**Chapter-1: Introduction**

Profitable broiler rearing relies on many factors like availability of feed ingredients at a reasonable cost, proper management, quality chicks etc. Among those factors, feed cost comprises of 65-75 percent of the total production cost. Moreover, the prices of protein ingredients are comparatively higher than that of the other ingredients. Protein cost involves about 45 percent of the total feed cost (Ahmad et al., 2006). In broiler ration fish meal, meat and bone meal and other animal proteins are predominantly used as a principal source of protein (Ahmad et al., 2006). Globally, the feed industry is considering alternatives (e.g., soybean meal, cottonseed meal and legumes) due to the rising cost of animal protein meals and worldwide intensive growth of poultry production.

In recent era in Europe, using the animal by-product as animal protein source containing animal tissue has become an important issue due to concern over the spread of transmissible diseases namely Bovine Spongiform Encephalopathy (BSE) (CEC, 2000). Furthermore, the high prevalence of contaminants (e.g. *Salmonella spp*.) detected in the animal protein meal is another reason to look for suitable alternatives (Hofacre et al.,2001). Finally, a critical cost appraisal of poultry feed formulation shows that protein, especially protein of animal origin, to be the most expensive per unit cost of production (Oluyemi and Roberts, 2000). Animal proteins are expensive and less profitable (Karimi, 2006). The quality of animal protein is quite uncertain due to the use of varieties part of fish, animals and different processing technologies. In addition, it is often contaminated with foreign particles like sand, sawdust, fibres etc. The use of chemical preservatives often causes toxicity to poultry birds (Khatun et al.,2003; Karimi, 2006). To solve those problems major protein component of poultry diet can be vegetable protein sources. It is available and can be efficiently incorporated in poultry ration. In this perspective soybean meal can be used as a good substitute for animal protein in broiler ration. It is well known due to its high profile of certain essential amino acids and can provide up to 60% crude protein in an ideal ration (Newkirk and Classen, 2002). Plant proteins have some flaws also. Except sulphur amino acids, all essential amino acids are supplied by the soybean meal. It has also been reported that cotton seed meal have deficiencies of lysine, methionine and leucine; groundnut cake in sulphur amino acids; corn gluten meal in lysine and tryptophan. The constrains of vegetable proteins can be overcome by adding different supplements such as exogenous enzymes, synthetic amino acids, vitamin mineral premix etc. to enrich nutritional quality of feeds for getting optimum performance of poultry(Hossain et al., 2011). Consequently, there has been recent research interest in the identification and utilization of plant protein sources in formulating poultry diets to replace animal protein.

The reduction of feed cost is a must without compromising with the quality of the product for a sustainable poultry industry (Ahmad et al., 2006). To minimize the feed cost in terms of protein and also to keep the standard quality of the broiler meat, animal originated protein can be replaced by plant originated protein (Suchý et al., 2002). In order to fulfill those demands this study has been undertaken for the justification of effect of plant protein over animal protein on performance of broiler.

**Therefore, the objectives of the present study were:**

* To observe the effects of plant protein on performance of broiler.
* To estimate the economic benefit of rearing broilers fed on plant protein.

**Chapter-2: Review of literature**

**2.1 Protein in broiler nutrition**

Proteins are large molecules made up of amino acids bonded together by peptide linkages. They provide the essential amino acids, which are the initial materials for tissue synthesis and constituent of tissue protein. Thus, it was often referred to as the “currency” of protein nutrition and metabolism. The connective tissues, ligaments, enzymes, hormones, haemoglobin in blood and even the hereditary material (DNA) are all made up of proteins (Aduku, 2004). Essential Amino acids cannot be synthesized by the animal and therefore must be supplied in the diet. Monogastric livestock such as swine and poultry, unlike ruminants do not have the ability to synthesize amino acids. Thus nearly all their amino acid requirements must be met through their diet. So any complete diet must therefore contain some protein but the nutritional value of the protein relates directly to its amino acid composition and digestibility (Wikipedia, 2013).

The essential amino acids for poultry are lysine, methionine, cystine, tryptophane, threonine, arginine, isoleucine, leucine, valine, histidine, phenylalanine etc. The protein feed which contains most of all essential amino acids are of high quality protein for poultry. For broiler production there need crude protein 22% in starter, 21% in grower and 20% in finisher diet. The provision of quality protein devoid of any essential amino acids is critical in the early nutrition in the young poultry (Dibner, 2006).

The provision of proper nutrition to chicks in early life is essential, to ensure the rapid growth of the gastrointestinal tract and the rest of the body. The need for essential amino acids progressively reduced as the birds grow older. Protein appears to be the most essential component of such nutrition, as it drives the initial intestinal development and muscle attachments in later phases. The quality and therefore the source of such protein may be important. This was demonstrated by differences in growth performance of the birds on diets based on vegetable protein (VP) compared to animal protein (AP) diets (Hossain et al., 2012; 2013a).

**2.2 Sources of protein for broiler**

There are two types of protein source: animal protein and plant protein. It is easily assumed that no two protein sources are same in characteristics. The pattern of digestibility, biological value, quality, physical or chemical structure or properties of protein sources vary widely between sources. These characteristics of individual protein ingredients may affect neonatal intestinal development and function, and thus subsequent performance of the broiler chickens (Hossain et al., 2014). The interaction between dietary nutrients, intestinal growth, and digestive function is crucial during the post-hatch period (Ullah et al., 2012).

**2.3 Sources of animal protein**

Protein supplements of animal origin are derived from meat packing and rendering operations, poultry and poultry processing, milk and dairy processing, fish and fish processing etc (Denton et al., 2005). There is a long history of worldwide animal protein use in the poultry industry (Firman and Robbins, 2004). They are meat and bone meal, protein concentrate, poultry meal, hatchery by product, blood meal, hydrolyzed poultry feather meal, fish meal etc (Moritz and Latshaw, 2001). Before the discovery of vitamin B-12, it was generally considered necessary to include one or more of these protein supplements in the rations of chickens. Animal proteins are useful constituent of poultry rations. They provide a high level of protein/amino acids, highly available phosphorus, a number of other minerals, and moderate amounts of energy. The animal protein is considered as excellent and high class protein containing all essential amino acid particularly lysine, first limiting amino acids in cereals for broiler (Giang et al., 2001; Robinson and Singh, 2001). Broiler chickens fed on animal protein, found better productivity and performance than those birds fed only on plant-based diets (Hossain et al.,2012, 2013). However, benefits of animal protein, as poultry feed, depend on method of processing and cost effectiveness (Ra'fat, 2008).

**2.4 Constrains of animal protein**

Though animal protein is of excellent quality, it has some drawbacks also. In some countries like India, Pakistan, USA etc; these feedstuffs are excluded from poultry diets in order to prevent cross-contamination of diets for ruminant animals and to prevent zoonoses (Mendes, 2003; Hossain et al., 2013). Animal protein is the risk factor for spreading infections of zoonotic importance like TB, Salmonellosis, BSE etc (CEC, 2000; Hofacre et al.,2001). The exclusion of these feed ingredients from formulations not only reduces the nutritive value of the diets, but also limits the ability of the formulations to meet the essential nutrient needs for poultry (Hossain et al., 2011a).

Many protein supplements of animal origin are troublesome to process and store without some spoilage and nutrient loss. If they cannot be dried, they must be usually refrigerated. If not heated to destroy pathogenic bacteria, they may be a source of infection. On the other hand, protein availability will be reduced and some nutrients are lost if the feed is heated excessively (Ensminger, 1990; Ra'fat, 2008). Performance of broiler fed with animal byproducts may be highly changeable as a function of raw material type and quality, processing temperature, use of antioxidants to maintain their quality, contamination by pathogenic microorganisms and unwanted substances like sands, fibers, dusts, hair follicles etc, high polyamine content, amino acid unbalance, nutrient content and digestibility, and storage conditions (Bellaver, 2001; Shirley and Parsons, 2001). The use of chemical preservatives in production of animal by products often causes toxicity to poultry birds (Khatun et al.,2003; Karimi, 2006).

Furthermore, a critical cost appraisal of poultry feed formulations shows that protein of animal origin is more expensive than vegetable protein sources (Oluyemi and Roberts, 2000;Blair, 2008; Chadd, 2008).

Due to these consequences like public health risk, chronic scarcity and high cost of animal protein supplements, particularly fish meal, meat and bone meal have increased interest to seek alternative protein sources for feeding poultry (FAO, 2004).

**2.5** **Sources of plant protein**

The sources of plant protein for poultry are soybean meal, cottonseed meal, linseed meal, alfalfa meal, corn gluten meal and legumes. Broiler productions dependent entirely on vegetable ingredients may be an emerging trend for producers, and be in great demand from consumers as well. Broilers grown solely on plant protein diets are preferred in the European Union and Middle East (Mendes, 2003). Meat chickens produced from plant-based diets, except any growth promoter or animal by-products, may be considered as organic meat, which has huge demand in the world food market (Mendes, 2003). This tendency is creating the pressure on feed formulators and nutritionists to supply organic, safe and hygienic poultry products to consumers, by providing quality diets to poultry without using animal by-products or growth promoters. Adding vegetable ingredients, mainly soybean, canola, sunflower and mustard, in diets, instead of using animal meals as a protein source, can lead to optimum broiler performance as long as the diets are properly balanced with necessary nutrients such as digestible amino acids. These ingredients are a good source of nutrients, are comparatively inexpensive, easily available, and easy to process, and pose less risk of disease contamination. Producing poultry products, i.e meat and eggs, at economical rate may be feasible using plant protein sources in practical diets, as they are considered cheaper and safer than animal protein sources (Hossain and Iji, 2015). Despite cutting feed cost considerably, these ingredients can serve as excellent sources of nutrient for poultry when processed properly and supplemented with other pro-nutrients (Cruz et al., 2009).

The extra fat deposition in the carcass and egg is generally considered as the un favorable trait in the poultry industry (Remignon and Le Bihan-Duval, 2003). Many researchers have been claimed that broiler chickens deposit less abdominal fat when the birds fed on all vegetable ingredients than those fed on animal protein diets (Pawlak et al., 2005; Hossain et al., 2013, 2015).

When lean meat is desired, animals may be fed plant based diets, which will result in low fat and higher protein accumulation in their carcasses (Singh and Panda, 1992). Moreover, broiler meat fed on all vegetable diets may also contribute a better profile of fatty acids in their carcasses, which may enhance the shelf life of meat (Hossain and Iji, 2015).

**2.6 Constrains of plant protein**

However, vegetable sources contain numerous anti-nutritive factors (ANF) and amino acids are imbalanced in the vegetable proteins, even though a single plant protein may contain all essential amino acids but not available in an ideal ration or as per as the requirement of the animals (Sing and Panda, 1992). Two or more plant protein feed ingredients together can make their proper availability in the diet. According to the NRC (1994) except sulphur amino acids, all essential amino acids are supplied by the soybean meal. On the other hand, all the other plant proteins have multiple deficiencies. Sing and Panda (1992) also reported that cotton seed meal was deficiencies of lysine, methionine and leucine, groundnut cake in sulphur amino acids, lysine and threonine, corn gluten meal in arginine, lysine, threonine and tryptophan. Corn gluten meal is notably adequate in sulphur amino acids in contrast to the other proteins. Besides, another plant feed such as lupin seed meal, sunflower meal contains lower protein efficiency ratios because of the relatively low concentration of sulphur amino acids and low available lysine content (Villamide and San Juan, 1998).

The constraints of these vegetable proteins can be overcome by adding different supplemental feeds such as exogenous enzymes, fat or oils, synthetic amino acids, vitamin mineral premix and also growth promoters like feed additives in order to enrich nutritional quality of feeds for getting optimum performance of poultry (Hossain et al., 2011).

**2.7 Meat and bone meal**

Meat and bone meal are recovered after slaughter of animal and are further processed by the rendering industry to use as poultry feeds. Meat and bone meal is an excellent source of protein. In poultry diets, meat and bone meal is typically limited to 5% of the diet content because of the high calcium, phosphorus, and lysine content of the meal. Proteins found in hair, skin, and bone can be hard to digest because they are high in keratin and other collagenous protein, which can be partially denatured during the heating process. However, prolonged drying time or overheating can reduce amino acid (AA) digestibility. So it needs to ensure good processing of animal by product to preserve its quality as poultry feed. It also costs high due to processing. It also possesses higher risk of spreading diseases which are zoonotic like TB, BSE, Salmonellosis etc. For this reason, it has been banned in many countries.

Meat and bone meal has 1080-1150kcal/kg ME, 45-50% CP, 8.5% EE, 2.5% CF, 9.2-11% Ca, 0.53- 0.67% methionine and 2.2-2.6% lysine (Batal and Dale, 2011). Being a protein source, meat and bone meal is also a significant source of totally available calcium (Ca) and phosphorus (P), whereas in plant feedstuffs, phosphorus is only 33% bio available to animals due to the presence of phytate (Caires et al., 2010).

The inclusion of 4% meat and bone meal and 3% poultry offal meal in broiler diets did not influence live performance at 21 days of age as compared to corn-soybean meal based diets (Bellaver et al., 2005). However, at 35 and 42 days, broilers fed animal meals presented lower average weight. Meat chickens fed on animal protein diets, demonstrated better productivity and increased performance than those birds fed exclusively on plant-based diets (Hossain et al.,2012, 2013).

**2.8 Protein concentrate**

Protein concentrate refers a dietary supplement for human or animal having a very high protein content and being extracted or prepared from vegetable or animal source. The most commonly used protein concentrates are of animal origin like fish protein concentrate (FPC). In physical appearance protein concentrate may be ground or textured. In powder form it is felt sticky due to presence of fat. Chemically it is devoid of soluble sugar as they are removed during extraction process from protein part and hence the protein of protein concentrate becomes to be concentrated. Protein concentrate is of high protein value having minimum 60% crude protein. All kinds of essential amino acids are present in the protein concentrates of animal origin like fish protein concentrate (FPC). The maximum moisture level of protein concentrate (FPC) is not exceeding 10%. It has a fat level of 10% (max) depending on raw materials used and extraction method. It has low total ash content about 5-10% but high level of individual phosphorus level (FPC) and low calcium level. Protein concentrate has high digestibility percentage. Protein concentrate is incorporated in ration of poultry, ruminant, pet animals and fish as a source of protein. It is mainly used to balance the protein part of ration for broiler birds (starter, grower), layer (starter), High Yielding Varity (HYV) cow (for milk production) to fulfill the protein requirement. It cannot be used as main protein ingredient in ration because of its high production cost. So it occupies the place of protein supplement and has maximum inclusion level of 10 %. The cost of feeding chickens decreased when fish meal was replaced by protein concentrates. They also reported that the cost of feed per kg live weight gain and overall production cost were lower when fish meal was completely replaced by protein concentrates. Protein concentrates available in the market could replace fish meal from broiler diet with satisfactory performance (Ahmad et al., 2006).

**2.9 Soybean meal**

A cheap, highly palatable and available feedstuff, soybean meal is the simplest form of soybean protein and a by-product of the oil milling after soybean oil extraction. It contains 44-48% CP, 0.6-07% methionine and 2.7-3% lysine (NRC, 1994). It contains higher energy (2,460 metabolizable energy (ME) kcal/kg) and protein than other plant protein sources and has an excellent balance of highly digestible amino acids with the exception of methionine, cystine (both are sulpher containing amino acids) which tends to be low. Soybean meal is however rich in the essential amino acids like lysine, tryptophan, threonine, isoleucine, and valine which are deficient in cereal grains (corn and sorghum) mostly be utilized by poultry. The bioavailability of the amino acids lysine, threonine, and methionine from soybean meal are 88, 81, and 90%, respectively. Amino acid digestibility is also very high (more than 90 for lysine in poultry) (Sauvant et al., 2004). These factors favor the substitution of other protein sources for soybean meal in diets of monogastric animals.

However, both methionine and lysine supplementation are necessary for increasing feed efficiency in poultry diet based on soybean meal (Douglas and Persons, 2000). Several other studies (Opapeju et al., 2006; Coca-Sinova et al., 2008) have evaluated various methods of enhancing the digestibility of individual amino acids and protein of soybean meal.

Soybean meal is deficient in methionine, cystine and to some extent lysine. However, soybean meal possesses anti-nutritional properties which must be overcome to increase its nutritional value. These include trypsin inhibitors, oligosaccharides (rafinose and stachyose) which are poorly utilized by poultry. Phytic acid and antigenic factors found in certain soybean proteins cause inflammatory response in the gastrointestinal tract of monogastric animals. Soybeans also contain lectins, compounds that bind with intestinal cells and interfere with nutrient absorption and other compounds such as saponins, lipoxidase, phytoestrogens and goitrogens whose anti-nutritional effects are not known.

**2.9.1 Way to overcome limitations of soybean meal in poultry diets**

Methionine and lysine supplementation are necessary for increasing feed efficiency in poultry diet based on soybean meal. Antinutritive factors of soybean meal like trypsin inhibitor can be destroyed by heat treatment during processing (Hossain et al., 2011). Use of microbial phytase enzymes in soy-based diets to hydrolyze phytic acid increases phosphorus bioavailability and minimizes excess phosphorus excretion. Phytase supplementation in corn-soybean diets significantly improved the digestibility of phosphorus and calcium by 11.08 and 9.81%, respectively and 2-8% improvement of the digestibility of amino acids was also noted (Liu et al., 2007).In addition supplementation with direct-fed microbes increased the utilization of oligosaccharides of soybean meal that serve as prebiotics for microbes exerting synergistic effect to the host. Moreover modification of soybean via genetic engineering can able to lower the amount of antinutritive facts like trypsin inhibitor, phytic acid and oligosaccharides.

**2.10 Partial replacement of animal protein by plant protein**

Specially modified rape expellers can serve as a high quality protein feed that can completely replace meat and bone meals in diets used for the fattening of broiler chickens (Suchý et al., 2002). The main goal of their study was to test diets that were specially formulated for the fattening of broiler chickens and in which feed of animal origin (meat and bone meal) was utterly replaced by feed of plant origin (Proenergol – treated rape expellers). The results obtained in this study proved that this type of diet was suitable for the fattening of broiler chickens. At the end of the fattening period (on the 42nd day) the average live weight of chickens in the control group was practically identical to that of the experimental group; i.e. 2.13 kg and 2.10 kg for pullets and 2.34 kg and 2.31 kg for cockerels. On the 14th day, the average weight of both pullets (P ≤ 0.05) and cockerels (P ≤ 0.01) in the experimental group was higher than that in the control group. On the 35th day of the fattening period, the average weight of cockerels in the experimental group was found to be higher than that in the control group (P ≤ 0.05). Furthermore, diets free of animal origin feed affected neither carcass weight nor carcass yield. 5% dietary MBM (containing 42.03% crude protein and 38.23% crude ash) can be used successfully for finished broiler diets (kurt et al., 2004). Comparing the inclusion of 4% meat and bone meal, 3% poultry offal meal, and vegetable diets, did not reveal any influence of diets on 21-day-old broiler performance (Bellaver et al., 2005). Ra'fat (2008) found any significant differences among feed intake, weight gain, feed conversion ratio, and carcass characteristics in different dietary treatments using plant and animal protein in broiler ration.

At 35 days of age, it was verified that the combination of the four animal proteins compromised weight gain (Caires et al., 2010). Broiler performance at 42 days of age was influenced by treatments, and the worst weight gain and true feed conversion were observed in birds fed diets with the combination of the four animal meals. They concluded that meat and bone meal, fish meal, and offal meal inclusion can be individually used with no negative influence on broiler performance or carcass yield and combination of them can decrease performance.

The feed intake up to 21 days was highest on the animal protein (AP) diets, and the lowest in the vegetable protein (VP) based diet (Hossain et al., 2013). Birds in the AP diet groups were significantly heavier at 21 days and 35 days than those on the VP diets. Up to 35 days, birds on AP diets had superior feed conversion ratio, Birds raised on VP diets ha d a significantly lower abdominal fat content than birds on the AP diets. Other meat characteristics measured in this experiment did not differ significantly. The responses of birds generally indicated that the AP diets were superior to the VP diets.

From the study conducted by Yisa et al. (2013), it can be concluded that withdrawing fish meal from broiler finisher may not have any adverse effect on their growth performance provided protein is obtained from non-animal sources. However, total withdrawal of fish meal negatively affects optimum development of the cut-up parts and as such 0.5-1% fish meal may be included in broiler finisher diets for full development of carcass components.

Hossain and Iji (2015) observed that broilers fed animal protein diets grew better than those fed only plant-based diets. However, broilers on former diets tended to reduce litter quality and were fattier than those on plant-based diets. Although growth responses were poorer in the birds fed plant-based diets, reduced abdominal fat accumulation assures better quality of meat than those on conventional diets. Meat chickens with low fat content can be produced successfully with all-vegetable diets, and has potential to reduce production cost if cheaper ingredients like plant feedstuffs are used in diet formulation.

**2.11 Conclusion of the review of literature**

Plant protein is one of the good sources of protein for broilers. It is cost effective than animal protein and also save for mankind. Plant originated protein has potentialities to replace the animal protein and thus to produce safe broiler meat and also to make broiler industry profitable.

**Chapter-3: Materials and methods**

**3.1 Study area**

The current experiment was conducted from September to October 2015, at the Experimental Poultry Farm and Laboratory of Department of Animal Science and Nutrition, Chittagong Veterinary and Animal Sciences University (CVASU), Khulshi, Chittagong, Bangladesh.

**3.2 Preparation of poultry shed**

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 around the shed for bio-security.

**3.3 Experimental design**

The experiment was carried out for 28 days where starter period was 0 to 14 days and grower period was 15 to 28 days. The statistical design used for the experiment was CRD (Completely Randomized Design). In experiment, total 100 birds were allocated to two treatment groups with five replications in each. Chicks were equally and randomly distributed in two dietary treatment groups (T1 and T2) with five replications in each. There were 50 birds per treatment group and 10 birds per replication. Meat and bone meal and protein concentrate were given as animal protein source on dietary treatment group T1 and soybean meal as plant protein source on dietary treatment group T2. All rations during starter (0-14 days) and grower periods (15-28 days) supplied in both cases were iso-caloric and iso-nitrogenous. Layout of the experiment is shown in Table 3.3.a.

**Table 3.3.a:** **Layout of the experiment (CRD) showing the distribution of DOC to the treatment group and replication**

|  |  |  |  |
| --- | --- | --- | --- |
| **Dietary treatment group** | **No. of broilers/replications** | | **Total no. of broilers per treatments** |
| T1  (Soybean meal + Meat and bone meal + Protein concentrate) | R1 | 10 | 50 |
| R2 | 10 |
| R3 | 10 |
| R4 | 10 |
| R5 | 10 |
| T2  (Soybean meal) | R1 | 10 | 50 |
| R2 | 10 |
| R3 | 10 |
| R4 | 10 |
| R5 | 10 |
| **Grand total** | | | **100** |

**3.4 Collection of day-old chicks**

A total of 100 unsexed Day-Old Chicks (Cobb 500 strain) were purchased from an agent of Nahar Agro Complex Limited, Jhautala Bazar, Khulshi, Chittagong, Bangladesh on 13rd September, 2015. During purchasing all chicks were examined for uniform size and any kind of abnormalities.

**3.5 Collection of soybean meal, meat and bone meal and protein concentrate**

Soybean meal, meat and bone meal and protein concentrate are available in the local market. For this research work both plant and animal proteins were collected from Jhautala Bazar, Khulshi, Chittagong.

**3.6 Feeding standard**

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

**3.7 Feed formulation and feeding diets**

The birds were supplied mash feed. Mash feed was prepared manually from raw feed ingredients, which were collected from retail and wholesale market. Four types of ration were used such as broiler starter for T1, T2 and broiler grower for T1, T2. Rations were formulated according to the requirement of birds. Feed was supplied ad-libitum along with fresh clean drinking water. The composition of different feed ingredients and nutritive value of starter and grower rations are given in Table 3.7.a and 3.7.b.

**Table 3.7.a Feed ingredients used in experimental broiler diets**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Ingredients (kg/100kg)** | **Starter ration (0-14 days)** | | **Grower ration (15-28 days)** | |
| **T1** | **T2** | **T1** | **T2** |
| Maize | 60 | 51 | 59 | 60 |
| Broken Wheat | 3.2 | 6.8 | 5 | 1.5 |
| Rice Polish | 1 | 1.2 | 1 | 1 |
| Molasses | 1 | 1 | 1 | 1 |
| **Soybean meal** | **24** | **35** | **24** | **32.5** |
| **Meat and bone meal** | **3** | **0** | **2** | **0** |
| **Protein Concentrate** | **5** | **0** | **4** | **0** |
| Soybean oil | 1.4 | 3 | 2.6 | 3 |
| Limestone | 0.553 | 1.01 | 0.53 | 0.15 |
| Salt | 0.25 | 0.25 | 0.25 | 0.25 |
| Vitamin mineral premix | 0.25 | 0.25 | 0.25 | 0.25 |
| DCP | 0.25 | 0.06 | 0.273 | 0.008 |
| Lysine | 0 | 0.263 | 0 | 0.205 |
| Methionine | 0 | 0.07 | 0 | 0.04 |
| Maduramycin | 0.06 | 0.06 | 0.06 | 0.06 |
| Enzyme | 0.025 | 0.025 | 0.025 | 0.025 |
| Antioxidant | 0.012 | 0.012 | 0.012 | 0.012 |
| **Total** | **100** | **100** | **100** | **100** |

**N.B:** T1 = (Soybean meal + Meat and bone meal + Protein concentrate), T2 = Soybean meal. 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 3.7.b Estimated chemical composition** **(DM basis) of the experimental broiler diets**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Parameters** | **Starter ration (0-14 days)** | | **Grower ration (15-28 days)** | |
| **T1** | **T2** | **T1** | **T2** |
| ME  (Kcal/kg) | **3007.44** | **3006.39** | **3086.45** | **3080.90** |
| CP (gm/100gm) | **21.51** | **21.51** | **20.51** | **20.54** |
| CF  (gm/100gm) | 3.191 | 3.5 | 3.17 | 3.4 |
| EE (gm/100gm) | 3.53 | 2.88 | 3.36 | 3.01 |
| Ca (gm/100gm) | 1 | 0.54 | 0.8 | 0.51 |
| P  (gm/100gm) | 0.6 | 0.49 | 0.5 | 0.47 |
| Lysine (gm/100gm) | 1.2 | 1.27 | 1.1 | 1.15 |
| Methionine (gm/100gm) | 0.5 | 0.59 | 0.5 | 0.5 |

**N.B:** T1 = (Soybean meal + Meat and bone meal + Protein concentrate), T2 = Soybean meal. ME-Metabolizable energy, CP-Crude protein, CF-Crude fibre, EE-Ether extract, Ca-Calcium, P-Phosphorus.

**3.8 Managemental procedure**

The following management procedures were followed during the whole experimental periods and the uniformity in the management practices were maintained as much as possible.

**3.8.1 Brooding of the chicks**

After proper cleaning and drying, the brooding boxes were ready for broiler chicks rearing under strict hygienic conditions. The experiment was conducted in winter season. Dry and clean newspaper was also placed in the brooding box. Newspaper was changed four times in a day from the floor of the brooding box. This is continued for seven days. During the brooding period chicks were brooded at a temperature of 90-95°F during 1st week and 90-85°F during 2nd week respectively with the help of electric bulbs.

**3.8.2 Maintaining room temperature**

Basis on requirement, temperature was increased and decreased in the brooding box as well as in the whole house. The key concern was the comfort of broiler birds. Electric bulbs and fans were used to maintaining the temperature. Temperature was maintained according to Table 3.8.2.a.

**Table 3.8.2.a Temperature schedule maintained in broiler house during experiment period**

|  |  |
| --- | --- |
| **Week** | **Temperature (°F)** |
| 1st | 95 |
| 2nd | 90 |
| 3rd | 85 |
| 4th | 80 |

**3.8.3 Brooder and cage spaces**

Each box brooder having 2.38 ft. X 2.08 ft. was allocated for 30 birds. After 14 days later broiler birds were transferred to cage having 3.5 ft. X 1.63 ft. for 10 birds. Therefore, floor space for each bird in the brooding box was 0.17 sq. ft. and cage was 0.57 sq. ft. respectively.

**3.8.4 Feeder and drinker spaces**

In the early stage of brooding feed and water were given to birds on paper and small drinker. Feeding and watering were performed by using one small round plastic feeder and one round drinker with a capacity of 1.5 liter in each brooding box. The feeders and drinker were fixed in such a way so that the birds could eat and drink conveniently. After 5th day small round feeder was replaced by small liner feeder (2.21 ft. X 0.25 ft.) in each brooding box. During the period of cage rearing large liner feeder (3.5 ft. X 0.38 ft.) and large round drinker with a capacity of three liters was used for feeding and drinking.

**3.8.5 Method of feeding, watering and lighting**

Formulated mash feed and fresh clean drinking water was supplied ad-libitum to the birds throughout the experimental period. Feed and drinking water were given three times a day. Starter ration was supplied for 0 to 14 days and grower ration for 15 to 28 days. During the early stage of growth feed and water were given to birds on paper and small drinkers. The birds were exposed to a continuous lighting of 24 hours of photo period.

**3.8.6 Litter management**

Dry newspapers were used as litter materials at a considerable depth during the brooding period. After the ends of brooding period birds were replaced in the cage for rearing until the end of experiment. Litter materials were cleaned by dandy brush form the tray and disinfected hygienically with detergent for four times in a day.

**3.8.7 Vaccination and chemo prophylaxis/medication**

All birds were vaccinated properly against Newcastle disease on the 4th days and booster dose again on 14th day according to the following schedule:

**Table 3.8.7.a Schedule of vaccination used during experiment period**

|  |  |  |  |
| --- | --- | --- | --- |
| **Age of birds** | **Name of diseases** | **Name of the vaccines** | **Route of administration** |
| 4th days | New Castle Disease | BCRDV (Live) | One drop in one eye |
| 14th days | Infectious Bursal Disease | IBD(Live) | One drop in one eye |

After each vaccination, Rena -WS multivitamin was supplied at 1g/5 liter of drinking water along with vitamin-C to overcome the stressed effect of vaccination and cold weather.

Chemo prophylactic measures/medication with water soluble vitamins, minerals and electrolyte were used at different ages of birds, details of which are given below:

**Table 3.8.7.b Schedule of chemo prophylaxis/medication**

|  |  |
| --- | --- |
| **Age of the birds (days)** | **Drugs used through water** |
| 1-7 | Rena-WS +Electrolyte + Gluco-C |
| 10-17 | Rena-WS +Electrolyte + Gluco-C |
| 18-28 | Rena-WS +Electrolyte +Ghur + Lemon |

**3.8.8 Bio-security/sanitation**

Drinkers were washed with caustic soda and dried up daily in the morning, and feeders were also cleaned and washed with caustic soda every 3 days after. Potassium permanganate was used for washing the floor & nearer places of the shed. Lime powder and bleaching powder was also used for strict bio-security measures those were followed during the whole experimental period.

**3.9 Record keeping**

Following parameters were recorded throughout the experimental period.

**3.9.1 Body weight**

Body weight of the chicks was recorded at first day and then regular basis at the weekly intervals by a digital weighing balance for whole experimental period.

**3.9.2 Feed intake**

Weekly feed intake was calculated by deducting the left over feeds from the total amount of supplied feed to the broilers.

**3.9.3 Mortality**

Mortality was recorded throughout the experimental period when death occurred in any replication.

**3.10 Calculation of data**

**3.10.1 Body weight gain**

The body weight 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

**3.10.2 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.

**3.10.3 Feed conversion (FC)**

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)

FC =

Weight gain (kg)

**3.10.4 Mortality**

It was calculated on the basis of total number of birds housed and number of birds died during the experimental period. The mortality was expressed in percent.

**3.11 Evaluation of carcass traits**

On day 28, five birds per experimental unit representative of average body weight were selected for the evaluation of carcass traits. Birds were fasted for eight hours, slaughtered, defeathered, and eviscerated. The following traits were evaluated: carcass yield (CY), weight of primal parts (Drumstick, thigh, breast, back, neck, wing and feet) and weight of internal edible offal (Gizzard and proventriculus, heart, liver, abdominal fat and neck fat). Carcass yield (CY) was calculated relative to live weight before slaughter.

Carcass yield (CY) % =

**3.12 Chemical analysis of meat**

For chemical analysis of meat, 50 gm meat sample (breast meat) was collected from each of ten slaughtered broilers of 28 day old (five birds per experimental unit) after evaluation of carcass traits. After collection the samples were preserved in plastic bags. The meat samples were minced, dried in oven and grinded. Crude protein (% CP) and ether extract (% EE) were estimated according to the methodology of AOAC method (AOAC, 2005). In order to know about the protein and fat level of broiler meat as the effect of partial replacement of animal protein by plant protein, only crude protein and ether extract were considered only among other proximate components.

% CP =

% EE =

**3.13 Cost-benefit analysis**

In case of cost analysis, chick cost, total feed cost, management cost and finally total cost were calculated in Taka per bird. Total feed cost included to feed raw materials cost. Management cost included vaccination cost, labour cost, electricity cost, disinfectant cost and litter materials cost. In case of return, market sale price, total sale price and net profit were calculated in Taka per bird.

**3.14 Study design & statistical analysis**

Completely randomized design (CRD) was used as study design. All the data of live weight, weight gain, feed consumption and feed conversion etc., data related to carcass parameters and chemical analysis of meat were entered into MS excel (Microsoft office excel-2007, USA). Data were compared among the groups by one way ANOVA in STATA version-12.1 (STATA Corporation, College Station, Texas). Results were expressed as means and SEM. All P values of <0.05 and <0.01was considered significant and highly significant respectively.

**3.15 Picture gallery related to methodology**

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**Figure 1:** Box brooding of DOC

**Figure 2:** Mixing of feed

**Figure 4:** Broilers in cage

**Figure 3:** Vaccination

**Figure 5:** Weighing of broilers



**Figure 6:** Evaluation of carcass traits



**Figure 7:** Estimation of crude protein

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**Figure 8:** Estimation of ether extract

**Chapter-4: Results**

Different parameters (feed consumption, body weight, body weight gain and feed conversion) were recorded to observe the effect of partial replacement of animal protein by plant protein on growth performance of broilers. Cost-benefit analysis was included in this experiment. At the end of the experiment carcass characteristics were recorded and chemical analysis of broiler meat was also done.

**4.1 Effect of partial replacement of animal protein by plant protein on weekly feed intake of broiler**

Feed consumption by birds was recorded daily and calculated at the end of week.

**Table 4.1.1: Weekly feed intake of broiler among different dietary treatment groups**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Age of Birds**  **(Wks)** | **Mean (gm)** | | **SEM** | **Level of Sig.** |
| **T1** | **T2** |
| **1st** | 184.14 | 238.94 | 3.47 | \*\* |
| **2nd** | 324.13 | 358.23 | 9.59 | \*\* |
| **3rd** | 744.24 | 768.36 | 5.84 | \*\* |
| **4th** | 1000.47 | 1015.56 | 10.50 | NS |

**N.B:** T1 = (Soybean meal + Meat and bone meal + Protein concentrate), T2 = Soybean meal. SEM = Standard error of mean, NS = Non significant at 5% level, \*\* = Significant at 1% level

Table 4.1.1 shows the weekly feed intake of broilers which differed more significantly (P<0.01) between two dietary treatment groups during first three weeks of rearing. The T2 (Soybean meal) treatment group consumed more feed than that of T1 (Soybean meal + Meat and bone meal + Protein concentrate) treatment group.Though no significant difference (P>0.05) was observed statistically between two dietary groups at 4th weeks of age, the T2 (Soybean meal) group ate more feed than that of T1 (Soybean meal + Meat and bone meal + Protein concentrate).

**Table 4.1.2: Cumulative feed intake of broiler between different dietary treatment groups**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Age of Birds (Wks)** | **Mean (gm)** | | **SEM** | **Level of Sig.** |
| **T1** | **T2** |
| **0-1** | 184.14 | 238.94 | 3.47 | \*\* |
| **0-2** | 508.27 | 597.17 | 6.97 | \*\* |
| **0-3** | 1252.51 | 1365.53 | 13.22 | \* |
| **0-4** | 2252.98 | 2381.09 | 15.20 | \* |

**N.B:** T1 = (Soybean meal + Meat and bone meal + Protein concentrate), T2 = Soybean meal. SEM = Standard error of mean, \* = Significant at 5% level, \*\* = Significant at 1% level

From table 4.1.2, it is found that the cumulative feed intake of the broiler of two groups differed more significantly (P<0.01) for the first two weeks of age. However, the difference in cumulative feed intake between two groups was significant (P<0.05) for 0 to 3rd and 0 to 4th weeks. During the entire rearing period (four weeks), the bird of plant protein group (T2) cumulatively consumed more feed than those of animal protein group (T1).

**4.2 Effect of partial replacement of animal protein by plant protein on weekly body weight of broiler**

Live weight of birds was recorded at 1st day and then at the end of each week.

**Table 4.2.1: Weekly body weight of broiler between different dietary treatment groups**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Age of Birds (Wks)** | **Mean (gm)** | | **SEM** | **Level of Sig.** |
| **T1** | **T2** |
| **Day 1** | 38.49 | 37.06 | 0.42 | NS |
| **1st** | 200.02 | 226.7 | 2.99 | \*\* |
| **2nd** | 409.14 | 463.94 | 7.2 | \*\* |
| **3rd** | 857.48 | 915.92 | 12.01 | \*\* |
| **4th** | 1475.06 | 1557.06 | 13.81 | \*\* |

**N.B:** T1 = (Soybean meal + Meat and bone meal + Protein concentrate), T2 = Soybean meal. SEM= Standard error of mean, NS = Non significant at 5% level, \*\* = Significant at 1% level

Table 4.2.1 represents that initially no significant difference (P>0.05) in live weight was observed among birds of two dietary treatment groups. Highly significant difference (P<0.01) in body weights of the broiler was found between two groups at 1st week of age. The treatment group feeding only plant protein showed better body weight than the group feeding both plant and animal protein. Similarly, highly significant differences (P<0.01) were recorded in body weights of the broiler fed two different feed regimes from the 2nd to 4th weeks of age. The broiler of plant protein dietary treatment group gained better body weight than that of the combined plant and animal protein treatment group.

**Table 4.2.2: Cumulative body weight of broiler between different dietary treatment groups**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Age of Birds**  **(Wks)** | **Mean (gm)** | | **SEM** | **Level of Sig.** |
| **T1** | **T2** |
| **0-1** | 200.02 | 226.7 | 2.99 | \*\* |
| **0-2** | 609.16 | 690.64 | 7.19 | \*\* |
| **0-3** | 1466.64 | 1606.56 | 13.78 | \* |
| **0-4** | 2941.7 | 3163.62 | 22.30 | \* |

**N.B:** T1 = (Soybean meal + Meat and bone meal + Protein concentrate), T2 = Soybean meal. SEM = Standard error of mean, \* = Significant at 5% level, \*\* = Significant at 1% level

From table 4.2.2, it is observed that the cumulative body weight of the broiler of two groups differed more significantly (P<0.01) for the first two weeks of age. However, the difference in cumulative body weight between two groups was significant (P<0.05) for 0 to 3rd and 0 to 4th weeks. During the entire rearing period (four weeks), the bird of plant protein group (T2) cumulatively achieved higher live weight than that of the animal protein group (T1).



**Fig 4.2.a: Boxplot of body weight of broiler in two different dietary groups at the end of 4th week**

The figure (Fig 4.2.a) shows the body weight of broilers in two different dietary groups at the end of 4th week in the form of a boxplot. From the boxplot it is observed that 75% of broilers of treatment group T1 achieved average body weight of 1,500 gm and 1,450 gm mean body weight was achieved by the 25% of the broilers. On the other hand, in the plant protein group (T2), the 75% of broilers covered the mean 1,600 gm body weight and the 25% of the broilers scored 1,500 gm body weight on average. According to the boxplot, it can be said that sole plant protein diet group (T2) gained better body weight at the end of 4th week than that of combined (plant and animal protein) diet group and it was also found highly significant (P<0.01).

**4.3 Effect of partial replacement of animal protein by plant protein on weekly body weight gain of broiler**

**Table 4.3.1: Weekly body weight gain (BWG) of broiler between dietary treatment groups**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Age of Birds (Wks)** | **Mean (gm)** | | **SEM** | **Level of Sig.** |
| **T1** | **T2** |
| **1st** | 161.53 | 189.64 | 3.03 | \*\* |
| **2nd** | 209.12 | 237.24 | 7.74 | \*\* |
| **3rd** | 448.34 | 451.98 | 12.24 | NS |
| **4th** | 617.58 | 641.14 | 15.46 | NS |

**N.B:** T1 = (Soybean meal + Meat and bone meal + Protein concentrate), T2 = Soybean meal. SEM = Standard error of mean, NS = Non significant at 5% level, \*\* = Significant at 1% level

Table 4.3.1 demonstrates that highly significant difference (P<0.01) was observed in body weight gain of the broiler feeding two different diets both in 1st and 2nd weeks of age. In these two weeks, combined plant and animal protein group gained less weight than that of the plant protein group. However, numerically higher body weight gain was also observed in plant protein treatment group than that of the combined plant and animal protein treatment group at 3rd and 4th weeks of age but it was not found statistically significant (P>0.05).

**Table 4.3.2: Cumulative body weight gain of broiler between different dietary treatment groups**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Age of Birds**  **(Wks)** | **Diets** | | **SEM** | **Level of Sig.** |
| **T1** | **T2** |
| **0-1** | 161.53 | 189.64 | 3.03 | \*\* |
| **0-2** | 370.65 | 426.88 | 4.52 | \*\* |
| **0-3** | 818.99 | 878.86 | 6.70 | \* |
| **0-4** | 1436.57 | 1520 | 12.20 | NS |

**N.B:** T1 = (Soybean meal + Meat and bone meal + Protein concentrate), T2 = Soybean meal. SEM = Standard error of mean, \* = Significant at 5% level, NS = Non significant at 5% level

From the table 4.3.2, it is shown that the cumulative body weight gain of the broiler of two treatment groups differed more significantly (P<0.01) for first two weeks and significantly (P<0.05) from 0 to 3rd weeks. During 0-1st, 0-2nd and 0-3rd week, the bird fed on only plant protein (T2) showed higher cumulative body weight gain than that of the animal protein group (T1). There was no significant difference (P>0.05) in cumulative BWG between them during 0 to 4th weeks but it was higher numerically in plant protein treatment group.

**4.4 Effect of partial replacement of animal protein by plant protein on weekly feed conversion (FC) of broiler**

**Table 4.4.1: Weekly feed conversion (FC) of broiler between different dietary treatment groups**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Age of Birds (Wks)** | **Mean (gm)** | | **SEM** | **Level of Sig.** |
| **T1** | **T2** |
| **1st** | 1.14 | 1.26 | 0.02 | \*\* |
| **2nd** | 1.55 | 1.51 | 0.00 | \*\* |
| **3rd** | 1.66 | 1.70 | 0.02 | NS |
| **4th** | 1.62 | 1.58 | 0.04 | NS |

**N.B:** T1 = (Soybean meal + Meat and bone meal + Protein concentrate), T2 = Soybean meal. SEM = Standard error of mean, \*\* = Significant at 1% level, NS = Non significant at 5% level

The table 4.4.1 demonstrates the feed conversion(FC) of broilers in two different feed regimes. Feed conversion was better incombined plant and animal protein treatment group than only plant protein treatment group and the difference between them was also highly significant (P<0.01). However, with the advancement of age feed conversion gradually became better in plant protein treatment group. At the 2nd week of age significantly higher (P<0.01) feed conversion was found in combined protein treatment group and plant protein treatment group showed better feed conversion. On the contrary no significant difference (P>0.05) was observed at 3rd and 4th weeks of age between two treatment groups.

**Table 4.4.2: Cumulative feed conversion (FC) of broiler in different dietary treatment groups**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Age of Birds**  **(Wks)** | **Mean (gm)** | | **SEM** | **Level of Sig.** |
| **T1** | **T2** |
| **0-1** | 1.14 | 1.26 | 0.02 | \*\* |
| **0-2** | 1.37 | 1.40 | 0.01 | NS |
| **0-3** | 1.52 | 1.55 | 0.01 | NS |
| **0-4** | 1.57 | 1.56 | 0.01 | NS |

**N.B:** T1 = (Soybean meal + Meat and bone meal + Protein concentrate), T2 = Soybean meal. SEM = Standard error of mean, \*\* = Significant at 1% level, NS = Non significant at 5% level

The table 4.4.2 demonstrates the feed conversion(FC) of the broiler in two different feed regimes. The difference in cumulative FC of the broiler during first week of age (0-1 w) was found more significant (P<0.01). The feed conversion of combined plant and animal protein group (T1) was better than that of plant protein group (T2) for first week age. However, the cumulative feed conversion of plant protein group became better than that of animal protein group for the time period of 0 to 4th weeks but it was not found statistically significant (P>0.05) .

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**Fig 4.4.a: Boxplot of feed conversion of broiler in two different dietary groups at the end of 4th week**

If the data of FC of broilers at the end of 4th week, are plotted in a form of a boxplot (Fig4.4.a); it will find that 75% of the broilers in group T1 (Soybean meal + Meat and bone meal + Protein concentrate) achieved average FC 1.75 and the 75% of the broilers in group T2 (Soybean meal) achieved average FC 1.68 which is better than that of T1 group. The boxplot also exhibits the mean FC 1.5 was gained by the 25% birds of the T1 group, whereas the mean value of FC 1.45 was gained by the 25% birds of the group T2 which is better than that of T1. Though the FC at the end of 4th week was better in T2 (Soybean meal) than T1 (Soybean meal + Meat and bone meal + Protein concentrate) group, statistically it was found no significant (P>0.05).

**4.5 Effect of different diets on carcass characteristics of broiler**

The following tables (4.5.1 and 4.5.2) represent the carcass characteristics of birds fed two different diets.

**Table 4.5.1: Final body weight, eviscerated weight and carcass yield of broiler among different dietary treatment groups at 28th day of age**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Traits** | **Mean** | | **SEM** | **Level of Sig.** |
| **T1** | **T2** |
| **Final body weight (gm)** | 1479 | 1541 | 10 | NS |
| **Eviscerated weight (gm)** | 1050.4 | 1071.8 | 5.75 | NS |
| **Carcass yield (CY) %** | 71.07 | 69.50 | 1.54 | NS |

**N.B:** T1 = (Soybean meal + Meat and bone meal + Protein concentrate), T2 = Soybean meal. SEM = Standard error of mean, NS = Non significant at 5% level

**Table 4.5.2: Weight of primal parts and internal edible offal of broiler among different dietary treatment groups at 28th day of age**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Traits** | **Mean (gm)** | | **SEM** | **Level of Sig.** |
| **T1** | **T2** |
| **Primal Parts** | | | | |
| **Drumstick** | 63 | 64.8 | 3.12 | NS |
| **Thigh** | 67.6 | 67.8 | 5.69 | NS |
| **Breast** | 261.2 | 267.8 | 7.28 | NS |
| **Back** | 170 | 166.4 | 5.96 | NS |
| **Neck** | 37.6 | 36.6 | 1.54 | NS |
| **Wing** | 39.8 | 42.2 | 3.17 | NS |
| **Feet** | 61 | 60.4 | 3.19 | NS |
| **Internal Edible Offal** | | | | |
| **Gizzard and proventriculus** | 61.4 | 68 | 3.01 | NS |
| **Heart** | 9 | 8.6 | 5.56 | NS |
| **Liver** | 45.8 | 44.8 | 3.14 | NS |
| **Abdominal Fat** | 4.39 | 3.18 | 0.46 | \* |
| **Neck Fat** | 11.8 | 19.2 | 2.77 | NS |

**N.B:** T1 = (Soybean meal + Meat and bone meal + Protein concentrate), T2 = Soybean meal. SEM = Standard error of mean, NS = Non significant at 5% level, \* = Significant at 5% level

There were no significant differences (P>0.05) between two dietary treatment groups in case of different carcass parameters i.e. eviscerated weight, carcass yield, weight of primal parts (drumstick, thigh, breast, back, neck, wing and feet) and weight of internal edible offal (Gizzard and proventriculus, heart, liver and neck fat) of broilers at 28th day of age. There was significant difference (P<0.05) between diets was found in the case of the fat-building effect (evaluated directly on the basis of the weight of abdominal fat) and the weight of abdominal fat was less in birds of plant protein group (T2) than that of animal protein group (T1). However, slightly improved breast meat (gm/bird) was observed in the birds when they offered plant-based diets (T2) but the difference was not significant (P>0.05).

**4.6 Effect of partial replacement of animal protein by plant protein on protein and fat content of meat of broiler**

**Table 4.6 Estimated protein and fat content of meat of broiler**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Traits** | **Mean (%)** | | **SEM** | **Level of Sig.** |
| **T1** | **T2** |
| **Crude protein** | 20.76 | 21.75 | 0.76 | **\*** |
| **Ether Extract** | 2.45 | 2.44 | 0.44 | NS |

**N.B:** T1 = (Soybean meal + Meat and bone meal + Protein concentrate), T2 = Soybean meal. SEM = Standard error of mean, NS = Non significant at 5% level, \* = Significant at 5% level.

Table 4.6 represents the protein and fat contentof broiler meat. There was found significant (P<0.05) difference in case of % crude protein (CP) level of meat of broilers fed on two different diets. The % CP level of meat of broiler of treatment group based on plant protein source was higher than that of treatment group based on animal protein source. On the other hand, there was found no effect of two different diets on the % ether extract(EE) level of the broiler meat. Though the % EE level of broiler meat of animal protein based treatment group was found little higher numerically than that of plant protein based treatment group, it was not significant (P>0.05) statistically.

**4.7 Cost- benefit analysis between two different treatment groups**

**Table 4.7 Cost- benefit analysis between two different treatment groups**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Parameters** | **Mean** | | | **SEM** | **Level of sig.** |
| **T1** | **T2** | |
| Chick cost (Tk./Chick) | 38.00 | 38.00 | | 0 | NS |
| Total feed cost  (Tk./Kg) | 35 | 33 | | 0.01 | **\*** |
| Management cost (Tk./broiler) | 16 | 16 | | 0 | NS |
| Total feed cost  (Tk./broiler) | 85.33 | 83.40 | | 0.51 | \* |
| Total cost  (Tk./broiler) | 139.33 | 137.4 | | 0.51 | \* |
| Total cost  (Tk./Kg live broiler) | 123.74 | 119.32 | | 1.37 | \* |
| **Return** | | | | | |
| Market sale price  (Tk./Kg broiler) | 135 | | 135 | 0 | NS |
| Total sale price (Tk./broiler) | 162.51 | | 165.84 | 1.6 | \* |
| Net Profit (Tk./broiler) | 23.18 | | 28.44 | 1.4 | \* |
| Net Profit  (Tk./Kg live broiler) | 9.36 | | 9.78 | 0.2 | \* |

**N.B:** T1 = (Soybean meal + Meat and bone meal + Protein concentrate), T2 = Soybean meal. SEM = Standard error of mean, NS = Non significant at 5% level, \* = Significant at 5% level. Total feed cost included to feed raw materials cost, Management cost included vaccination cost, labour cost, electricity cost, disinfectant cost and litter material cost.

The table 4.7 shows the cost- benefit analysis between two different treatment groups. There were significant (P<0.05) differences in total feed cost, total cost, total sale price and net profit between two dietary treatment groups. The total feed cost (Tk./broiler) was higher in animal protein based diet than that of plant protein based diet. From the economic perspective, the plant protein dietary group earned more profit (P<0.05) than that of both plant and animal protein dietary group.

**Chapter-5: Discussion**

**5.1 Effect of partial replacement of animal protein by plant protein on weekly feed Intake (FI) of broiler**

The research showed that the feed intake of the broiler chicken was significantly higher (P<0.01) in plant protein group than that of animal protein group from 1st to 3rd weeks of age while no significant difference (P>0.05) was observed at the end of 4th week of age (Table 4.1.1). On the other hand, in case of cumulative feed consumption of broiler, there found significant difference (P<0.05) from 0 to 4th weeks of rearing period (Table 4.1.2). During the entire rearing period (four weeks), the bird of plant protein group consumed more feed than those of animal protein group. The result of average feed intake and weight gain positively correlate with one another. The feed intake of this study was in disagreement with opinions of Ra'fat (2008), Alali et al. (2011), Hossain et al. (2014), Hossain and Iji(2015). Ra'fat (2008) found no significant difference in feed intake of birds between plant and animal protein based diets. Increased feed intake was found in birds of animal protein group than that of plant protein group by Hossain et al. (2014), Hossain and Iji(2015). The reason behind such disagreement may be due to some factors like poor quality of animal protein sources, feed preference, ventilation, climate condition etc which might influence the feed intake of birds in this experiment. Khatun et al. (2003); Karimi (2006) reported that poor processing, contamination, use of chemical preservatives in production of animal by products often cause toxicity to poultry birds which may result in reduced feed intake. The variability in the nutrient profile of meat and bone meal could be lead to unwanted variability in poultry performance and thus reduced feed intake.

**5.2 Effect of partial replacement of animal protein by plant protein on weekly body weight (BW) of broiler**

The results of this experiment demonstrated that highly significant difference (P<0.01) was found in body weight of the bird fed on two different diets for 28 days of rearing period (Table 4.2.1). At the same time, in case of cumulative body weight of the broiler, there was found significant difference (P<0.05) between two treatment groups from 0 to 4th weeks of age (Table 4.2.2). The bird fed on solely plant protein diet achieved increased body weight (BW) than that of the bird fed on animal protein diet throughout the rearing period. These findings are supported by previous findings of Cancherini et al. (2004); Caires et al. (2010). They suggested that vegetable protein (soybean meal) might be used for increased body weight of the broiler. On the other hand, the result differs from some earlier observations of Ra'fat **(**2008); Hossain et al. (2013); Hossain and Iji (2015). Bellaver et al. (2005) and Ra'fat (2008) found no significant differences (P>0.05) in body weights of broilers fed on animal and plant protein diets during their experimental periods. Hossain et al. (2013); Hossain and Iji(2015) reported that the broiler reared on animal protein diet gained better body weight than that of broiler reared on plant protein diet. The type of contrast in findings of the previous authors’ with the finding of this experiment might happen due to some reasons like strain, housing and management systems, supplementation of essential amino acids and macronutrients with the plant protein diet, quality and processing of meat and bone meal and protein concentrate. Shirley and Parsons (2001) reported that due to poor quality and processing of animal by products, the reduced digestibility of protein might happen and thus might reduce the body weight of broiler.

**5.3 Effect of partial replacement of animal protein by plant protein on weekly body weight gain (BWG) of broilers**

In this study, broiler chicks on the different feeding regimes developed more significant difference (P<0.01) in body weight gain at the end of 1st and 2nd week (Table 4.3.1) and significant difference (P<0.05) in cumulative body weight gain for 0 to 3rd weeks of rearing (Table 4.3.2). There were no significant difference (P>0.05) made in BWG and cumulative BWG at the later stage of rearing (3rd and 4th week) and these are supported by the earlier reports by authors (Ra'fat,2008; Hossain et al., 2014). The broiler of plant protein diet gained increased BWG than that of animal protein group for 0 to 3rd weeks of rearing which was in contrary of the reports done by the researchers (Ra'fat,2008; Hossain et al., 2014 and Hossain and Iji,2015). Ra'fat(2008) found no significant difference in BWG of broilers fed on animal and plant protein diets during the early growing period (hatch to 14th day). The bird fed on the animal protein diet get better BWG than those that were fed solely on vegetable protein diets at the earlier stage of growth (Hossain et al., 2014). This kind of difference may occur due to the poor quality of animal protein, environment of rearing, the breed variation, strain etc (Bellaver, 2001; Shirley and Parsons, 2001).

**5.4 Effect of replacement of animal protein by plant protein on weekly feed conversion (FC) of broilers**

Initially feed conversion was better inanimal protein treatment group than plant protein treatment group and the difference between them was also highly significant (P<0.01) (Table 4.4.1). No significant difference (P>0.05) was observed at 3rd and 4th weeks of age between two treatment groups. However, feed conversion became better numerically in plant protein treatment group at 3rd and 4th weeks of age. The cumulative feed conversion of plant protein group became better numerically than that of animal protein group for the time period of 0-4 weeks but it was not found statistically significant (P>0.05) (Table 4.4.2). The results of mean feed intake, weight gain, FC correlate with each other. The findings are not similar to the findings of the previous authors (Ra'fat,2008; Hossain et al., 2014; Hossain and Iji, 2015). They found better FC in case of birds fed on animal protein diet. The reason behind the dissimilarities might be the bioavailability of nutrients from ration based on plant protein might have been better as compared to the other ration. Shirley and Parsons (2001) reported that meat and bone meal supplementation in diet might have negative effect on FC due to lower protein quality and nutrient digestibility of meat and bone meal as far contained high ash.

**5.5 Effect of partial replacement of animal protein by plant protein on carcass characteristics of the broiler**

No significant differences (P>0.05) in carcass weight (except weight of abdominal fat) and carcass yield between the plant and animal protein groups of broiler chickens were found (Table 4.5.1, 4.5.2). These results are consistent with the former reports of the scientists (Junqueira et al., 2000; Faria Filho et al., 2002; Suchý et al., 2002; Al-Masri, 2003, 2006; Caires et al., 2010; Xavier et al., 2011, 2012; Hossain et al., 2013). The value of dressing percentages obtained is consistent with the range of 65-70% reported by Oluyemi and Roberts (2007).

There was significant difference (P<0.05) between diets was found in the case of the fat-building effect (evaluated directly on the basis of the weight of abdominal fat) and the weight of abdominal fat was less in birds of plant protein group than that of animal protein group. The result is similar with the result of the report by the author, Hossain et al.(2015), who observed significantly increased abdominal fat content when broiler fed diets containing animal protein than that of plant protein.

However, slightly improved breast meat (gm/bird) was observed in the birds when they offered plant-based diets (T2) but the difference was not significant (P>0.05). Similar response was also found by Al-Ostwani et al. (2000), who reported improved relative weight of breast muscle in broilers fed plant-based diets containing corn, barley, soy bean and cotton seed meal.

**5.6 Effect of partial replacement of animal protein by plant protein on protein and fat content of meat of broiler**

The result showed that % CP level of meat of broiler fed on plant protein diet was higher than that of birds fed on animal protein diet and the difference between two dietary treatment groups was significant (P<0.05) (Table 4.6). There was no significant difference (P>0.05) found in the % EE of meat of broilers fed two different diets. The result of this study is similar with the results of the author (Ali et al., 1993). The result of % CP level might be correlated with the feed intake and body weight gain of the broilers fed two different diets. The digestibility co efficient for amino acids in SBM is greater than 90% whereas for animal protein meals, it is much lower (Parsons et al., 1991). The digestible amino acids might lead to increased protein levels in meat of broilers fed plant protein diet than that of animal protein diet.

**5.7 Cost and benefit analysis**

There were significant (P<0.05) differences in total feed cost, total cost, total sale price and net profit between two dietary treatment groups (Table 4.7). The total feed cost (Tk./broiler) was more in animal protein based diet than that of plant protein based diet due to higher price of animal protein sources. From the economic view, the plant protein dietary group generated more profit than that of animal protein dietary group. The findings are consistent with the previous works of the researchers (Oluyemi and Roberts, 2000;Blair, 2008; Chadd, 2008). A critical cost appraisal of poultry feed formulations shows that protein of animal origin is more expensive than vegetable protein sources (Oluyemi and Roberts, 2000;Blair, 2008; Chadd, 2008). The lowest profit margin from broilers fed on animal protein based diet might be correlated with its high feed cost, poor feed intake, poor body weight gain than broilers fed on plant protein based diet.

**Chapter-6: Conclusion**

This study was designed to assess the effect of partial replacement of animal protein by plant protein on production and carcass traits of broilers. For this purpose soybean meal was fed as plant protein; meat and bone meal and protein concentrate were fed as animal protein to the broilers. To interpret the result, records of weekly body weight, weekly feed intake, weekly body weight gain, weekly feed conversion, carcass yield and weight were kept and finally chemical analysis of broiler meat was done. Overall results indicate that the broilers fed on only plant protein (soybean meal) consumed more feed, gained better body weight and feed conversion than the broilers fed on both plant and animal protein diet. The bird fed on plant protein diet accumulated less fat in abdomen than that of animal protein diet. In chemical analysis higher crude protein content was found in meat of broiler fed on only plant protein (soybean meal) than that of another dietary treatment group. More profit was earned from selling of birds of plant protein group than those of combined plant and animal protein dietary treatment group. So it may be concluded that plant protein i.e. soybean meal may be used as the protein source that can partially replace the sources of animal protein for fattening of the broiler without any adverse effect on productive performance and thus may be able to serve quality, healthy, lean meat for human.

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

In present experiment it is revealed that supplementation of solely plant protein increases market weight of broilers. Though it is a pilot study, further studies may be conducted on similar field to make a concrete remark. However, according to this research work, the following recommendations may be done:

* Animal protein in broiler diet may be replaced partially by soybean meal and the inclusion level could be up to 35%.
* Farmers may be able to reduce their production cost mainly feed cost and thus gain more profit in broiler farming.

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**APPENDICES**

**Appendix A.**Ingredients and calculated nutritive composition of the experimental broiler diets on different treatment groups

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Ingredients**  **(kg/100kg)** | **Starter ration (0-14 days)** | | **Grower ration (15-28 days)** | | |
| **T1** | **T2** | **T1** | | **T2** |
| Maize | 60 | 51 | 59 | | 60 |
| Broken Wheat | 3.2 | 6.8 | 5 | | 1.5 |
| Rice Polish | 1 | 1.2 | 1 | | 1 |
| Molasses | 1 | 1 | 1 | | 1 |
| **Soybean meal** | **24** | **35** | **24** | | **32.5** |
| **Meat and bone meal** | **3** | **0** | **2** | | **0** |
| **Protein Concentrate** | **5** | **0** | **4** | | **0** |
| Soybean oil | 1.4 | 3 | 2.6 | | 3 |
| Limestone | 0.353 | 1.01 | 0.43 | | 0.15 |
| Salt | 0.25 | 0.25 | 0.25 | | 0.25 |
| Vitamin mineral premix | 0.25 | 0.25 | 0.25 | | 0.25 |
| DCP | 0.15 | 0.06 | 0.073 | | 0.008 |
| L-lysine | 0.1 | 0.263 | 0.1 | | 0.205 |
| DL-Methionine | 0.2 | 0.07 | 0.2 | | 0.04 |
| Maduramycin | 0.06 | 0.06 | 0.06 | | 0.06 |
| Enzyme | 0.025 | 0.025 | 0.025 | | 0.025 |
| Antioxidant | 0.012 | 0.012 | 0.012 | | 0.012 |
| Total | 100 | 100 | 100 | | 100 |
| **Parameters** | **Estimated chemical composition (DM basis)** | | | | |
| ME(Kcal/kg) | **3007.44** | **3006.39** | **3086.45** | **3080.90** | |
| CP (gm/100gm) | **21.51** | **21.51** | **20.51** | **20.54** | |
| CF(gm/100gm) | 3.191 | 3.5 | 3.17 | 3.4 | |
| EE (gm/100gm) | 3.53 | 2.88 | 3.36 | 3.01 | |
| Ca (gm/100gm) | 0.96 | 0.54 | 0.79 | 0.51 | |
| P (gm/100gm) | 0.59 | 0.49 | 0.55 | 0.47 | |
| Lysine (gm/100gm) | 1.3 | 1.27 | 1.20 | 1.15 | |
| Methionine (gm/100gm) | 0.74 | 0.59 | 0.71 | 0.5 | |

**N.B:** T1 = (Soybean meal + Meat and bone meal + Protein concentrate), T2 = Soybean meal. SBM=Soybean meal, MBM=Meat and bone meal, PC=Protein concentrate**,** ME-Metabolizable energy, CP-Crude protein, CF-Crude fibre, EE-Ether extract, Ca-Calcium, P-Phosphorus; 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.

**Appendix B.** Cost of different items on different treatment groups

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Treat.** | **Rep.** | **Chick cost (Tk./b)** | **Total feed cost (Tk./kg)** | **Total feed cost (Tk./b)** | **Management cost (Tk./b)** | **Total cost (Tk./Kg live b)** | **Total cost (Tk./b)** |
| **T1** | **R1** | 38.00 | 35 | 84.5 | 16 | 120 | 138.5 |
| **R2** | 38.00 | 35 | 85.5 | 16 | 121.50 | 139.5 |
| **R3** | 38.00 | 35 | 88 | 16 | 130 | 142 |
| **R4** | 38.00 | 35 | 83.65 | 16 | 125 | 137.65 |
| **R5** | 38.00 | 35 | 85 | 16 | 122.20 | 139 |
| **Mean** | **38.00** | **35** | **85.33** | **16** | **123.74** | **139.33** |
| **T2** | **R1** | 38.00 | 33 | 80.5 | 16 | 108.50 | 134.5 |
| **R2** | 38.00 | 33 | 88.5 | 16 | 120.10 | 142.5 |
| **R3** | 38.00 | 33 | 82.75 | 16 | 130 | 136.75 |
| **R4** | 38.00 | 33 | 80.25 | 16 | 110 | 134.25 |
| **R5** | 38.00 | 33 | 85 | 16 | 128 | 139 |
| **Mean** | **38.00** | **33** | **83.40** | **16** | **119.32** | **137.4** |

**N.B:** T1 = (Soybean meal + Meat and bone meal + Protein concentrate), T2 = Soybean meal.

**Appendix C.** Return from different treatment groups

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Treat.** | **Rep.** | **Market sale price (Tk./Kg broiler)** | **Total sale (Tk./broiler)** | **Net Profit (Tk./broiler)** | **Net Profit (Tk./Kg live broiler)** |
| **T1** | **R1** | 135 | 150.79 | 12.29 | 8.5 |
| **R2** | 135 | 165.5 | 26 | 9.5 |
| **R3** | 135 | 170.7 | 28.7 | 10.3 |
| **R4** | 135 | 155.56 | 17.91 | 9.5 |
| **R5** | 135 | 170 | 31 | 9 |
| **Mean** | **135** | **162.51** | **23.18** | **9.36** |
| **T2** | **R1** | 135 | 160 | 25.5 | 9 |
| **R2** | 135 | 178.8 | 36.3 | 12 |
| **R3** | 135 | 160.4 | 23.65 | 10 |
| **R4** | 135 | 170 | 35.75 | 9 |
| **R5** | 135 | 160 | 21 | 8.9 |
| **Mean** | **135** | **165.84** | **28.44** | **9.78** |

**N.B:** T1 = (Soybean meal + Meat and bone meal + Protein concentrate), T2 = Soybean meal.

**Appendix D.** Chemical analysis of meat of broilers on different treatments

|  |  |  |  |
| --- | --- | --- | --- |
| **Treatments** | **Replications** | **Crude Protein (CP) %** | **Ether Extract (EE) %** |
| **T1** | **R1** | 19.87 | 1.95 |
| **R2** | 20.49 | 2.5 |
| **R3** | 21.85 | 1.5 |
| **R4** | 20.64 | 3 |
| **R5** | 20.95 | 3.28 |
| **Mean** | **20.76** | **2.45** |
| **T2** | **R1** | 20.5 | 1.95 |
| **R2** | 24 | 2.5 |
| **R3** | 22.58 | 1.5 |
| **R4** | 19.8 | 3 |
| **R5** | 21.86 | 3.25 |
| **Mean** | **21.75** | **2.44** |

**N.B:** T1 = (Soybean meal + Meat and bone meal + Protein concentrate), T2 = Soybean meal.

**Brief biography of the author**

Aditi Dey Mau completed her graduation degree on Doctor of Veterinary Medicine (DVM) from Chittagong Veterinary and Animal Sciences University (CVASU), Bangladesh. As an intern student she received clinical training from Madras Veterinary College and Research Institute of Tamilnadu Veterinary and Animal Sciences University, India. Aditi has a great enthusiasm in research and has done some epidemiological research works. In order to detect prevalence and associated risk factors of Infectious Bursal Disease (IBD) in broiler, she has performed several post mortems of birds and also different biochemical tests in affected broilers during her internship at Upazilla Veterinary Hospital, Kotoali, Chittagong. She has studied to assess the quality of commercial layer feed and home-made mixed layer feed used in different commercial layer farms and also has made cost-benefit analysis of those feeds. She wants to work more on poultry especially on layer birds. Her research interest is to provide quality and less costly layer feed by using unconventional feed ingredients for poultry by making them conventional one.