**Chapter 1: Introduction**

Bangladesh, in 2018 for the first time in history, has fulfilled the eligibility criteria set forth by the United Nations (UN) to be recognized as a developing country. In July, 2015, Bangladesh transitioned from a low income to a lower-middle income country. This distinction, based on the per capita income of a country, is used by the World Bank. Poultry industry has undergone a significant transformation from a backyard, peasant and subsistence husbandry to a modern large scale and commercial production. One of the major challenges for poultry farmers is to improve performance of the birds to ensure better net returns while minimizing cost of production particularly that spent on feed. (Payne, 1990) observed that the increasing worldwide need for energy and protein sources for ration formulation for poultry may in the long run delay or even halt the complete industrialization of the poultry industry. It is in light of this that efforts are geared towards investigation into the utilization of some cheap and readily available alternative sources of some energy and protein feed stuffs for mono-gastric animals. This has been the main focus of animal nutritionist in the country. The search was precipitated by high cost of most conventional feedstuffs which have always been in high demand by humans. A lot of research and production strategies have been employed, including the use of antibiotics to achieve this aim (Kehinde *et al*., 2013; [Fakhim *et al*., 2013).](https://scialert.net/fulltextmobile/?doi=ajpsaj.2015.242.249#1493545_ja)The use of antibiotics in poultry industry as feed additives and treatment of infection for many years have caused microbiological and clinical evidence of resistant bacteria that might be zoonotic resulting in infections that are more difficult to treat. Owing to grow concern of this health implication, the use of antibiotics has been banned in many countries. Consequently, there is an increasing interest in finding alternatives to antibiotics in poultry production.

Herbs, spices and plant extracts can be valuable alternatives for the health and nutrition of the chicken (Dhama *et al*., 2015). (Puvaca *et al*., 2013) noted that phyto additives in animal nutrition have attracted attention for their potential role as alternative to antibiotic growth promoter. Some leaf meal/extracts which have been used as growth promoter in broiler chicken include *Moringa olerifera* (Kakengi *et al*., 2007; Portugaliza and Fernandez, 2012), lemon grass leaf (Mmereole, 2010), pawpaw leaf and bitter leaf (Oleforuh-Okoleh *et al*., 2015). Another plant leaf which could be of importance is the banana leaf (*Musa parasidica*).

*Musa paradisiaca* and *Musa sapientum* (Musaceae) are mainly grown in the tropical and subtropical countries and are widely used for its nutritional values all over the world. In different countries about 300 varieties of bananas are grown, of which a vast majority have been growing in Asian, Indo-Malaysian and Australian tropics and are now widely found throughout the tropical and subtropical countries. India, China, Philippines, Ecuador, Brazil, Indonesia, Mexico, Costa Rica, Colombia, Thailand are the top banana producing countries. It is extensively grown and cultivated as a fruit plant all over Bangladesh. The banana grows almost everywhere in the country throughout the year. The principal banana growing areas however, are Rangamati, Barisal, Rangpur, Dinajpur, Noakhali, Faridpur and Khulna (Rahman and Kabir, 2003).

Banana leaves are the unconventional animal feed which is available everywhere in the world. The leaf contains 85% water, 10-17% crude protein, 27.9% crude fibre, and 7.7% ether extract on dry matter basis (Dubale, 2017; [Marin *et al*., 2003)](https://scialert.net/fulltextmobile/?doi=ajpsaj.2015.242.249#1493572_ja). Banana leaf contains large amounts of polyphenols, including epigallocatechin gallate. They also contain polyphenol oxidase, an enzyme that produces l-3, 4-dihydroxyphenylalanine ([Chu *et al*., 1993](https://scialert.net/fulltextmobile/?doi=ajpsaj.2015.242.249#1493541_ja)).

The use of banana as a medicinal plant has been reported as an anti hyperglycemic agent ([Ray, 2013](https://scialert.net/fulltextmobile/?doi=ajpsaj.2015.242.249#79913_an)), a natural eraser, treatment of kidney ailments ([Kailash and Varalakshmi, 1992](https://scialert.net/fulltextmobile/?doi=ajpsaj.2015.242.249#1493584_ja)) and as laxatives and antihypertensive. (Bera *et al*., 2013) noted that several oligosaccharides comprising fructose, xylose, galactose, glucose and mannose occur naturally in banana, making it an excellent prebiotic for the selective growth of beneficial bacteria in the intestine. Banana fruit has been reported to prevent anemia by stimulating the production of hemoglobin in the blood. It has been reported that banana leaves were a good source of lignin. Leaf blade and leaf sheaths have a high content of pentosan, as well as cellulose (20.4 – 37.3%) (Mohapatra *et al*., 2010). Moreover, protein content in leaf blade was also substantial. Hence, banana leaves could be an ideal substitute of roughage for cattle. To improve the digestibility of banana leaves, addition of protein extract has been commonly practiced in ruminants (Katangole *et al*., 2008). However, information about the utilization of banana leaf for broiler chickens was not available in the literature to date. Probably, the high content of cellulose in the leaf limits the utilization of such stuff in broiler ration.

**1.1 Scope of the study**

The study was done for development of sustainable feeding strategy to use various levels of banana leaf for the improvement of production performance and carcass characteristics in commercial broiler. By the study of the feasibility and effectiveness of using higher levels of banana leaf in diets of broiler chickens than that of traditional levels and to elucidate possible problems that might be associated with such practice in Bangladesh. Study on banana leaf as poultry feed was done based on following objectives:

**Objectives**

* To investigate the efficacy of banana leaf as a growth and health promoter for broiler chickens.
* To assess the economic benefit of using banana leaf for least cost ration formulation for broiler

**Chapter-2: Review of Literature**

**2.1 Present situation of poultry sector in Bangladesh**

As we know poultry industry includes both the layer farms and broiler farms in the country. Large numbers of farms in different sizes are operating all over the country. The poultry industry was hit by bird flu in 2007, 2009 and 2011. The number of firms reduced to 55,000 in 2013 from 115,000 in 2007 due to outbreak of diseases along with other problems. Another source reported that there are about 65,902 poultry farms up to February 2013 in the country. In two years since 2011, nearly 25,000 farms were closed mainly due to the outbreak of the diseases (Daily Star, 2013).There are 6 Grand Parent farms which supply 80% of the total demand for parent stock and rest20% are imported. In the country 82 parent stock farms are operating and of producing 55-60lakh DOC of broiler and 5 lakh Layer DOC per week. Table2.1 reveals that the highest consumption of egg per head per year was highest (48%) in 2012 that means 53.85% are deficit as compared to minimum requirement of 104 eggs per head peryear.Net availability and per capita consumption of chicken meat and eggs have been increasing from 199596 to 2012-2013. The fall in consumption and availability during 2006-67 to 2008-89could be attributed to outbreak of avian influenza in the country (Daily Star, 2013).

**Table 2.1:** Availability and consumption of meat and eggs in the country

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Year | Populationestimated(million) | Netavailability of meat(metric ton) | Per capitaconsumptionof meat (kg.) | Netavailability ofeggs(millionnumber) | Per capita consumptionof eggs(no.) |
| 1997-98  | 126.5 | 639 | 5.1 | 3691 | 29 |
| 1998-99  | 128.2 | 656 | 5.1 | 3926 | 31 |
| 1999-00  | 129.8 | 673 | 5.2 | 4177 | 32 |
| 2000-01  | 129.9 | 693 | 5.3 | 4446 | 34 |
| 2001-02  | 131.6 | 867 | 6.7 | 4446 | 33.8 |
| 2002-03  | 133.4 | 935.6 | 6.9 | 7026.0 | 52.0 |
| 2003-04  | 135.2 | 1020.2 | 7.4 | 8037.9 | 58.7 |
| 2004-05  | 137.0 | 1166.1 | 8.5 | 8037.9 | 58.6 |
| 2005-06  | 138.8 | 1130 | 8.14 | 5422 | 39.06 |
| 2006-07  | 140.6 | 1040 | 7.39 | 5369 | 38.18 |
| 2007-08  | 142.4 | 1040 | 7.30 | 5653.2 | 39.69 |
| 2008-09  | 144.2 | 1084 | 7.52 | 4692 | 32.53 |
| 2009-10  | 146.1 | 1264 | 8.65 | 5742.4 | 39.30 |
| 2010-11  | 149.7 | 1279 | 8.54 | 4211 | 28.12 |
| 2011-12  | 151.6 | 2332 | 15.38 | 7303.8 | 48.17 |
| 2012-13\*  | 153.6 | 2532 | 16.48 | 5134.7 | 33.42 |

Note: 2012-13\* Figures except population refer up to February 2013.
Bangladesh Economic Survey: 2001-02, 2012-13.

**2.2 Contribution of poultry to the society**

Based on this poultry industry a number of industries are developed both in inputs sector and outputs sector along with a number of service providing organizations. Poultry industry contributes 1 percent to the country’s GDP while at least 6million people are involved in the sector, but the industry lacks proper support from the government as claimed by stakeholders. But an opposite picture is seen in Table 2.2.1 Actual production and the expected demand for poultry products are shown in Table 2.2.1.

**Table 2.2.1:** Current demand and production of poultry and poultry products

|  |  |  |  |
| --- | --- | --- | --- |
| **Particulars** | **Production** | **Demand** | **Excess** |
| Poultry meat (tons)/day | 1500 | 1400 | 100 |
| Eggs (crore)/day | 1.6 | 1.5 | 0.1 |
| Chicken (lakh piece) /week | 95 | 85 | 1.0 |

Source: Bangladesh Poultry Association as cited by Moazzem and Raz, 2014

Table 2.2.1 indicates that the country has achieved self-sufficiency in production of poultry products but the local poultry farmers are now facing losses due to lack of coordination between demand and supply (Round table conference, July 9, 2014 Tribune 10 July 2014). It was highlighted that the farmers are incurring losses over few months due to excess production of chicken and egg. Excess production of chicken meat is forecasted by Business Monitor International which is presented in Table 2.2.2.

**Table 2.2.2:** Forecasts of production and consumption of chicken in Bangladesh

|  |  |
| --- | --- |
| **Year** | **Chicken meat (Lakh Ton)** |
| **Production** | **Consumption** | **Excess** |
| 2012 | 1.98 | 1.39 | 0.59 |
| 2013 | 2.04 | 1.44 | 0.60 |
| 2014 | 2.10 | 1.50 | 0.60 |
| 2015 | 2.18 | 1.57 | 0.61 |
| 2016 | 2.25 | 1.64 | 0.61 |
| 2017 | 2.32 | 1.71 | 0.61 |

Source: Ministry of Livestock and Fisheries, Bangladesh.

**2.3 Banana leaf**

Banana plant (Musa spp.) is a tropical plant of Asian origin. There are more than 32 species and100 sub-species of bananas in existence, each with minor morphological differences from the others (Mmereole, 2010). Musa sapientum and Musa parasidica are the most common species. Banana leaves are a by-product of banana production. Banana leaves can be fed to animals in fresh, ensiled or dried form (Ecoport, 2010). The leaves have moderately high CP content (about 17.6%). Banana leaves can be used as supplementary feeds to pasture and crop residue based diets. Whole, fresh banana leaves, stalks and pseudo stems are chopped and directly fed either fresh, sun-dried or ensiled with molasses in many tropical countries. Banana leaves contain about 15 percent DM and 10-17 percent CP. The NDF and ADF vary between 50-70 percent and 30-40 percent, respectively. Banana leaves contain 8 percent polyphenols, but very few condensed tannins (Marie-Magdeleine *et al.,* 2010).The high tannin content of leaves may also be responsible for low digestibility (Marie Magdeleine *et al.,* 2010).

**2.4 Taxonomical classification**Kingdom : *Plantae*Division : *Magnoliophyta*Class : *Liliopsida*Order : *Zingiberales*Family : *Musaceae*Genus : *Musa*Species : *Musa paradisiaca, Musa sapientum*

**2.5 Chemical composition of Banana leaf**

Banana leaf contains large amounts of polyphenols, including epigallocatechin gallate. They also contain polyphenol oxidase, an enzyme that produces l-3, 4-dihydroxyphenylalanine (Chu *et al*., 1993). Presence of tannins, flavonoids and terpenoids enhance resistance to internal parasites (Marie-Magdeleine *et al.,* 2010; Ademola *et al.,* 2005). Banana leaf has the ability to improve carbohydrate metabolism due to the presence of an active phytochemical compound, rutin (quercetin-3-*O-*rutinoside), a flavonol glycoside in the leaf. Reports on benefits of banana include that it contains high levels of fructooligosaccharide (FOS) that along with insulin promotes calcium absorption. The FOS further nourishes healthy bacteria in the colon that manufacture vitamins and digestive enzymes that boost the body's overall ability to absorb nutrients. The leaf has been reported to constitute 85% water and 10-17% protein on dry matter basis (Oleforuh-Okoleh *et al*., 2015). Marin *et al* (2003) reported 14.6% CP, 22-27.9% CF and 3-7.7% EE on dry matter basis. Devendra (1992); (Dixon and Egan, 1987) reported that DM (89-92%), CP (16.1 %), CF (23.7 %), EE (8.4 %), ash (9.4%), NFE (42.2%).

**Table 2.5:** Chemical composition of banana leaf

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Banana leaf | DM (Dry matter basis) | CP | CF | EE | ash |
| Nutrients (%) | 90 | 13.8 | 25 | 4.2 | 8.6 |

DM=Dry matter; CP=Crude protein; EE =Crude fat, CF=Crude fiber

**2.6 Use of banana leaf in animal and poultry diet**

The use of banana leaf has been reported to have a significant effect on the growth, nutrient digestibility and performance of ruminants and pseudo-ruminant such as rabbits (Kimambo and Muya, 1991). Fomunyam, (1984) indicated that banana leaves used as supplement to sheep basal diet of rice straw increased the total feed intake and digestibility as well as rumen ammonia. (Göhl Bo, 1981) reported that banana leaves could be used as emergency feed for ruminants, but that the digestibility decreased as the level of banana leaves increased in the ration. (Foulkes and Preston, 1978) reported that the dry matter of banana leaf was relatively digestible for ruminants, i.e.; 65% digestibility for leaves. However, despite this apparently high DM digestibility, the leaves alone can barely meet the maintenance requirements of ruminants.

**2.7 Inclusion level of banana leaf in animal and poultry diet**

Banana leaf meal (leaves chopped and sun dried) up to 40 percent in the forage based ration on DM basis increased weight gains and feed efficiency of Zebu cattle and sheep (Garcia *et al*., 1973). In an experiment, (Duwa *et al*., 2006) studied the effect of banana peel meal (0, 5 10, and 15 %) and the results showed that the productive performance results indicated high significant (P<0.05) difference in final weight, daily weight gain and feed conversion ratio among the treatment group at different levels of replacement (Oleforuh-Okoleh *et al*., 2015) concluded that banana leaf extract 50g/kg feed increase the growth performance of the broiler

(Abel *et al*., 2015) concluded that banana peel meal can be added up to 10% in broiler chicken diet without any adverse eﬀect on the performance of the birds thus enriching the poultry productions business. (Mandey *et al*., 2015) conducted an experiment on banana leaf and results showed that daily feed intake was significantly affected (P˂0.01) by the dietary treatments, in which feed intake was highest in broilers fed diet containing 10% banana leaves fermented for 10 days. The daily weight gain, feed efficiency and carcass yield were significantly affected (P˂0.01) by the treatments, in which the highest values of daily weight gain, feed efficiency, and carcass yield were observed in birds fed diet containing 10% banana leaves fermented for 10 days. It can be concluded that diet containing 10% banana leaves fermented for 10 days can be included in broiler ration without detrimental effects on the performance and carcass yield.

**2.8 Phytochemicals and bioactive compound in banana plant**

Carbohydrates have been isolated from *M. sapientum* (Anhwange, 2008). Catecholamines such as norepinephrine, serotonin, dopamine, tryptophan, indole compounds (Shanmugavelu and Rangaswami, 1962), pectin have been found in the pulp. Several flavonoids and related compounds (Leucocyanidin, quercetin and its 3 Ogalactoside, 3-O-glucoside, and 3-O-rhamnosyl glucoside) were isolated from the unripe pulp of plantain (Lewis *et al*., 1999; Ragasa *et al.,* 2007). Serotonin, nor-epinephrine, tryptophan, indole compounds, tannin, starch, iron, crystallisable and non-crystallisable sugars, vitamin C, B-vitamins, albuminoids, fats, mineral salts have been found in the fruit pulp of *M. paradisiaca*and *M. sapientum.* Acyl steryl glycosides such as sitoindoside-I, sitoindoside-II, sitoindoside-III, sitoindoside-IV and steryl glycosides such as sitosterolgentiobioside, sitosterol*myo*-inosityl- β-D-glucoside have been isolated from fruits of *M. paradisiacal* (Ghoshal, 1985)*.* Ragasa *et al* (2007) reported the isolation of several triterpenes such as cyclomusalenol, cyclomusalenone, 24- methylenecycloartanol, stigmast-7-methylenecycloartanol, stigmast-7-en-3-ol, lanosterol and β-amyrin. An antihypertensive principle, 7, 8-dihydroxy-3-methylisochroman-4-one, was isolated from the fruit peel of *M. sapientum.* Cycloartane triterpenes such as 3-epicycloeucalenol, 3-epicyclomusalenol, 24- methylene pollinastanone, 28 nor cyclomusalenone, 24-oxo-29- nor cycloartanone have been isolated from the fruit peel of *M.sapientum* (Akihisa *et al.,* 1998). Cellulose, hemicelluloses, arginine, aspartic acid, glutamic acid, leucine, valine, phenylalanine and threonine have been isolated from pulp and peel of *M. paradisiacal* (Ketiku, 1973).

**2.9 Functional properties from different morphological parts of banana plant**

Banana leaves (ashes) are used in eczema, as cool dressings for blister and burns (Ghani, 2003). The fruit of *M. paradisiacal* and *M. sapientum* is traditionally used in diarrhoea (unripe), dysentery, intestinal lesions in ulcerative colitis, diabetes (unripe), in sprue, uremia, nephritis, gout, hypertension, cardiac disease (Ghani, 2003).

Banana is used in the herbal medicine to treat peptic ulcer disease. The use of *M. sapientum*in peptic ulcer as a component of herbal medicine has been evaluated and found effective (Goel and Sairam, 2002). Dunjić *et al.,* 1993) reported that pectin and phosphatidylcholine in green banana strengthens the mucous phospholipid layer that protects the gastric mucosa. They also reported that the gastric mucosa protective activity of the banana is due to multiple active components. Lewis *et al* (1999) reported that a natural flavonoid from the unripe banana (*M. sapientum* var. *paradisiaca*) pulp, leucocyanidin, protects the gastric mucosa from erosions. Leucocyanidin and the synthetic analogues, hydroxyl ethylated leucocyanidin and tetra allylleucocyanidin were found to protect the gastric mucosa in aspirin-induced erosions in rat by increasing gastric mucus thickness (Lewis and Shaw, 2001). Goel *et al* (1986) reported that banana pulp powder (*M. sapientum*var. *paradisiaca*) showed significant antiulcerogenic activity in aspirin-, indomethacin-, phenylbutazone-, prednisolone-induced gastric ulcers and cysteamine- and histamine-induced duodenal ulcers in rats and guinea-pigs, respectively.

Aqueous extract of unripe fruit peels and leaves of *M. paradisiacal* var. *sapientum* has been reported to show antimicrobial activity against *Staphylococcus* and *Pseudomonas* species in dehydrogenase assay (Alisi *et al*., 2008). In this assay the fruit peel extract showed better activity against both the bacteria than leaf extract while the peel extract was more active against *Staphylococcus* (Gram-positive) than *Pseudomonas* species (Gram-negative). However, the alcoholic extract of stem of *M. paradisiacal* showed no activity against *Staphylococcus aureus, Salmonella paratyphi, Shigella dysenteriae, Escherichia coli, Bacillus subtilis, Candida albicans* (Ahmad and Beg, 2001).

The green fruit of *M. paradisiacal* has been reported to have hypoglycemic effect due to stimulation of insulin production and glucose utilization (Ojewole and Adewunmi, 2003). Its high potassium (K) and sodium (Na) content has been correlated with the glycemic effect. Fibers from *M. paradisiacal* fruit increased glycogenesis in the liver and lowered fasting blood glucose (Usha *et al*., 1989). Antihyperglycemic effect of the hydromethanolic extract of *M. paradisiacal* root has been found significant. *Musa sapientum*showed antihyperglycemic effect in hyperglycemic rabbit. The chloroform extract of flowers of *M. sapientum* showed blood glucose and glycosylated haemoglobin reduction and total hemoglobin increase after oral administration in rats. However, *M. paradisiacal* stem juice showed hyperglycemic activity (Singh *et al*., 2007). Isolated pectin from the juice of the inflorescence stalk of *M. sapientum* increases the glycogen synthesis, decreases glycogenolysis and gluconeogenesis.

Hemicellulose and other neutral detergent fibers (NDF) from the unripe *M. paradisiacal* fruit showed low absorption of glucose and cholesterol and low serum and tissue levels of cholesterol and triglycerides (Usha *et al.,* 1984). Flavonoids isolated from unripe fruits showed hypolipidemic activity evidenced by decrease in cholesterol, triglycerides (TG), free fatty acids and phospholipids levels in serum, liver, kidney and brain of rats. The cholesterol lowering effect was attributed to a higher degradation rate of cholesterol than synthesis. The pectin content in the juice of the inflorescence stalk of *M. sapientum* has also been reported to possess cholesterol and triglyceride lowering activity in rats.

The antihypertensive effect of *M. paradisiacal* in albino rats was reported by. Later (Osim and Ibu, 1991) reported that banana diet has a mean arterial blood pressure lowering as well as onset preventing effect in rats with elevated blood pressure induced by desoxycorticosterone acetate (DOCA) administration. Perfumi *et al* (1994) reported that the antihypertensive effect of ripe banana pulp in deoxy corticosterone enantate-induced hypertensive rats which may be due to the high tryptophan and carbohydrate content of banana that increases serotonin levels and gives serotonin-mediated natriorexic effect. However, Orie, (1997) reported that serotonin produced a contraction in place of relaxation in isolated rat aortic rings. The aqueous extract of the ripe *M. paradisiacal* fruit was found to give a concentration-dependent hypotensive effect in both nor adrenaline and potassium chloride-contracted aortic rings isolated from rat. The effect was due to the non-specific interference in calcium ion availability needed for the smooth muscle contraction that results in relaxation. (Saraswathi and Gnanam, 1997) reported that *M. paradisiacal* inhibits cholesterol by crystallization *in vitro* which may have an effect on atherosclerosis plaque and gallstones *in vivo*. Parmar and Kar, (2007) tested the peel extract of *M. paradisiacal* in rats with diet induced atherosclerosis. This study reports the protective role of the extract in atherosclerosis and thyroid dysfunction though it was not very effective like other plants tested. Yin *et al* (2008) further studied the effect of banana in human and found that plasma oxidative stress was significantly reduced and the resistance to oxidative modification of LDL was enhanced only after a single banana meal. The effect may be due to the presence of dopamine, ascorbic acid and other antioxidants present in banana.

Ash of the peel of *M. sapientum* showed an increase in urine volume and K+ as well as other electrolyte excretion than normal saline in a study in rats. Phytochemicals such as saponin, flavonoids and terpenoids are known to be responsible for this effect. Agarwal *et al* (2009) reported the wound healing activity of both methanolic and aqueous extract of plantain banana (*M. sapientum* var. *paradisiaca*) in rats. Both extracts were found to increase hydroxyproline, hexuronic acid, hexosamine, superoxide dismutase as well the wound breaking strength and reduced glutathione level. They also decreased the wound area, scar area and lipid peroxidation. The effects were attributed to the antioxidant property of the plantain.

The stem juice of plantain banana tree (*M. sapientum* var. *paradisiaca*) has been found to induce contraction in skeletal muscles by enhancing excitation-contraction coupling and transmembrane Ca2+ fluxes.

**2.10 Conclusion**

Chemical composition of banana leaf is widely variable. Factors responsible for these variations are discussed. Despite variability, this is a potential source of fiber, crude protein, phosphorus and other trace minerals. Taking into consideration of the nature of variation, inclusion levels and its subsequent consequences on productive performance, carcass characteristics and hemato biochemical parameters in broilers could be explored as a noble study.

**Chapter-3: Materials and Methods**

**3.1 Location of the experiment area**

The experiment was conducted during May to June 2017 in the experimental farm and research laboratories of the Department of Animal Science and Nutrition, Chittagong Veterinary and Animal Sciences University, Khulshi, Chittagong-4225, Bangladesh. May-June is considered as summer season in Bangladesh. During May, average temperature was 31.5oC, average humidity was 82.0% and average precipitation was 184.8 mm. In June average temperature was 32.8o C, humidity was 88.0% and average precipitation was 67.5 mm (BMD, 2015).

**3.2 Preparation of poultry shed for the experiment**

At first, the selected broiler shed was thoroughly washed and cleaned up by using tap water with caustic soda. Brooding boxes and broiler cages were also cleaned by using tap water with caustic soda. Then copper sulphate solution was used as sprayer for 2 days. Formalin solution was also used as disinfectant for two days. After that potassium permanganate solution was used for two days. After cleaning and disinfecting, the house was left for one week for drying. All windows were opened for proper ventilation. After one-week lime was spread on the floor and around the shed for bio-security.

**3.3 Design of the experiment**

The experimental birds were assigned to a Completely Randomized Design. A total of 90 birds were randomly distributed into three dietary treatment groups designated as T0, T1, and T2 and supplemented with 0%, 1%, and 2% banana leaf for T0, T1, and T2 groups, respectively. Each treatment was further divided into three replicates having 10 birds per pen.

**Table 3.3:** Layout of the experiment showing the distribution of day old chicks (DOC) to treatment and replications

|  |  |  |
| --- | --- | --- |
| **Dietary treatment groups** | **No. of broilers/replications** | **Total no. of broilers per treatments** |
| To (control) | R1R2R3 | 101010 | 30 |
| T1 (1%banana leaf) | R1R2R3 | 101010 | 30 |
| T2 (2%banana leaf) | R1R2R3 | 101010 | 30 |
| Grand total |  |  | 90 |

**3.4 Collection of banana leaf and processing**

Banana leaves were collected from banana plant nearby the Veterinary campus. The leaves allowed to sundry for one week. Dried banana leaves were cut into small pieces with scissors and then grinded for fine milled powder in the lab of Department of Animal Nutrition. A proximate composition of banana leaves powder was determined using the analytical methods of (AOAC 1996). The banana leaves powder obtained from the process above was used with other feed ingredients to formulate diets to meet the nutrient requirement of broiler chicken.

**3.5 Collection and brooding of experimental broiler chicks**

A total of 90 day-old chicks (Cobb 500) of mixed sex were purchased from an agent of M .M .AGHA Limited, Chittagong, Bangladesh on May 2018. During purchasing all chicks were examined for any kind of abnormality and uniform size. Average body weight of the chicks was 48.74±0.26 g. The experimental shed was brick cemented with corrugated metal wiring. Floor space for each bird was 0.17 square feet in brooding box and 0.75 square feet in the cage. The pens were selected in an unbiased way for uniform distribution of chicks. The chicks were brooded in the wooden box. After 14 days, birds were transferred to the respective pens. Each pen was allocated for 10 birds. Dry and clean newspaper was placed in the brooding box and changed for every 6 hours. Room temperature and humidity was maintained using 200 watt incandescent lamps and ceiling fans. The birds were exposed to continuous lighting. During brooding period, chicks were brooded at a temperature of 95 °F, 90 °F, 85 °F and 80 °F for the 1st, 2nd, 3rd and 4th weeks, respectively with the help of incandescent bulbs. Temperatures were measured by using thermometer.

**3.6 Feed formulation and feeding diets**

Feed ingredients were purchased from Pahartali market, Chittagong, Bangladesh. During purchase, cleanliness and date of expiry were checked. Banana leaf powder was supplemented at 0%, 1%, 2% to prepare the experimental mash diets. Dry mash was provided to the birds throughout the whole experimental period. Three different types of rations were formulated. Each ration had two different types i.e., starter (0 to 14 days) and finisher (15 to 28 days). All rations were iso-caloric and iso-nitrogenous. The composition of different feed ingredients and nutritive value of starter and grower rations are given in Table 3.6.1 and 3.6.2.

**Table 3.6.1** Ingredient and nutrient composition of the broiler starter ration (0-14 days)

|  |  |
| --- | --- |
| **Ingredients(kg/100kg)** | **Dietary treatments** |
| **T0** | **T1** | **T2** |
| Maize | 50 | 50 | 50 |
| Auto Rice Polish | 4.15 | 3.15 | 2.15 |
| Banana leaf | 00.0 | 1.00 | 2.00 |
| Soybean Meal | 35.50 | 35.5 | 35.4 |
| Full fat Soya | 4.50 | 4.50 | 4.50 |
| Soybean oil | 2.00 | 2.00 | 2.00 |
| Molasses | 0.50 | 0.50 | 0.50 |
| Limestone | 1.50 | 1.50 | 1.50 |
| Salt | 0.30 | 0.30 | 0.30 |
| Vitamin mineral premix | 0.25 | 0.25 | 0.25 |
| DCP | 0.90 | 0.90 | 0.90 |
| L-lysin | 0.10 | 0.10 | 0.10 |
| DL-Methionine | 0.20 | 0.20 | 0.20 |
| Maduramycin | 0.06 | 0.06 | 0.06 |
| Enzyme | 0.025 | 0.025 | 0.025 |
| Antioxidant | 0.012 | 0.012 | 0.012 |
| Total | 100 | 100 | 100 |
| Calculated values |  |  |  |
| Metabolizable Energy (Kcal/kg)  | 2940 | 2928 | 2893 |
| Crude Protein (gm/100gm) | 22.69 | 22.10 | 21.95 |
| Crude Fiber (gm/100gm) | 3.8 | 3.65 | 3.40 |
| Calcium (gm/100gm) | 0.93 | 0.91 | 0.84 |
| Phosphorous (gm/100gm) | 0.75 | 0.73 | 0.75 |
| Lysin (gm/100gm) | 1.38 | 1.34 | 1.28 |
| DL Methionine (gm/100gm) | 0.53 | 0.53 | 0.43 |

T0=Diet without banana leaf powder; T1=Diet containing 1% banana leaf powder; T2=Diet containing 2% banana leaf powder. Vitamin Mineral Premix provided following per kg diet. Vit. A 5000 IU, D3 1000 IU, K 1.6 mg, B1 1 mg, B2 2mg, B3 16 mg, B6 1.6 mg, B9 320 µg, B12 4.8 µg, H 40 mg, Cu 4 mg, Mn 40 mg, Zn 20 mg, Fe 2.4 mg, I 160 µg.

**Table 3.6.2** Ingredient and nutrient composition of the broiler finisher ration (14-28 days)

|  |  |  |  |
| --- | --- | --- | --- |
| **Ingredients (%)** | **T0** | **T1** | **T2** |
| Maize | 53 | 53 | 52.35 |
| Auto Rice Polish | 2.283 | 1.283 | 1.23 |
| Banana leaf | 00.0 | 1.00 | 2.00 |
| Soybean Meal | 33.45 | 33.45 | 32.80 |
| Full fat Soya | 4.50 | 4.50 | 4.50 |
| Soybean oil | 3.00 | 3.00 | 3.00 |
| Molasses | 0.50 | 0.50 | 0.50 |
| Limestone | 1.35 | 1.35 | 1.35 |
| Salt | 0.30 | 0.30 | 0.30 |
| Vitamin mineral premix | 0.25 | 0.25 | 0.25 |
| DCP | 0.90 | 0.90 | 0.90 |
| L-lysin | 0.07 | 0.07 | 0.07 |
| DL-Methionine | 0.20 | 0.20 | 0.20 |
| Toxi mold | 0.05 | 0.05 | 0.05 |
| Maduramycin | 0.05 | 0.05 | 0.05 |
| Enzyme | 0.06 | 0.06 | 0.06 |
| Antioxidant | 0.025 | 0.025 | 0.025 |
| Total | 100 | 100 | 100 |

Calculated values

|  |  |  |  |
| --- | --- | --- | --- |
| Metabolizable Energy (Kcal/kg) | 3019 | 3079 | 2994 |
| Crude Protein (gm/100gm) | 21.92 | 21.32 | 21.12 |
| Crude Fiber (gm/100gm) | 3.27 | 3.70 | 3.25 |
| Calcium (gm/100gm) | 0.85 | 0.77 | 0.67 |
| Phosphorous (gm/100gm) | 0.56 | 0.63 | 0.68 |
| Lysin (gm/100gm) | 1.29 | 1.23 | 1.27 |
| DL Methionine (gm/100gm) | 0.52 | 0.57 | 0.57 |

T0=Diet without banana leaf powder; T1=Diet containing 1% banana leaf powder; T2=Diet containing 2% banana leaf powder; Vitamin Mineral Premix provided following per kg diet: Vit. A 5000 IU, D3 1000 IU, K 1.6 mg, B1 1 mg, B2 2mg, B3 16 mg, B6 1.6 mg, B9 320 µg, B12 4.8 µg, H 40 mg, Cu 4 mg, Mn 40 mg, Zn 20 mg, Fe 2.4 mg, I 160 µg.

**3.7 Feeding Standard**

Feeding standard that had been followed in the experiment was Bangladesh standard specification for poultry feed (2nd Revision, BDS 233: 2003; Bangladesh Standards and Testing Institution). The birds were provided with dry mash feed throughout the experimental period. All the rations were iso-energetic and iso-nitrogenous. Feeds were supplied ad-libitum along with fresh clean drinking water for all the time.

**3.8 Vaccination and Medication**

All birds were vaccinated against Newcastle disease (BCRDV live) and Infectious Bursal Disease on the 4th day followed by a booster dose on 14th day. After each vaccination, multivitamin (Rena-WS, Renata; 1g/ 5liter of drinking water) was supplied along with vitamin-C to overcome the effect of stress due to vaccination and cold shock.

**3.9 Carcass quality examination**

A sample of 9 chicks of each group was slaughtered at the age of 4 weeks for the carcass evaluation. On the day before slaughter, all chickens were fasted over-night, killed the following morning by exsanguinations, scalded in boiling water and manually plucked. The live weight of the chicken was taken before slaughtering. The carcasses were stored at 4°C for 24 h. The legs were cut at the tibio-tarsus-metatarsal articulation and the head was separated from the neck at the cranium-atlas junction. The abdominal and thoracic cavity organs were then removed, as well as the abdominal fat. The carcass weight as well as weights of the waste products and the giblets (head, legs, liver, heart, gizzard and proventriculus) was determined. The various cuts taken were the following: the breast, the whole thigh-drumstick, the wings and the rest of the carcass.

**3.10 Analysis of feed and meat**

From each treatment, 100 g of prepared mash feed was taken and preserved in an air tight bag to carry them in the laboratory for analysis during the experimental period. After slaughter, 120 g of meat was collected in the air tight bag from each carcass for estimation of the chemical composition of meat. Feed and meat samples were dried at 80°C and ground to powder. After drying, chemical analyses of the feed and meat samples were carried out in triplicate for dry matter (DM), crude protein (CP), crud fiber (CF), nitrogen free extracts (NFE), ether extracts (EE) and total ash (TA) in the animal nutrition laboratory, Chittagong Veterinary and Animal Sciences University, Chittagong as per AOAC (2006).

**3.11 Hematological analysis**

Blood samples were collected from the brachial vein of six birds from each group (Two birds from each replicate) using a 3 ml sterile syringe and a 23-gauge needle. Each blood sample was transferred immediately into a sterile tube containing the anticoagulant, ethylene diamine tetra acetic acid. The total red blood cell counts were performed in a 1:200 dilution of blood in Hayem’ssolution.The differential leukocyte counts were determined by preparation of blood smears stained with Wright’s stain. The hemoglobin concentration was estimated by matching acid hematin solution against a standard colored solution found in Sahl’s hemoglobin meter. Packed cell volume was measured after centrifugation of a small amount of blood using micro-hematocrit capillary tubes.

**3.12 Serum analysis**

Blood was collected without anticoagulant from a total of four birds from each group at 21st and 28th days of age. Clotted blood in the vacutainer tube was centrifuged at 3000 rpm for 20 minutes and prepared serum was collected into the ependroff tube by micropipette. Sera samples were marked and stored in -20°C until being analyzed for glucose, total protein, albumin, serum glutamic oxaloacetic transaminase (SGOT), serum glutamate-pyruvate transaminase (SGPT) by Humalyzer 3000 (Semi-automatic, microprocessor-controlled photometer with large graphic LCD screen, Wisbaden, Germany). Randox® veterinary reagent kits were used for determination of the blood parameter of interest. Serum sample was mixed with the respective reagents in an ependroff tube. The serum with reagent was aspired by spectrophotometric method which measured the target parameter and immediately the printed result was recorded.

**3.13 Calculation of data**

**3.13.1 Body weight gain**

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

Body weight gain=final body weight-Initial body weight.

**3.13.2 Feed intake**

Quantity of offered feed was weighed weekly. Refusal feed was recorded to determine the feed intake per week. Feed intake was calculated weekly as gm/bird.

**3.13.3 Feed Conversion Ratio (FCR)**

The amount of feed intake per unit of weight gain is the feed conversion (FC). This was calculated by using following formula.

Feed intake (kg)

 FCR =

Weight gain (kg)

**3.14 Statistical analysis**

Data were compiled in MS Excel. Raw data related to weight gain, feed intake, FCR, carcass characteristics, hematological and biochemical parameters were tested for normality by using normal probability plot and analyzed for ANOVA by using STATA (2017).Means showing significant differences were compared by Duncan’s New Multiple Range Test (Duncan, 1955). Statistical significance was accepted at p<0.05 for F-tests.

**Chapter-4: Results**

The experiment was carried out to investigate the effects of various levels of banana leaf powder on the performance parameters, carcass characteristics and hemato biochemical parameters of Cobb-500 broilers. The results obtained from the present study have been presented in this chapter.

**4.1 Live weight**

The body weights of broiler containing banana leaf at different ages are presented in table 4.1. There was no significant difference in weight of birds among treatment groups in day1 (initial weight) and 2nd week. However, highly significant (P<0.01) differences were observed in live weight among the treatment groups at 1st, 3rd and 4th weeks. Along the whole experimental period, increased body weight was observed in group T1 and T2 compared to the control group. The highest body weight was observed in T2 group and the lowest was observed in control (T0) group although body weight of T1 group showed better result than the control group although it was noted that among the treatment groups, T2 showed the constant higher body weight than T1 and T0 group.

**Table 4.1:** Live weight (g/bird/d) of the experimental broiler birds fed diets supplemented with different levels of banana leaf from 1stto 4th weeks of age

|  |  |  |  |
| --- | --- | --- | --- |
| **Age of birds** | **Dietary treatments** | **SEM** | **­­­****P value** |
| **T0** | **T1** | **T2** |
| Initial | 41.43**±**1.83 | 41.4**±**1.61 | 41.04 **±**1.29 | 1.476 | 0.56 |
| 1stwk | 178.63a **±**6.99 | 183.3b**±**7.06 | 185.73b **±**5.71 | 6.386 | 0.00 |
| 2ndwk | 411.66**±**22.71 | 421.4**±**17.20 | 442.16**±**16.27 | 18.626 | 0.15 |
| 3rdwk | 796.13a**±**16.67 | 862.1b**±**36.91 | 901.36c**±**28.36 | 27.213 | 0.00 |
| 4thwk | 1377.06a**±**25.0 | 1443.66b**±**31.6 | 1541.03c**±**26.5 | 27.640 | 0.00 |

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Mean values having uncommon superscripts differ significantly.

T0=Diet without banana leaf powder; T1=Diet containing 1% banana leaf powder; T2=Diet containing 2% banana leaf powder; SEM=Standard error of mean.

**4.2 Weight gain**

The responses of banana leaf on weekly body weight gain of broilers are presented in table 4.2. Highly significant (P<0.01) differences were observed among the treatment groups at 1st and 4th and weeks of age. But no significant (P>0.05) difference was observed at 2nd and 3rd week of age. Supplementation of banana leaf diet groups T1 and T2 increased weekly body weight gain of broiler than control group T0. The highest body weight gain was observed in the banana leaf supplemented group T2and the lowest body weight was observed in the control group T0.

**Table 4.2:** Weight gain (g/bird/d) of the experimental broiler birds fed diets supplemented with different levels of banana leaf from 1st to 4th weeks of age

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Variable** | **Age** | **Dietary treatments** | **SEM** | **P** **Value** |
| **T0** | **T1** | **T2** |
| Weight gain  | 1stwk2ndwk3rdwk4thwk | 137.2a **±**7.78230.03**±**25.3385.46**±**30.4580.93a**±**27. | 141.9b **±**7.02238.1**±**18.09438.7**±**37.80580.56a**±**42.2 | 144.7c **±**5.83257.4**±**18.10454.2**±**38.23641.66b**±**41.3 | 6.7720.4034.5036.16 | 0.000.100.410.00 |

Mean values having uncommon superscripts differ significantly.

T0 = Diet without banana leaf powder; T1 = Diet containing 1% banana leaf powder; T2=Diet containing 2% banana leaf powder; SEM=Standard error of mean.

**4.3 Feed intake**

Table 4.3 represents the effect of banana leaf supplementation on weekly feed intake of broilers. No significant (P>0.05) differences were observed among the treatment groups at 2nd weeks. The feed intake was closely similar in different groups with higher feed intake observed in control group T0 and lower feed intake was found in banana leaf supplemented diet groups T1 and T2. However, feed intake was significantly differed at 1st, 3rd and 4th weeks. Among the treatment groups, control groupT0 showed the highest feed intake compared to other experimental diets groups.

**Table 4.3:** Weekly feed intake (g/broiler) of broiler on different treatment groups

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Variable** | **Age** | **Dietary treatments** | **SEM** | **P value** |
| **T0** | **T1** | **T2** |
| Feed intake  | 1stwk2ndwk3rdwk4thwk | 174.56a**±**6.4346.86**±**16.2586.41a**±**36.990.76a**±**14.6 | 172.86a **±**4.89334.16**±**15.35636.56b**±**17.9961.26b**±**25.2 | 168.66b**±**7.79332.73**±**10.96645.38c**±**11.86962.99c**±**31.33 | 6.3813.1921.0222.75 | 0.000.100.000.00 |

Mean values having uncommon superscripts differ significantly.

T0=Diet without banana leaf powder; T1=Diet containing 1% banana leaf powder; T2=Diet containing 2% banana leaf powder; SEM=Standard error of mean.

**4.4 Feed Conversion Ratio**

The feed conversion (FCR) of broilers during different weeks of age at different dietary groups is given in table 4.4. No significant (P>0.05) difference was observed among the treatment groups at 1st week of age, though highly significant (P<0.01) difference were observed among these groups at 2nd and 3rd weeks of age. Feed conversion was significantly lower or better in T2 group compared to other groups. Along the whole experimental period the highest FC was seen in control group (T0) and lowest FC in T2 group.

**Table 4.4:** Weekly feed conversion (FCR) of broiler on different treatment groups

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  | **Dietary treatments** | **SEM** | **P value** |
| **Variable** | **Age** | **T0** | **T1** | **T2** |
| FCR | 1stwk2ndwk3rdwk4thwk | 1.26**±**0.071.50a**±**0.221.51a**±**0.221.70a**±**0.08 | 1.20**±**0.071.40b**±**0.21.44b**±**0.21.65b**±**0.1 | 1.15**±**0.081.2b**±**0.101.41b**±**0.11.50c**±**0.1 | .063.136.136.103 | 0.620.000.000.05 |

Mean values having uncommon superscripts differ significantly.

T0=Diet without banana leaf powder; T1=Diet containing 1% banana leaf powder; T2=Diet containing 2% banana leaf powder; SEM=Standard error of mean.

**4.5 Hematological and Biochemical analysis**

The blood samples were collected from the brachial vein of two birds from each group (one bird from each replicate). The blood hematological parameters of experimental birds have been presented in the Table 4.5.

**Table 4.5:** Haematological and serum biochemical parameters of the experimental broiler birds fed diets supplemented with different levels of banana leaf

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameters (%)** | **Dietary treatments** | **SEM** | **P value** |
| **T0** | **T1** | **T2** |
| Packed Cell VolumeRBC (×106/mm3)WBC (×106/mm3)Haemoglobin (g/ dL)Cholesterol (mg/dl)Glucose (g/dl)Total Protein (mg/dl)ALT (IU /L)AST (IU /L ) | 29.004.0548.00b8.703.33a8.70a5.1716.70a57.67  | 30.004.2951.30a9.002.27b7.30b5.4021.3b57.00  | 30.734.8754.30b9.302.21b7.14b5.4321.70b52.33  | 1.560.141.000.500.240.220.231.43.76  | 0.830.290.010.830.010.000.360.000.37 |

Means on the same row followed by different superscripts are significantly different (p<0.05).

T0=Diet without banana leaf powder; T1=Diet containing 1% banana leaf powder; T2=Diet containing 2% banana leaf powder; Red blood cell, WBC: White blood cell, ALT: Alanine amino transferase, AST: Aspartate aminotransferase, SEM=Standard error of mean.

**4.5.1. Packed Cell Volume (PCV) value**

The packed cell volume (%) did not differ (p˃0.05) within all treatment groups at 4th week. The maximum average value of PCV (30.73) was observed in T2 group and the minimum average value (29) was observed in the T0 at the same study period.

**4.5.2. Haemoglobin Value**

Supplementation of banana leaf had no marked influence (p˃0.05) on haemogloblin (%) in the experimental birds. The highest average value (9.3) was found in the T2 group and the lowest average value of haemoglobulin (8.70) was found in T0 group.

**4.5.3. Serum Cholesterol Value**

Dietary treatment significantly (p<0.05) reduced the concentration of serum cholesterol. The highest average value of serum cholesterol (3.33) was recorded in T0 group whereas the lowest value (2.21) was found in the T2 group at 4th week during the experimental period.

**4.5.4. Serum Total Protein (TP) Value**

Total protein (mg/dl) differ (P˃0.05) significantly. Maximum average value (5.43) was observed in T2 group at 4th week and the minimum average value (5.17) was observed in the T0 group at the same week.

**4.5.5 Red blood cell value**

The level of red blood cell increases significantly where the maximum level observed (4.87) in T2 group at 4th week and the minimum average value (4.05) was observed in the T0 group at the same week.

**4.5.6 Blood glucose value**

Dietary treatment significantly (p<0.05) reduced the concentration of glucose up take.The highest average value (8.70) was recorded in T0 group whereas the lowest value (8.14) was found in the T2 group at 4th week during the experimental period

**4.6 Carcass Charateristics**

The carcass parameters significantly differed (p<0.05) in terms of dressing percentage, thigh and abdominal fat weight at 28 days. However, though other parameter differed numerically but it did not differ significantly (p˃0.05) amongst dietary treatments. Other carcass parameters were statistically similar (p˃0.05) throughout the entire experimental period.

**Table 4.6**: Carcass characteristics of the experimental birds fed banana leaf powder at 4th week of age.

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameters (%)** | **Dietary treatment** |  **SEM** | **Sig.** |
| **T0** | **T1** | **T2** |
| Dressing (%) | 58.00a | 58.35a | 58.75a | 0.56 | \* |
| Drumstick (%) | 8.54 | 7.8 | 8.93 | 0.16 | NS |
| Thigh (%) | 9.09a | 10.20a | 10.09a | 0.21 | \* |
| Breast (%) | 21.22 | 22.43 | 22.44 | 0.26 | NS |
| Neck (%) | 2.83 | 3.96 | 3.97 | 0.16 | NS |
| Back (%) | 8.56 | 8.74 | 8.44 | 0.15 | NS |
| Wing (%) | 8.59 | 9.25 | 9.00 | 0.24 | NS |
| Liver (%) | 3.12 | 3.20 | 3.78 | 0.08 | NS |
| Heart (%) | 0.36 | 0.35 | 0.38 | 0.01 | NS |
| Abdominal fat (%) | 1.41a | 1.39c | 1.36b | 0.01 | \* |
| Gizzard (%) | 1.27 | 1.33 | 1.32 | 0.02 | NS |
| Proventriculus (%) | 0.68 | 0.68 | 0.70 | 0.01 | NS |
| Head (%) | 2.29 | 2.40 | 2.51 | 0.07 | NS |

Mean values having uncommon superscripts differ significantly.

The measurement of carcass parameters are based on live weight of birds; T0=Diet without banana leaf powder; T1=Diet containing 1% banana leaf powder; T2=Diet containing 2% banana leaf powder; SEM=Standard error of mean; \* = Significant (p<0.05); \*\* = Significant (p˂0.01).

**4.7 Meat Quality Test of Experimental Birds**

The meat composition of the birds changed significantly in terms of dry matter and protein in different treatment group. But no significant changes(p>0.05) were observed in Ether extract and ash percentage in different treatment group.

**Table 4.7:** Meat quality test of the experimental broiler birds supplemented with banana leaf.

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameter (%)** | **Dietary treatment** | **SEM** | **P value** |
| **T0** | **T1** | **T2** |
| Dry MatterCrude ProteinEther ExtractAsh | 27.38b69.51ab9.724.49 | 25.98a73.37bc14.274.38 | 26.41ab71.26a17.164.28 | 0.552.081.610.17 | .01.002.87.68 |

Means having different superscript in the same row differ significantly.

T0=Diet without banana leaf powder; T1=Diet containing 1% banana leaf powder; T2=Diet containing 2% banana leaf powder; SEM=Standard Error of Mean.

**4.8 Cost-benefit analysis**

The data on cost benefit analysis are presented in Table 4.9. No significant (P>0.05) differences observed for cost items in chick cost (Tk./Chick) management cost (Tk./broiler) and for sale items including market sale price (Tk./Kg broiler). On the other hand, significant (P<0.05) differences were observed in total feed cost (Tk./broiler), total cost (Tk./broiler) and total cost (Tk./Kg live broiler) in between T2 and others. In terms of income, significant (P<0.05) differences were observed in total sale price (Tk./broiler), net Profit (Tk./broiler) and net profit (Tk./Kg live broiler) in T2 group with other two groups. Tabular data showed that total cost (Tk./broiler) was higher in banana leaf supplemented dietary group T2 comparing to T1 and control group. But total cost (Tk./Kg live broiler) was highest in control group and lowest in T2

**Table 4.8** Cost of production and returns of broilers in different treatment groups

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Parameters** | **T0** | **T1** | **T2** | **SEM** | **P value** |
| Chick cost (Tk./Chick) | 50.00 | 50.00 | 50.00 | 50.00 | .10 |
| Management cost (Tk./broiler) | 15.00 | 15.00 | 15.00 | 15.00 | .41 |
| Total feed cost (Tk./broiler) | 82.40b±0.03 | 81.83ab±0.14 | 81.35a±0.10 | .09 | .02 |
| Total cost (Tk./broiler) | 134.88b±0.03 | 136.33a±14 | 137.40a±0.1 | .09 | .04 |
| Total cost(Tk./Kg live broiler) | 122.41a±0.36 | 120.74b±0.15 | 120.32b±0.88 | .453 | .05 |
| Market sale price (Tk./Kg broiler) | 130 | 130 | 130 | 130 | .25 |
| Total sale price (Tk./broiler) | 158.37b±0.82 | 161.51b±0.91 | 167.84a±0.61 | .77 | .02 |
| Net Profit (Tk./broiler) | 22.49b±0.81 | 24.18b±0.7 | 30.44a±0.68 | .756 | .04 |
| Net Profit (Tk./Kg live broiler) | 6.49b±0.34 | 9.16a±0.15 | 9.58a±0.88 | .446 | .05 |

Mean values having uncommon superscripts differ significantly.

T0=Diet without banana leaf powder; T1=Diet containing 1% banana leaf powder; T2=Diet containing 2% banana leaf powder; SEM= Standard error of mean

**Chapter 5: Discussion**

The study investigated the effects of banana leaf supplementation below and above recommended levels on productive performance, carcass characteristics and hemato-biochemical parameters in commercial broiler for a typical period of 28 days.

**5.1 Weight gain**

Supplementation of banana leaf from 1st to 4th weeks of age in commercial broiler birds indicated that, weight gain substantially improved in treatment groups compared to control. The result is closely consistent with previous studies where, increasing levels of dietary protein had significant positive effects on body weight gain in broilers. In present study, highest weight gain was recorded in 2% Banana leaf supplemented group which is aligned with other studies (Abel *et al.,* 2015; Oleforuh-Okoleh *et al*., 2005). Increased weight gain in intervention groups achieved in earlier studies could have been due to potential effect of Banana leaf to improve the digestibility of other nutrients of the ration (Ghazalah and Ali, 2008). In compliance with present study, formulation of diet with 3% banana leaf had better performance in terms of weight gain (Esonu *et al.,* 2006). Although, there seem to be dearth of information on the use of banana leaf as a feed additive in broiler chicks, the improved performance of birds in the treated group could possibly be due to nutritional benefits of banana leaf. Herbs contain active substances that improve digestion metabolism and possess antibacterial and immune stimulant activities (Ghazalah and Ali, 2008).

Reports on benefits of banana include that it contains high levels of fructooligosaccharide (FOS) that along with insulin promotes calcium absorption. The FOS further nourishes healthy bacteria in the colon that manufacture vitamins and digestive enzymes that boost the body's overall ability to absorb nutrients. Bananas protect the healthy constitution of the stomach in two ways. Firstly, they trigger the production of mucus in the stomach, which provides a protective barrier against stomach acids. Secondly, bananas possess protease inhibitors, a substance that breaks down bacteria in the stomach that cause ulcers. Alisi *et al* (2008) reported that aqueous extract of unripe fruit peels and leaves of *Musa paradisica* var. *sapientum* showed antimicrobial activity against *Staphylococcus* and *Pseudomonas* species. This antibiotic property could have enhanced food digestion and assimilation consequently improving the feed conversion ratio of treated birds as observed in the present study. Bera *et al* (2013) in their study to investigate the possible toxic effects of the petroleum ether, ethyl acetate and methanol extract of *M. paradisiacal* leaf in adult Swiss albino mice did not observe any change in the final body weight and food intake of mice administered with the various extracts. They concluded that the extracts may be safe in Swiss albino mice. The result of the present findings indicated better growth performance implying that banana leaves can be used as a growth promoter in broiler chicks.

**5.2 Feed intake**

In present study, gradually increasing levels of banana leaf had remarkable positive effects on feed intake in commercial broiler. It was evident that, inclusion of 3% increased (p<0.05) feed intake in treatment groups compared to control at 4th week. Birds consumed relatively more feed during finisher phase despite reduced total feed intake (Dubale *et al*., 2007; Oleforuh-Okoleh *et al*., 2005).

**5.3 Feed conversion ratio**

It was speculated that, FCR at different ages of broilers fed diets supplemented with banana leaf markedly improved during 1st to 4th weeks of age. These results are in compliance with previous studies (Duwa *et al*., 2014) where supplementation of broiler diets with banana leaf improved FCR in treatment groups compared to control. Birds on banana leaf powder T2 consumed insignificantly lesser quantity of feed. This translated to a better feed conversion ratio.

**5.4** **Haematological changes**

Hematological parameters are good indicators of the physiological status of the animal (Esonu *et al.,* 2006). In the hematological studies, the leaves did not appear to affect the treated birds as evidenced by comparable values by both control and treated groups at the end of the experimental period. The PCV, Hb and RBC concentrations improved numerically in the treated group while the WBC did not show any particular trend. However, all the values of the hematological constituents studied fall within the normal ranges for broilers as reported by (Mitruka and Rawnsley, 1981). The present findings contradicts the findings of (Eseyin *et al.,*2010), who reported that ethanolic extracts of the leaf of *Musa paradisiacal* significantly reduced the circulating red cell counts, hemoglobin and packed cell volume but increased lymphocyte concentration as compared to the control in rats. They adduced this to a possibility that the extract reduced iron intake from the GIT or inhibited hematopoiesis. They, further, noted that reduction in RBC count could also be a consequence of cytotoxicity or an inhibitory effect of some of the components of the extracts on bone marrow homopoiesis. The improvement in the hematological constituents observed in the present study is an indication that the inclusion of banana leaves did not have any pathological effect on the birds, thus, did not cause any hematological disorder.

**5.5 Biochemical changes**

Dietary treatment significantly reduced the concentration of serum cholesterol of chickens. Banana leaf meal caused significant (p<0.05) decreases of 54.82 serum total cholesterol when compared to the control. The decrease in the plasma total cholesterol might be attributed to the presence of hypolipidemic agents in banana leaves. Banana leaf has been reported to possess antimicrobial and antioxidant activity in rats and mice (Karadi *et al.,* 2011). Barbara (2013) reported that banana leaves contain large amounts of polyphenols (natural antioxidants found in many plant based foods) such as epigallocatechin gallate, or EGCG, also found in green tea. (Walker, 2015) noted that the mode of action for EGCG may increase delivery of stored fat to cells for oxidation or increase fat burning capabilities. Supplementation with banana leaf had remarkable decreasing effects on the plasma glucose level in the treated birds compared with control. This indicates the presence of hypoglycemic components in the leaf. Kappel *et al* (2013) demonstrated the beneficial effects of banana leaves (*Musa paradisica*) on regulation of glucose homeostasis and concluded that banana leaf have the ability to improve carbohydrate metabolism. This ability was attributed to the presence of an active phytochemical compound, rutin (quercetin-3-*O-*rutinoside), a flavonol glycoside found in the leaf.

**5.6 Carcass characteristics**

The research showed significant differences (P<0.05) among different dietary treatment groups in eviscerated weight, final weight of birds. These results are consistent with previous study (Duwa *et al*., 2014) where banana leaf supplementation substantially increased thigh and drumstick weight in treatment group compared to control. Carcass yield (%) of birds did not differ significantly (P>0.05) among the different dietary treatment groups. No significant differences (P<0.05) were observed in weight of different primal parts and internal edible organs. However, weight of breast, drumstick, back and thigh head, neck, wing etc were higher in banana leaf treatment groups.

**5.7 Chemical composition of meat**

In this study, supplementation of banana leaf had no effects on the chemical composition of broiler meat in terms of DM, CP and TA except for EE (P<0.05). These results are consistent with another study (Eseyin *et al.,* 2010) where increasing dietary protein contents in iso-caloric diets increased protein content and decreased fat percent in broiler carcass. It indicated that, increased carcass protein and decreased fat resulted due to elevated dietary protein and decreased dietary energy.

**Chapter 6: Conclusion**

The study investigated the effects of banana leaf supplementation on performance parameters, carcass characteristics and blood parameters in commercial broiler under intensive rearing system. It was evident that, there was a positive relationship between gradually program in banana leaf supplementation and performance of commercial broiler without notable changes in blood parameters. Highest weight gain, optimum feed intake and best FCR were observed in birds fed diet containing 2% banana leaf. There were no unusual changes in the blood and serum parameters in comparison to the reference level. Similar to performance parameter, carcass characteristics were improved in terms of breast muscles yield in banana leaf meal supplemented group. Generally, the results of this study indicate that the use of banana leaf in the diets of broiler chickens improved the traits studied without any adverse effect on them. Of particular interest is the variation in the traits attributed to the method of applying the treatment In conclusion, banana leaf could be used as a phyto-additive for broiler chickens, preferably in the feed.

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**Chapter-7: Recommendations and Future perspectives**

The study, therefore, suggests that, banana leaf is an unconventional feed supplement with basal diet at an inclusion level of 2%. However, a long term investigation with larger sample size and multi-dimensional temporal pattern is suggested for increasing sensitivity and validity of the study under field condition. It was a pilot study, and further study may be done on dietary level of banana leaf and similar work to make concrete remarks for a field level. The study may be done on different strain, sex and age of broilers with different environmental condition considering temperature and humidity. However, based on the overall conclusion it may be recommended that the farmers can use banana leaf based diet in broiler ration.

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