhad, S. H., Javandel, F., Nosrati, M., Seidavi, A., Kadim, I. T., & Tufarelli, V. (2019). Effects of dietary chicory (Chicorium intybus L.) and probiotic blend as natural feed additives on performance traits, blood biochemistry, and gut microbiota of broiler chickens. *Antibiotics, 9(1), 5*

Kirkpinar, F. I. G. E. N., Ünlü, H. B., Serdaroğlu, M., & Turp, G. Y. (2014).Effects of dietary oregano and garlic essential oils on carcass characteristics, meat composition, colour, pH and sensory quality of broiler meat. *British Poultry Science, 55(2), 157-166*

Kirubakaran, A., Moorthy, M., Chitra, R., & Prabakar, G. (2016). Influence of combinations of fenugreek, garlic, and black pepper powder on production traits of the broilers. *Veterinary World, 9(5), 470*

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

Lal, B., Kapoor, A. K., Asthana, O. P., Agrawal, P. K., Prasad, R., Kumar, P., & Srimal, R. C. (1999). Efficacy of curcumin in the management of chronic anterior uveitis. *Phytotherapy Research: An International Journal Devoted to Pharmacological and Toxicological Evaluation of Natural Product Derivatives, 13(4), 318-322*

Lavinia, S., Gabi, D., Drinceanu, D., Stef, D., Daniela, M., Julean, C., Ramona, T., Corcionivoschi, N. (2009). The effect of medicinal plants and plant extracted oils on broiler duodenum morphology and immunological profile. *Romanian Biotechnological Letters, 14: 4606-4614*

Laxminarayan, R., Van Boeckel, T., & Teillant, A. (2015). The economic costs of withdrawing antimicrobial growth promoters from the livestock sector

Lee, K. W., Everts, H., & Beynen, A. C. (2004).Essential oils in broiler nutrition. *International Journal of Poultry Science, 3(12), 738-752*

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

Li, H. L., Zhao, P. Y., Lei, Y., Hossain, M. M., & Kim, I. H. (2015). Phytoncide, phytogenic feed additive as an alternative to conventional antibiotics, improved growth performance and decreased excreta gas emission without adverse effect on meat quality in broiler chickens. *Livestock Science, 181, 1-6*

Li, M., Lin, H., Jing, Y., & Wang, J. (2020). Broad-host-range Salmonella bacteriophage STP4-a and its potential application evaluation in poultry industry. *Poultry Science, 99(7), 3643-3654*

Madhupriya, V., Shamsudeen, P., Manohar, G. R., Senthilkumar, S., Soundarapandiyan, V., & Moorthy, M. (2018). Phyto feed additives in poultry nutrition: A review. *International Journal of Science and Environmental Technology, 7(3), 815-822*

Madigan, M. T., Martinko, J. M., & Parker, J. (2006). *Brock Biology of Microorganisms (Vol. 11, p. 136). Upper Saddle River, NJ: Pearson Prentice Hall*

Madrid, J., Hernandez, F., Garcia, V., Orengo, J., Megias, M. D., & Sevilla, V. (2003, August). Effect of plant extracts on ileal apparent digestibility and carcass yield in broilers at level of farm. *Poultry Nutrition, Lillehammer, Norway (pp. 187-188)*

Marshall, B. M., & Levy, S. B. (2011). Food animals and antimicrobials: impacts on human health. *Clinical Microbiology Reviews, 24(4), 718-733*

Marzoni, M., Castillo, A., Franzoni, A., Nery, J., Fortina, R., Romboli, I., & Schiavone, A. (2020). Effects of Dietary Quebracho Tannin on Performance traits and parasite load in an Italian Slow-growing Chicken (White Livorno breed). *Animals, 10(4), 684*

Mathew, A. G., Liamthong, S., Lin, J., & Hong, Y. (2009).Evidence of class 1 integron transfer between Escherichia coli and Salmonella spp. on livestock farms. *Foodborne Pathogens and Disease, 6(8), 959-964*

Mehala, C., & Moorthy, M. (2008). Production performance of broilers fed with Aloe vera and Curcuma longa (Turmeric). *International Journal of Poultry Science, 7(9), 852-856*

Mehdipour, Z., Afsharmanesh, M., & Sami, M. (2013).Effects of dietary synbiotic and cinnamon (Cinnamomum verum) supplementation on growth performance and meat quality in Japanese quail. *Livestock Science, 154(1-3), 152-157*

Mekonnen, M. M., Neale, C. M., Ray, C., Erickson, G. E., & Hoekstra, A. Y. (2019).Water productivity in meat and milk production in the US from 1960 to 2016. *Environment International, 132, 105084*

Mirzaei-Aghsaghali, A. (2012). Importance of medical herbs in animal feeding: A review. *Annual Biology, 3(9), 3-933*

Mitsch, P., Zitterl-Eglseer, K., Kohler, B., Gabler, C., Losa, R. and Zimpernik, I. (2004). The effect of two different blends of essential oil components on the proliferation of Clostridium perfringens in the intestines of broiler chickens. Poult Sci, 83: 669–75

Mohamed E, Mohamed T, Heba M, Amira M, Mohamed M, Gehan BA, et al., (2022) . Alternatives to antibiotics for organic poultry production: types, modes of action and impacts on bird's health and production. *Poultry Science*

Mountzouris, K. C. (2016). Phytogenic and probiotic feed additives for broilers: Evidence for growth performance links with gut performance indices. *In Proceedings of the 2016 World Nutrition Forum. Austria (pp. 107-116)*

Mpofu, D. A., Marume, U., Mlambo, V., & Hugo, A. (2016).The effects of Lippia javanica dietary inclusion on growth performance, carcass characteristics and fatty acid profiles of broiler chickens. *Animal Nutrition, 2(3), 160-167*

Muanda, F., Koné, D., Dicko, A., Soulimani, R., & Younos, C. (2011). Phytochemical composition and antioxidant capacity of three malian medicinal plant parts. *Evidence-Based Complementary and Alternative Medicine, 2011*

Muhl, A., & Liebert, F. (2007). Growth, nutrient utilization and threonine requirement of growing chicken fed threonine limiting diets with commercial blends of phytogenic feed additives. *The Journal of Poultry Science, 44(3), 297-304*

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

Najeeb, A. P., Mandal, P. K., & Pal, U. K. (2014). Efficacy of fruits (red grapes, gooseberry and tomato) powder as natural preservatives in restructured chicken slices. *International Food Research Journal, 21(6)*

Nakatani, N. (1997). Antioxidants from spices and herbs. *Natural Antioxidants: Chemistry, Health Effects, and Applications, 64-75*

Namagirilakshmi, S. (2005).Turmeric (Curcuma longa) as nutraceutical to improve broiler performance. *MV Sc. Disease Virus*

Nascimento, G. M., Cervi, R. C., Santos, J. B. D., Mota, B. D. P., Leonídio, A. R. A., Leandro, N. S. M. & Andrade, M. A. (2019). Effects of Curcuma longa on the intestinal health of chicks infected with Salmonella Typhimurium. *Revista Brasileira de Zootecnia*, *48*

Nouzarian, R., Tabeidian, S. A., Toghyani, M., Ghalamkari, G., & Toghyani, M. (2011).Effect of turmeric powder on performance, carcass traits, humoral immune responses, and serum metabolites in broiler chickens. *Journal of Animal Feed Science, 20(3), 389-400*

Osawa, T., Sugiyama, Y., Inayoshi, M., & Kawakishi, S. (1995).Antioxidative activity of tetrahydrocurcuminoids. *Bioscience, Biotechnology, and Biochemistry, 59(9), 1609-1612*

Park, B. S. (2008). Effect of dietary cinnamon powder on savor and quality of chicken meat in broiler chickens. *Journal of the Korean Society of Food Science and Nutrition, 37(5), 618-624*

Partovi, R., Seifi, S., Pabast, M., Mohajer, A., & Sadighara, P. (2020). Effect of dietary supplementation of nanocurcumin on oxidant stability of broiler chicken breast meat infected with Eimeria species.*In Veterinary Research Forum (Vol. 11, No. 2, p. 159). Faculty of Veterinary Medicine, Urmia University, Urmia, Iran*

Pashtetsky, V., Ostapchuk, P., Il'yazov, R., Zubochenko, D., & Kuevda, T. (2019, October).Use of antioxidants in poultry farming.*In IOP Conference Series: Earth and Environmental Science (Vol. 341, No. 1, p. 012042). IOP Publishing*

Petracci, M., Mudalal, S., Soglia, F., & Cavani, C. (2015).Meat quality in fast-growing broiler chickens. *World's Poultry Science Journal, 71(2), 363-374*

Prasad, S., & Aggarwal, B. B. (2011).Turmeric, the golden spice. *Herbal Medicine: Biomolecular and Clinical Aspects. 2nd edition*

Puvaca, N., Ljubojevic, D., Kostadinovic, L. J., Levic, J., Nikolova, N., Miscevic, B., & Popovic, S. (2015). Spices and herbs in broilers nutrition: hot red pepper (Capsicum annuum L.) and its mode of action. *World's Poultry Science Journal, 71(4), 683-688*

Puvaca, N., Ljubojevic, D., Kostadinović, L. J., Lukac, D., Levic, J., Popovic, S., & Duragic, O. (2015). Spices and herbs in broilers nutrition: Effects of garlic (Allium sativum L.) on broiler chicken production. *World's Poultry Science Journal, 71(3), 533-538*

Qasem, M., Alhajj, M., El Nabi, G., & Al-Mufarrej, S. (2015). Effects of turmeric powder as a dietary supplement on performance indicators and immune responses in broiler chickens. *Journal of Animal Veterinary Science, 14(2), 30-35*

Raghdad, A. and Al-Jaleel, A. (2012).Use of turmeric (Curcuma longa) on the performance and some physiological traits on the broiler diets.*The Iraqi Journal of Veterinary Medicine, 36 (1): 51-57*

Rahim, A., Mirza A., Aghazadeh and Daneshyar, M. (2011). Growth performance and some carcass characteristics in broiler chickens supplemented with Thymus extract (Thymus vulgaris) in drinking water. *Journal American Science, 7(11): 400-405*

Remignon, H., & Le Bihan-Duval, E. (2003). 4 Meat Quality Problems Associated with. *Poultry genetics, breeding and biotechnology*, 53

Ricke, S. C., Dittoe, D. K., & Richardson, K. E. (2020). Formic acid as an antimicrobial for poultry production: A review. *Frontiers in Veterinary Science, 7, 563*

Ricke, S. C., Richardson, K., & Dittoe, D. K. (2019).Formaldehydes in feed and their potential interaction with the poultry gastrointestinal tract microbial community–a review. *Frontiers in Veterinary Science, 6, 188*

Roofchaee, A., Irani, M., Ebrahimzadeh, M. A., & Akbari, M. R. (2011).Effect of dietary oregano (Origanum vulgare L.) essential oil on growth performance, cecal microflora and serum antioxidant activity of broiler chickens. *African Journal of Biotechnology, 10(32), 6177-6183*

Sadeghi, A. A., & Moghaddam, M. (2018). The effects of turmeric, cinnamon, ginger and garlic powder nutrition on antioxidant enzymes' status and hormones involved in energy metabolism of broilers during heat stress. *Iranian Journal of Applied Animal Science, 8(1), 125-130*

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

Samarasinghe, K., Wenk, C., Silva, K. F. S. T., & Gunasekera, J. M. D. M. (2003). Turmeric (Curcuma longa) root powder and mannanoligosaccharides as alternatives to antibiotics in broiler chicken diets. *Asian-Australasian Journal of Animal Sciences, 16(10), 1495-1500*

Sampath, H. K. R., & Atapattu, N. S. B. M. (2013). Effects of cinnamon (Cinnamomum zeylanicum) bark powder on growth performance, carcass fat and serum cholesterol levels of broiler chicken

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

Sarica, S., Corduk, M., Yarim, G. F., Yenisehirli, G., & Karatas, U. (2009). Effects of novel feed additives in wheat based diets on performance, carcass and intestinal tract characteristics of quail. *South African Journal of Animal Science, 39(2), 144-157*

Schneitz, C., & Hakkinen, M. (2016).The efficacy of a commercial competitive exclusion product on Campylobacter colonization in broiler chickens in a 5-week pilot-scale study. *Poultry Science, 95(5), 1125-1128*

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

Simsek, U. G., Ciftci, M., OZÇELİK, M., Azman, M. A., Tonbak, F., & OZHAN, N. (2015).Effects of cinnamon and rosemary oils on egg production, egg quality, hatchability traits and blood serum mineral contents in laying quails (Coturnix coturnix Japonica). *Ankara Universitesi Veteriner Fakültesi Dergisi, 62(3), 229-236*

Singh, J., Sethi, A. P. S., Sikka, S. S., Chatli, M. K., & Kumar, P. (2014).Effect of cinnamon (Cinnamomum cassia) powder as a phytobiotic growth promoter in commercial broiler chickens. *Animal Nutrition and Feed Technology, 14(3), 471-479*

Singh, V.K., Chauhan, S.S., Ravikanth, K. Maini, S.and Rekhe, D.S. (2009). Effect of dietary supplementation of polyherbal liver stimulant on growth performance and nutrient utilization in broiler chicken.*Veterinary World, .2 (9): 350-352*

Sorum, H., & Sunde, M. (2001).Resistance to antibiotics in the normal flora of animals. *Veterinary Research, 32(3-4), 227-241*

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

Steiner, T. (2006). The potential benefits of Natural Growth Promoters." *Feed Technology, 10.2: 26– 28*

Suganya, T., Senthilkumar, S., Deepa, K., Muralidharan, J., Gomathi, G., & Gobiraju, S. (2016). Herbal feed additives in poultry. *International Journal of Science and Environmental Technology, 5(3), 1137-45*

Sugiharto, S., Pratama, A. R., Yudiarti, T., Wahyuni, H. I., Widiastuti, E., & Sartono, T. A. (2020).Effect of acidified turmeric and/or black pepper on growth performance and meat quality of broiler chickens. *International Journal of Veterinary Science and Medicine, 8(1), 85-92*

Svitakova, A., Schmidova, J., Pesek, P., & Novotna, A. (2014). Recent developments in cattle, pig, sheep and horse breeding-a review. *Acta Veterinaria Brno*, *83*(4), 327-340

Swain, P. S., Rao, S. B., Rajendran, D., Dominic, G., & Selvaraju, S. (2016). Nano zinc, an alternative to conventional zinc as animal feed supplement: A review. *Animal Nutrition, 2(3), 134-141*

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

Tipu, M. A., Akhtar, M. S., Anjum, M. I., & Raja, M. L. (2006).New dimension of medicinal plants as animal feed. *Pakistan Veterinary Journal, 26(3), 144-148*

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

Tonbak, F., & Ciftci, M. (2012). Effects of cinnamon oil (Cinnamomum zeylanicum L.) supplemented to ration on growth performance and carcass characteristics in heat-stressed Japanese quails. *Saglık Bilimleri Veteriner Dergisi, Fırat Universitesi, 26(3), 157-164*

Torki, M., Akbari, M., & Kaviani, K. (2015). Single and combined effects of zinc and cinnamon essential oil in diet on productive performance, egg quality traits, and blood parameters of laying hens reared under cold stress condition. *International Journal of Biometeorology, 59(9), 1169-1177*

Torres-Pitarch, A., Manzanilla, E. G., Gardiner, G. E., O'Doherty, J. V., & Lawlor, P. G. (2019). Systematic review and meta-analysis of the effect of feed enzymes on growth and nutrient digestibility in grow-finisher pigs: Effect of enzyme type and cereal source. *Animal Feed Science and Technology, 251, 153-165*

Urusan, H., & BOLUKBASI, C. (2020). The Influence of Turmeric Powder (Curcuma longa) on Fatty Acid Composition and Shelf Life of Broiler Chicken Meat. *Alinteri Journal of Agriculture Science, 35(1), 29-35*

Van Boeckel TP, Charles B, Marius G, Bryan TG, Simon AL, Timothy PR, et al., (2015). Global trends in antimicrobial use in food animals. *Academic Science, USA*

Vandergrift, B. (1998). Biotechnology in the feed industry. *Altech's 14th Annual Symposium Altech Technical Publications Nottingham University Press. Nicholasville. KY pp (pp. 293-300)*

Wenk, C. (2000). Why all the discussion about herbs? *In the Feed Industry, 2000 (pp. 79-96). Nottingham University Press*

Wuthi-Udomlert, M., Grisanapan, W., Luanratana, O., & Caichompoo, W. (2000).Antifungal activity of Curcuma longa grown in Thailand. *The Southeast Asian Journal of Tropical Medicine and Public Health, 31, 178-182*

Yaghobfar, A., Hosseini-Vashan, S. J., Golian, A., Nassiri, M. R., & Raji, R. (2011). Evaluation of turmeric powder in diets based soybean oil on performance, energy and protein efficiency ratio and immune system of broiler chicks. *In Researches of the first International Conference, Babylon and Razi Universities*

Yarru, L. P., Settivari, R. S., Gowda, N. K. S., Antoniou, E., Ledoux, D. R., & Rottinghaus, G. E. (2009). Effects of turmeric (Curcuma longa) on the expression of hepatic genes associated with biotransformation, antioxidant, and immune systems in broiler chicks fed aflatoxin. *Poultry Science, 88(12), 2620-2627*

Zhai, H., Liu, H., Wang, S., Wu, J., & Kluenter, A. M. (2018). Potential of essential oils for poultry and pigs. *Animal Nutrition, 4(2), 179-186*

Zhang, J. F., Bai, K. W., Su, W. P., Wang, A. A., Zhang, L. L., Huang, K. H., & Wang, T. (2018). Curcumin attenuates heat-stress-induced oxidant damage by simultaneous activation of GSH-related antioxidant enzymes and Nrf2-mediated phase II detoxifying enzyme systems in broiler chickens. *Poultry Science, 97(4), 1209-1219*

Zhang, K.Y., Yan, F., Keen, C.A. and Waldroup, P.W. (2005).Evaluation of microencapsulated essential oils and organic acids in diets for broiler chickens. *International Journal of Poultry Science. 4 (9), 612-619*

Chapter-VIII

Appendix

Table 1: Cost of production and profit of broiler chicken fed herbal diet

Items/parameters	Dietary treatments			
	T_1	T_2	T_3	T_4
Live weight (kg/b) on the last day of trial (33th day)	1.77	1.83	1.79	1.81
Livability (%) at the end of trial	86	100	89	93
No. of birds' survivability / treat.	23	28	22	27
Feed intake (kg/b) on 33thday	2.172	2.299	2.172	2.235
Feed cost (Tk/kg) on an average	63.6	63.6	63.6	63.6
Total Feed intake (kg)	49.956 kg (23 birds @2.172kg)	64.372 kg (28 birds @2.299 kg)	47.784 kg (22 birds@2.172 kg)	60.345kg (27 bird @ 2.235 kg)
Total Feed cost (Tk)	49.956 ×63.6=3177.20Tk @ 63.6Tk	64.372 ×63.6=4094.06 Tk @ 63.6 Tk	47.784 ×63.6=3039.06Tk @ 63.6 Tk	60.345× 63.6= 3837.94Tk @ 63.6 Tk
Total live weight (kg) of birds per treatment	23 ×1.77=40.71 kg	28 × 1.83 =51.24 kg	22 ×1.79=39.38 kg	27 ×1.81=48.87 kg
A). Feed cost (Tk/kg live weight)	3177.20/40.71= 78.04	4094.06/51.24= 79.90	3039.06/39.38= 77.17	3837.94/48.87= 78.53
Day-old chick cost (Tk/bird)	36.0	36.0	36.0	36.0
B). Day-old chick cost (Tk/kg live bird)	36/1.77= 20.34	36/1.83= 19.67	36/1.79= 20.11	36/1.81=19.88
Other costs include:				
i) Vaccination cost (Tk)	400	400	400	400
ii) Medication cost(Tk)	170	170	170	170
iii) Disinfectant cost (Tk)	80	80	80	80
iv) Bulb & wire cost(Tk)	150	150	150	150
v) Water & Electricity cost(Tk)	100	100	100	100
vi) Transport cost(Tk)	400	400	400	400
vii) Cost of product supplementation(Tk)	0.0	2.5	3.0	3.5
Total other cost (Tk) [i…..vii]	1300	1302.5	1303	1303.5
Other costs (Tk/kg live wt)	1300/40.71= 31.93	1302.5/51.24= 25.42	1303/39.38= 33.09	1303.5/48.87= 26.67
C). Other cost (Tk/kg live weight)	31.93	25.42	33.09	26.67
D).Total production cost (Tk / kg live wt.) [A+B+C]	130.31	125.00	130.11	125.08
E). Selling live bird market price (Tk /kg live bird)	140.00	140.00	140.00	140.00
Profit (Tk/kg live bird) [E-D]	9.69	15.00	9.90	14.92

Table 2: Feed intake of Broilers

Treatment	FI d4-11(g/b)	FI d4-18(g/b)	FI d4-25(g/b)	FI d4-32(g/b)
T1	194	626.2857	1368	2385.714286
T1	171	589.7143	1236.047619	2070.714286
T1	174	568.2857	1180.285714	2062.285714
T1	175	576.8571	1257.142857	2167.142857
T2	170	573.1429	1322.857143	2327.714286
T2	194	637.1429	1380.857143	2362.285714
T2	180	586	1301.714286	2233.714286
T2	178	607.4286	1352.857143	2271.714286
T3	186	600.2857	1338.857143	2179.857143
T3	166	552.2857	1213.714286	2102.571429
T3	167	557.1429	1235.97619	2109.77619
T3	170	586.5714	1335.714286	2295.380952
T4	177	612.2857	1354.571429	2336
T4	166	564.8571	1206.571429	2094.857143
T4	173	603.7143	1316.857143	2258
T4	172	577.4286	1245.095238	2249.761905

Table 3: Water intake of Broilers

Treatment	WI(ml/b) d4-10	WI(ml/b) d11-17	WI(ml/b) d18-24	WI(ml/b) d25-31
T1	616.643	1099.429	1815.407	3016.522
T2	572.071	1082.357	1778.429	2514.143
T3	572.286	1098.714	1760.148	3105.364
T4	575.714	1075.143	1687.333	2581.111

Table 4: Feed conversion ratio (FCR) of Broilers

Treatment	FCR-d11	FCR-d18	FCR-d25	FCR-d32
T1	1.23589	1.31377095	1.44545667	1.51201737
T1	1.2200315	1.35718781	1.54952314	1.66450229
T1	1.2155039	1.34594094	1.67005629	1.68094907
T1	1.2670957	1.36018509	1.55540212	1.69637224
T2	1.2379421	1.34964357	1.50674038	1.57686793
T2	1.2270115	1.24477979	1.51995245	1.6019984
T2	1.2818471	1.36390679	1.49160656	1.63706882
T2	1.1796009	1.26339135	1.4673547	1.60344553
T3	1.2515152	1.37610945	1.53068662	1.69148802
T3	1.2131902	1.31912826	1.56523617	1.67786899
T3	1.2658333	1.36316358	1.7781475	1.61303549
T3	1.2251392	1.36506941	1.48243533	1.58412128
T4	1.2298762	1.22085211	1.47947108	1.52848783
T4	1.2019078	1.31935683	1.55062175	1.74337577
T4	1.2195313	1.2085476	1.48507905	1.61078905
T4	1.2294304	1.36321142	1.57723577	1.62795126

Table 5: Livability (%) of Broilers

Treatment	1st wk	2nd wk	3rd wk	4th wk
T1	100	100	100	86.71
T1	100	100	85.71	86.71
T1	100	100	100	86.71
T1	100	100	85.71	86.71
T2	100	100	100	100
T2	100	100	100	100
T2	100	100	100	100
T2	100	100	100	100
T3	100	100	85.71	85.71
T3	100	100	85.71	85.71
T3	100	100	85.71	71.43
T3	100	100	100	71.43
T4	100	100	85.71	85.71
T4	100	100	100	85.71
T4	100	100	100	100
T4	100	100	100	100

Table 6: Meat yield traits of Broilers

Treat.	Dress%	Brst%	Drum%	Thigh%	Shank%	Wing%	Back%	Head%	Neck%
T1	62.53575	20.019066	8.770257	8.865586	4.242135	6.387035	12.29743	2.764538	6.387035
T1	62.74864	23.960217	8.137432	8.047016	4.068716	5.786618	11.39241	2.260398	5.786618
T2	64.35955	24.359551	9.707865	9.348315	4.314607	5.752809	11.41573	3.146067	5.752809
T2	63.38475	24.77314	8.575318	9.346642	4.219601	6.442831	12.25045	2.359347	6.442831
T3	58.98367	21.869328	8.62069	8.348457	3.901996	5.626134	10.43557	2.450091	5.626134
T3	62.53746	23.376623	8.991009	9.340659	4.095904	6.193806	10.18981	2.297702	6.193806
T4	61.51762	23.215899	8.852755	9.033424	4.065041	5.96206	11.11111	2.529359	5.96206
T4	61.13886	23.276723	8.791209	8.491508	4.195804	5.794206	10.38961	2.697303	5.794206

Brief Bio-data of the Author

Md. Nahid Imtiaz Chowdhury, was born on October 28, 1996, in the Gaibandha district of Bangladesh. He is the son of Md. Zahedul Mowla Chowdhury and Mst. Nasrin Motahara Banu. In 2011, he earned his Secondary School Certificate (SSC) from Osmanpur High School in Ghoraghat, Dinajpur. In 2013, he got his Higher Secondary School Certificate (HSC) from Cantonment Public School and College in Parbatipur, Dinajpur. He recieved his Doctor of Veterinary Medicine (DVM) degree from Chattogram Veterinary and Animal Sciences University (CVASU) in Bangladesh in 2019 (held in 2020) with a CGPA of 3.58. (Out of 4.00). Now, he is a candidate of Master of Science in Poultry Science at the Department of Dairy and Poultry Science, CVASU. The author got a scholarship from NST for his MS research. He wants to work in the field of Poultry Science immensely.