**Chapter - I**

**INTRODUCTION**

Commercial broiler farming is a rapidly growing and highly demanding agricultural sector in Bangladesh. Broiler chicken provides tender meat for human consumption within a short period of time. The popularity of broiler meat is increasing day by day. For the production of broiler meat diets and dietary ingredients are most important. Corn serves as the major energy ingredient in the diets of most livestock and especially non-ruminants like poultry. In broiler production, corn accounts for approximately 55% of the feed (Mourao ***et al*.,** 2008).

Ninety percent of corn is being imported into Bangladesh. This has had a major impact on the livestock and poultry industries. A decrease in the availability of corn and an increase in the price for feed have a direct impact on the broiler industry worldwide **(Ayuk**, 2004), and in some cases, production output is reduced **(Donohue and Cunningham**, 2009). An increase in the price of grains and the cost of producing poultry meat and eggs increased significantly resulting in a decreased ability of some of the world's population to purchase and consume chicken meat (**Aho**, 2007). In order to compensate for this change, alternative feed ingredients must be identified **(Agwunobi**, 1999).

The new ingredients must be able to substitute for corn totally or partially and not have a negative impact on the efficiency of broilers; that is, it must not reduce feed efficiency, dressing percentage, and must produce a product of the same or superior quality (**Ojewola *et al*.,**  2006). Several studies have evaluated the use of possible alternative feed ingredients; however, more extensive feed trials must be done in order to meet the requirements set forth by the National Research Council.

One possible alternative is potato (Solanum tuberosum L.). It is a root crop produced in most countries and is consumed mainly as a starch source in the diet of humans but is also rich in other important nutrients (**Dominguez,** 2010). The storage roots of potato are a valuable source of carbohydrates, vitamins, and micro-nutrients. Potato is an extensively cultivated annual crop in Bangladesh. In some years, when the production of potato is surplus, tons of potatoes are damped due to insufficient storage facilities. Presently Potato is being grown exclusively for human consumption, while its foliage has always been considered as forage (Dominguez, 2009). Its main nutritional importance has been its starch content; however, nutrients such as [**vitamin A**](http://www.scialert.net/asci/result.php?searchin=Keywords&cat=&ascicat=ALL&Submit=Search&keyword=vitamin+A)**,**[**ascorbic acid**](http://www.scialert.net/asci/result.php?searchin=Keywords&cat=&ascicat=ALL&Submit=Search&keyword=ascorbic+acid)**,** thiamine, riboflavin and niacin are also adequate. Carbohydrates constitutes about 80-90% of dry weight of the tuber. Potato has been evaluated as a source of energy in the diets of pigs **(Lee** ***et al.,*** *1977****;*** **Lee and Yang**,1979**;** **Manfredini** ***et al.,*** *1990****;*** **Rose and White,**1980; **Wu,**1980**)**, however It is not known what levels of inclusion will produce the same quality product that is now produced by the broiler industry. Also, limited information is available on the impact on meat quality (**Agwunobi**, 1999). Therefore, the objectives of this study is to evaluate the effects of potato meal on productive performance and carcass characteristics in broiler.

**1.1 Justification of the study**

Potato meal is an important alternative energy ingredient in poultry nutrition because of high carbohydrate content and comparatively less cost than other energy sources. Thus, incorporation of the inclusion levels of potao meal instead of other energy sources in poultry diets might reduce feed cost. Limited studies are available regarding optimum levels of potato meal for high performing broiler in the contemporary environment of Bangladesh. Additionally, carcass quality and feed intake parameter of broiler birds fed diet supplemented with varying levels of potao meal as the source of energy are scarce.

**1.2 Research questions**

1.2.1 What is the effect of Potato Meal(PM) on productive performance of broiler?

1.2.2 Which level of PM can easily be added to diets without decreasing performance of broiler?

1.2.3 Does PM have any effect on feed intake of broiler?

1.2.4 Does PM have any effect on carcass characteristics of broiler?

**1.3 Scope of the study**

Development of sustainable feeding strategy to use various levels of PM substitution with maize and carcass characteristics in commercial broiler. Studying the feasibility and effectiveness of using various levels of PM in diets for broiler chickens and to elucidate possible problems that might be associated with such practice.

**1.4 Specific objectives**

1.4.1 To estimate the effects of different levels of PM on feed intake, weight gain and FCR in commercial broiler.

1.4.2 To measure the effects of various levels of PM on carcass characteristics in commercial broiler.

**Chapter - II**

 **REVIEW OF LITERATURE**

 **2.1 Background**

Poultry is an important source of protein to the ever expanding population in rural areas. Poultry meat and egg are the cheapest sources of high quality animal protein. and good source of essential polyunsaturated fatty acids (PUFAs), especially rich in omega (n)-3 fatty acids (**Anonymus**, 2013). Poultry meat contains lower level of fat compared to those of other animal protein. These factors contribute to the high demand for poultry meat and egg and motivate farmers to expand their present level of poultry farm and establish new one. The cost of feed has been indicated by farmers in the smallholder sector as the major constraint in poultry production **(Munyawu *et al*.,** 1998). For the formulation of poultry feed, corn (cereal) is the conventional choice of carbohydrate sources due to its high energy, low fibre, higher palatability, and the presence of pigments and essential fatty acids (**Panda *et al*.,** 2014). It possesses about 50–60% portion in total diet. Inclusion of corn meets up to 70% energy and 30% protein-dietary requirements (**Panda *et al*.,** 2014). However, its applications for use in food industries (such as beverage, juice, soup, and sauce) in respect of human consumption and in bio-fuel have been expanding rapidly. These competing demands for the corn result in inadequate supply, thus leading to a high price of poultry products (**Kreutzer *et al*.**, 2012; **Mozafari *et al*.,** 2013). As a results the poultry producers have experienced a rise in the cost of production due to the increasing cost of feed.

 To lower the production cost of poultry products (egg, meat, etc.), an alternative energy source for the poultry feed has been investigated which is lower in cost. In fact, the ingredient should be able to substitute corn totally or partially and not have any negative impact on the efficiency and the cost of poultry production (**Agwunobi *et al*.,** 1999 **, Ojeola *et al*.,** 2006 ). Many alternative ingredients, such as water yam (**Aina *et al*.,** 1997), cassava root meal **(Sultan *et al*.**, 2012 , **Sultana** **et al,** 2011), pearl millet (**Elrazig *et al*.,** 1998), sweet potato (**Ayuk *et al*.,** 2009 , **Beckford *et al*.,** 2015, **Mozafari *et al*.,** 2013 ), etc. have been investigated and reported. It was also demonstrated that these cereals are deficient in certain essential amino acids, especially lysine and tryptophan, which are very important for the hens to grow healthily. (**Mozafari *et al*.,** 2013; **Panda *et al*.,** 2014). Moreover, most of these available alternatives either suffer from processing complexity, such as mouldiness, and dustiness, or contain anti-nutrition factors, such as cyanogenic glycosides in cassava (**Sultan *et al*.,** 2012). Our aim of this study is to find the usefulness of potato (Solanum tuberosum L.) as an alternative of corn. As far as nutritious value is concerned, it contains substantially greater amount of all essential amino acids, especially lysine (**Dannielle *et al*.,** 2011). Potato (fresh basis) contains approximately 20–25% dry matter with 12% crude protein (50% pure) (**Mozafari *et al*.,** 2013). It contains reasonably high amounts of most amino acids but is deficient in tryptophan and sulphur containing amino acids (**Morrison *et al*.,** 1961). It is to be noted that synthetic amino acids as supplement in dietary ration could be added to meet the feeding requirement. It is also an important source of both macro and micro minerals. Of the minerals, potassium, phosphorus, magnesium, sulphur, chlorine, iron, and zinc are found in larger quantities. Although calcium, phosphorus and iron are not present in significantly higher amounts, but even with limited contents, they can still provide important nutritional value to potato (**Ahmed** ***et al*.,** 1997). Potato also contains a variety of vitamin groups such as, A, B, C (27–36/100 mg) and I3, while cereal does not (**Ahmed** ***et al*.,** 1997).

 Moreover, potato is an extensively cultivated annual crop in Bangladesh showing higher productivity (16.68 t/ha versus that of maize at 4.97 t/ha) with shorter harvesting period (90 days for potato compared to 140 days for maize). As a result, the cost of potato is significantly lower (four times lower than corn) in Bangladesh (**Azimuddin** ***et al*.**, 2009, **BBS**, 2012). The production of potato is surplus in Bangladesh, and several tons of unused potato are dumped each year due to insufficient storage facilities. It would greatly benefit the potato farmers if potato could be used in poultry ration. It should be noted that 90% of corn is being imported into Bangladesh. This also leads to serious adverse effects on nation’s gross domestic product (GDP). We believe that the results from this study would significantly contribute to the nation’s GDP where corn production is not so great as that of potato.

**2.2 Alternative feed ingredients as energy sources**

Corn is the most commonly used feed ingredient in commercial poultry diets. Corn is mostly imported in Bangladesh from other countries. In abroad demand for corn has increased with the use of corn in ethanol and other brewery products. For that the price of corn has increased. This has increased the interest in alternative feed ingredients as energy source for use in poultry diets. There are some energy sources given below.

**Oats**

Oats are more tolerant of wet weather and acidic soils than wheat or barley. Oats also requare less agrochemical and fertilizer input. There has been renewed interest in oats as a feed ingredient (**Jacob *et al*., 2015).**

**Spelt Wheat**

Spelt is an ancient wheat species that shows a higher resistance to environmental influences than common wheat (**Jacob *et al*., 2015).**

**Potato**

Potato is an important energy source for use in poultry diets as the production of it high in Bangladesh . This is good source for energy bt its water percentage is high in raw potato. So it should be use as potato meal by drying under sunlight (J**acob *et al*., 2015).**

**Rye**

Rye is versatile crop. It can be grown as forage for cattle and other ruminant livestock or as a green manure in crop rotations in organic farming. It can also be grown for grain that can be used as a feed ingredient for alcohol distillation or for human consumption (**Jacob *et al*., 2015).**

**Triticale**

Triticale is a hybrid developed by crossing wheat and rye.It is reported to grow well in regions not suitable for corn or wheat (**Bhuiyan** ***et al*.**, 2011).

**Pearl Millet**

Pearl millet is typically resistant to drought and heat , so it is grown widely in tropical region of Asia.Some pearl millet is also grown in Africa and USA (**Jacob *et al*., 2015).**

**Quinoa**

Quinoa is a pseudocereal grown for its edible seeds .It is not a member of the grass family (and therefore is not a cereal) and is more closely related to species such as beets and spinach (**Jacob *et al*., 2015).**

**Spent Brewers Grains**

Brewers grains are a by-product of beer making.Beer is the fifth most consumed drink in the world,surpassed only by tea,carbonate drinks,milk and coffee (**Jacob *et al*., 2015).**

**Buckwheat**

Buckwheat is often grouped with the cereals,but it is actually not a cereal.It has a cereal like fruit seed that is related more closely to rhubbarb than to cereals.It is often referred to as a pseudocereal.Buckwheat is a summer annual that has a potential role in organic crop production (**Jacob *et al*., 2015).**

**Rice bran**

Rice bran is high in fiber and low in energy.Rice bran also contains the antinutritional factor trypsin inhibitor.As a result,it is recommended that rice bran make up no more than 10% to 15% of the total content of a poultry diet (**Jacob *et al*., 2015).**

**2.3 Potato production in Bangladesh**

 Potato is widely cultivated in all the districts of Bangladesh during winter. Of the total 3,36,740 acres (1,36,332 ha) of land used for potato cultivation during 1997-98, 1,13,540, 2,18,445, and 4,755 acres were for local, high yielding, and Indian varieties respectively. Well-fertilized, sunny land with sufficient moisture in soil is appropriate for potato plantation. The first fortnight of November is the right time. In certain northwestern areas, farmers even plant potato in October to harvest the crop early. Virtually all potatoes in this country are planted manually. On the basis of the soil quality and potato variety farmers determine the spacing in between the seed tubers and the adjacent rows. Row spacing is usually from 45 to 60 cm. Optimum depth of planting depends on temperature and moisture of the soil, probable weather following planting, and mode of conducting field operations later. If planting is shallow and only about 5 cm deep, the soil must be gradually ridged over the row incidental to cultivation. This ensures that the developing tubers are well covered with soil to protect them from light and pests. Mulching is frequently done over the rows with water hyacinth, straw etc to preserve the soil moisture and to prevent the growth of weeds. As the potato plants become mature and the tubers are fully formed, the leaves become gradually yellowish and then brownish, and finally the plants die. It is always better to harvest the crop after these signs are evident in the field. Most varieties are harvested in this country during February-March. Collection of the tubers is usually done in Bangladesh manually using a spade or other devices. ( **National encyclopedia of Bangladesh**).

In volume of fresh product, the potato ranks first among the world's most important food crops. It is grown in almost all countries of the world. In many countries, including those of Europe, America, and Canada, potato is the staple food. Nearly 90% of the potato crop of the world is grown in Europe. In the last 2-3 decades, production of potato in Bangladesh has increased with the cultivation of high yielding varieties. Although the growing conditions are excellent, because of lack of desirable market, farmers do not like to grow more potatoes. Only a negligible portion of the total production is exported, while a substantial amount of seed potatoes are still imported. ( **National encyclopedia of Bangladesh**).

In 2005-06, about 4.66 million m tons of potato were produced in the country. This has increased to 8.2 million m tons in 2007-08. Most small farmers preserve potatoes, particularly local varieties, at home indigenously. Consequently, loss due to dehydration, pest attack and infection by disease organisms is substantial. There are 193 cold storages in the country with installed capacity of about 22,00,000 m tons. Rest of the potatoes are kept by farmers in an indigenous method (**National encyclopedia of Bangladesh**). Last year between 15 and 20 lakh tonnes of potato will remain unsold by the end of the year because of sluggish demand for the vegetable (**The Daily Star, 2016**).

**2.4 The Use of potato In poultry feeding**

 Potato meal and foliage products have been evaluated as a feed for poultry. (**Turner *et******al.***, 1976) examined various diets consisting of cooked potato and a protein supplement for poultry feeding. Chicks fed on a starter feed reached slaughter weight sooner than when fed on potato diets, however, with the latter the broilers had a higher dressing out percentage. The results of the organoleptic evaluation of birds slaughtered at 13 weeks of age showed that meat from chickens fed a diet, where 75% of the corn was replaced by sweet potato, had the best flavour (**Mohamed *et al.*,** 1974).

Yoshida and Morimoto (1958) reported that the carbohydrate fraction in potato to be about 90% digestible in chicks, while (**Fetuga and Oluyemi,** 1976) obtained a coefficient of metabolizable energy of 90,9 or 87,2 in diets where the tuber replaced 25 or 40% of the glucose in a basal diet; at both levels, rate and efficiency of gain were best for the sweet potato diets. These results suggest that, as an energy source, and at these levels of substitution the tuber is as efficiently used as maize by chicks.

**2.5 Chemical composition of potato meal**

Potato is rich in carbohydrate content and also contain proteins, fats, vitamins, minerals.The dry matter percentage of potato is less, approximately 20-25%.On dry matter basis the energy is 3228 kcal/kg.Which is good in quantity as energy source for poultry ration.In carbohydrate contents there are glucose and fructose as monosaccharides, sucrose as disaccharides, starch and dietary fiber as polysaccharides.In protein contents there present most of the amino acids included valine, histamine, glutamine, Isoleucine, Lucien, lysine, methionine, threonine, tryptophan, phenylalanine and conditionally essential amino acids tyrosine, cystein..There are also some non essential amino acids includes alanine, arginine, asparagine, glycine, proline, serenine.There are present some fats in potatoes includes saturated fatty acids,monounsaturated fatty acids, polyunsaturated fatty acids, cholesterol, phytosterols.The minerals present in potatoes are calcium, iron, magnesium, phosphorus, potassium, sodium, zinc, copper, maganese, selenium.There also present impotant vitamins in potatoes includes vitamin c (ascorbic acid), thiamin(vitamin B1), riboflavin (vitamin B2), niacin(vitamin B3), pantothenic acid(vitamin B5), , pyridoxine (vitamin B6),, folic acid (vitamin B9),, choline(vitamin B4), Beta carotene (vitamin A), alpha tocopherol (vitamin E).( **Bhattagharya** ***et al.*,** 2008)

**Table 1 Approximate composition of potato meal (dry matter basis)**

|  |  |
| --- | --- |
| **Compnentso (%)**  | **Potato meal** |
| Energy (k.cal/Kg)  | 3227 |
| Moisture (%)  | 75 |
| Crude fiber (%)  | 4.9 |
| Crude protein (%)  | 2.9 |
| Ash (%)  | 1.6 |
| Ether extract (%)  | 0.23 |

**2.6 Microbiology and palatability**

The variability in the nutrient profile of potato meal can lead to unexpected changes in poultry performance. Concerns about microbiological quality and palatability often limit the use of higher dietary quantities.Many types of spoilage and pathogenic microorganisms exist on fresh, minimally processed, and fully processed potato products. Potatoes are processed into many products including frozen, dried, ready-to-eat, and minimally processed.(**Davidson *et al.*,** 2008) The microbiological quality of finished potato products is influenced by the natural microflora, processing, handling, and human contact. The natural microflora of potatoes are influenced by soil and airborne inocula, agricultural practices, harvesting methods, and storage conditions. The microflora of processed products are influenced by all of the factors and conditions affecting the natural microflora as well as the processes applied to the product. This review considers the sources of microorganisms, microflora, foodborne disease pathogens, and outbreaks associated with, and selected microbiological research involving, potatoes and potato products.Palatibity depends on contamination and load of microbes.Less contaminated potato meal with good storage ensure better palatability and more intake of feed.

**2.7 Conclusion**

Chemical composition of potato meal is rich in carbohydrate,also present some essential amino acids, vitamins, minerals. The different composition of potato meal are also discussed. Despite variability, this is a potential source of carbohydrate, calcium, phosphorus and other trace minerals. Taking into consideration of the nature of variation, inclusion levels and its subsequent consequences on productive performance, carcass characteristics in broilers could be explored as a noble study.

**Chapter - III**

**MATERIALS AND METHODS**

**3.1 Study 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. In 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; Weatherbase, 2013; BBC** **weather, 2013).**

**3.2 Design of the experiment**

The experimental birds were assigned to a Completely Randomized Design(CRD). A total of 120 birds were randomly distributed into four dietary treatment groups designated as T0, T1, T2, and T3 and supplemented with 0%, 20%, 30%, and 40% PM for T0, T1, T2 and T3 groups, respectively. Each treatment was further divided into three replicates having 10 birds per pen.

**3.3 Animals and housing**

One hundred Ross-308 day old unsexed broiler chicks were purchased from Nahar Agro Complex Limited, Chittagong, Bangladesh. All chicks were examined for abnormalities and uniform size. Average body weight of the chicks was 40.74±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 cage was further divided into 12 pens. 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.

**3.4 Cleaning and sanitation**

The shed was thoroughly cleaned and washed by using tap water with caustic soda. For disinfection, phenyl solution (1% v/v) was sprayed on the floor, corners and ceiling. Following spray, cleaning was done by using brush and clean water. Brooding boxes, rearing cages and pens were cleaned in the same manner. After cleaning and disinfection, the house was left one week for proper drying. After drying, all doors and windows were closed. The room was fumigated (Adding 35 ml of formalin to 10 g potassium permanganate per cubic meter) and sealed for 24 hours. On the next day, lime was spread on the floor and around the shed. Footbath containing potassium permanganate (1% w/v) was kept at the entrance of the poultry shed and changed daily. Feeders were cleaned and washed with Temsen® solution (0.3% v/v) weekly before being used further. Drinkers were washed with potassium permanganate (1% w/v) and dried up daily in the morning.

**3.5 Experimental diets**

Feed ingredients were purchased from Pahartali market, Chittagong, Bangladesh. During purchase, cleanliness and date of expiry were checked. Good-quality, dust-free potatoes were collected from North Bengal region. They were then sliced, dried in sunlight and finally ground into meal by passing through a 1-mm screen using a WILEY MILL. Potato meal was supplemented at 0%, 20%, 30%, and 40% to prepare the experimental mash diets. Dry mash was provided to the birds throughout the whole experimental period. Four 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 2.

 **Table 2.** Ingredient and nutrient composition of the broiler starter ration (0-14 days)

|  |  |
| --- | --- |
| **Ingredients (%)** | **Dietary treatments** |
| **T0** | **T1** | **T2** | **T3** |
| Maize | 60 | 40 | 30 | 20 |
| **PM** | **0** | **20** | **30** | **40** |
| Soybean meal | 33.5 | 34.5 | 34.5 | 34.5 |
| Soybean oil | 3.8 | 2.8 | 2.8 | 2.8 |
| DCP | 1.4 | 1.4 | 1.4 | 1.4 |
| Limestone | 0.50 | 0.50 | 0.50 | 0.50 |
| Vit-min. premix2 | 0.20 | 0.20 | 0.20 | 0.20 |
| Common salt | 0.20 | 0.20 | 0.20 | 0.20 |
| L-Lysine5 | 0.08 | 0.08 | 0.08 | 0.08 |
| DL-Methionine4 | 0.22 | 0.22 | 0.22 | 0.22 |
| NaHCO3 | 0.10 | 0.10 | 0.10 | 0.10 |
| Total | 100 | 100 | 100 | 100 |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Met. energy7 | 3100.5 | 3098.4 | 3096.7 | 3095.6 |
| Crude protein | 20.05 | 19.97 | 19.87 | 19.85 |
| Crude fibre | 2.87 | 3.45 | 3.74 | 4.03 |
| Calcium | 1.18 | 1.20 | 1.22 | 1.25 |
| Phosphorus | 0.76 | 0.76 | 0.74 | 0.73 |
| Lysine | 1.13 | 1.12 | 1.11 | 1.11 |
| Methionine | 0.54 | 0.54 | 0.53 | 0.52 |
| Cysteine  | 0.37 | 0.37 | 0.36 | 0.35 |

T0=Diet without PM; T1=Diet containing 20% PM; T2=Diet containing 30% PM; T3=Diet containing 40% PM;, 1Vitamin-mineral premix (Per kg vitamin mineral premix provided-Vitamin A 5000 IU, D3 1000 IU, K 1.6 mg, B1 1 mg, B2 2 mg, B3 16 mg, B6 1.6 mg, B9 320 µg, B12 4.8 µg, Cu 4 mg, Mn 40 mg, Zn 20 mg, Fe 2.4 mg, I 160 µg); DCP2 (18% P, 23% Ca); 3DL-Methionine (Purity 99.0%); 4L-Lysine (Purity 99.0%); 5Metabolizable energy (kcal/kg).

**Table 3.** Ingredient and nutrient composition of the broiler finisher ration (14-28 days)

|  |  |
| --- | --- |
| **Ingredients (%)** | **Dietary treatments** |
| **T0** | **T1** | **T2** | **T3** |
| Maize | 65 | 45 | 35 | 25 |
| **PM** | **0** | **20** | **30** | **40** |
| Soybean meal | 30.50 | 31.50 | 31.50 | 31.50 |
| Soybean oil | 2.8 | 1.8 | 1.8 | 1.8 |
| DCP | 0.50 | 0.50 | 0.50 | 0.50 |
| Limestone | 0.50 | 0.50 | 0.50 | 0.50 |
| Vit-min. premix2 | 0.20 | 0.20 | 0.20 | 0.20 |
| Common salt | 0.20 | 0.20 | 0.20 | 0.20 |
| L-Lysine5 | 0.07 | 0.07 | 0.07 | 0.07 |
| DL-Methionine4 | 0.18 | 0.18 | 0.18 | 0.18 |
| NaHCO3 | 0.05 | 0.05 | 0.05 | 0.05 |
| Total | 100 | 100 | 100 | 100 |

|  |  |  |
| --- | --- | --- |
| **Estimated chemical composition (%)** |  |  |
| Met. energy7 | 3108.5 | 3098.4 | 3094.7 | 3091.6 |
| Crude protein | 19.15 | 18.98 | 18.87 | 18.79 |
| Crude fibre | 2.83 | 3.41 | 3.70 | 3.99 |
| Calcium | 1.18 | 1.19 | 1.19 | 1.20 |
| Phosphorus | 0.75 | 0.75 | 0.73 | 0.72 |
| Lysine | 1.01 | 1.01 | 1.00 | 1.00 |
| Methionine | 0.42 | 0.42 | 0.41 | 0.41 |
| Cysteine  | 0.30 | 0.30 | 0.30 | 0.30 |

T0=Diet without PM; T1=Diet containing 20% PM; T2=Diet containing 30% PM; T3=Diet containing 40% PM;, 1Vitamin-mineral premix (Per kg vitamin mineral premix provided-Vitamin A 5000 IU, D3 1000 IU, K 1.6 mg, B1 1 mg, B2 2 mg, B3 16 mg, B6 1.6 mg, B9 320 µg, B12 4.8 µg, Cu 4 mg, Mn 40 mg, Zn 20 mg, Fe 2.4 mg, I 160 µg); DCP2 (18% P, 23% Ca); 3DL-Methionine (Purity 99.0%); 4L-Lysine (Purity 99.0%); 5Metabolizable energy (kcal/kg).

**3.6 Feeding of birds**

Feed was prepared manually and supplied ad-libitum to the birds on round small feeder and waterer for 0-7 days. After 7th day, small round feeders and waterers were replaced by medium linear feeders (2.21 ft X 0.25 ft) and round waterers. At 15th day, large linear feeder (3.5 ft X 0.38 ft) and round waterers (3 liter capacity) were provided for feeding and drinking of the birds.

**3.7 Vaccination & Medications**

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.

**3.8 Carcass measurement**

On 4th week of the study period, four birds were randomly selected from each replicate and killed by severing the jugular vein and carotid artery. Once a bird was adequately bleed out, it was scalded and feather was removed. After defeathering, the birds were eviscerated and the head and feet were removed as per technique described by **Jones (1984)**. During evisceration process, abdominal fat, lung, liver, kidney, spleen, gizzard and proventriculus were excised separately and weighed. Dressed birds were weighed to obtain a dressed carcass weight.

**3.9 Analysis of feed**

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. Feed and meat samples were dried at 80°C and ground to powder. After drying, chemical analyses of the feed samples were carried out in triplicate for dry matter (DM), crude protein (CP), crude 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).**

**3.10 Data collection**

Weight gain, feed intake and FCR were recorded at weekly intervals. Carcass characteristics was recorded at 4th weeks. Weight gain was calculated by deducting initial body weight from the final body weight of the birds. Feed intake was calculated by deducting leftover from the total amounts of feed supplied to the birds. FCR was calculated dividing feed intake by the weight gain.

**3.11 Statistical analysis**

Data were compiled in MS Excel. Raw data related to weight gain, feed intake, FCR, carcass characteristics 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 NewMultiple Range Test **(Duncan, 1955).** Statistical significance was accepted at p<0.05 for F-tests.

**Chapter - IV**

**RESULTS**

The experiment was carried out to investigate the effects of various levels of potato meal on the performance parameters and carcass characteristics of Ross broilers. The results obtained from the present study have been presented in this chapter.

**4.1 Live weight**

Effects of potato meal on live weight gain of broiler are presented inTable [4](https://link.springer.com/article/10.1186/s40538-016-0081-5#Tab4). Significant (p< 0.01) difference was observed in weekly average live weight gain among the treatment groups. Higher body weight of the birds was found in control group and with the increasing potato meal portion in the diets, the body weight of the birds decreased linearly. Highest (1265.3 g/bird) and lowest (1032.2 g/bird) average live weights were recorded in T0 and T3 groups, respectively at 4th week.

**4.2 Weight gain**

Average weekly weight gain differed significantly (p<0.05)among different dietary treatment groups (Table 4). Maximum (70.9 g/d) and minimum (51.8 g/d) average weight gains were recorded in T0 and T2 groups, respectively at 4th week.

**4.3 Feed intake**

Similar to weight gain, average weekly feed intake differed significantly (p<0.05)among various dietary treatment groups (Table 4). Highest (121.1 g/bird/d) and lowest (114.3 g/bird/d) average feed intakes were recorded in T3 and T0 groups, respectively at 4th week.

**Table 4.** Live weight (g/bird), weight gain (g/bird/d), feed intake (g/bird/d) and FCRof the experimental broiler birds fed diets supplemented with different levels of PM from 1st to 4th weeks of age.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Variable** | **Age** | **Dietary treatments** | **SEM** | **P value** |
| **T0** | **T1** | **T2** | **T3** |
| Live weight | 1st wk | 187.9 | 176.6 | 172.3 | 218.7 | 1.25 | 0.27 |
| 2nd wk | 402.4 | 377.4 | 363.3 | 386.2 | 4.73 | 0.07 |
| 3rd wk | 768.5 | 685.1 | 669.6 | 698.2 | 11.64 | 0.02 |
| 4th wk | 1265.3 | 1051.5 | 1032.2 | 1124.1 | 24.52 | 0.004 |
|  |  |  |  |  |  |  |  |
| Weight gain | 1st wk | 21.1 | 19.2 | 18.6 | 19.6 | 0.32 | 0.33 |
| 2nd wk | 30.6 | 28.7 | 27.2 | 29.5 | 0.45 | 0.33 |
| 3rd wk | 52.3 | 43.9 | 43.7 | 44.6 | 1.11 | 0.03 |
| 4th wk | 70.8 | 52.2 | 51.8 | 60.8 | 2.22 | 0.07 |
|  |  |  |  |  |  |  |  |
| Feed intake | 1st wk | 31.7 | 32.6 | 33.9 | 34.2 | 0.39 | 0.42 |
| 2nd wk | 58.7 | 63.6 | 65.8 | 69.8 | 1.40 | 0.35 |
| 3rd wk | 92.5 | 94.6 | 95.9 | 98.6 | 0.57 | 0.09 |
| 4th wk | 114.3 | 119.2 | 120.5 | 121.1 | 1.26 | 0.07 |
|  |  |  |  |  |  |  |  |
| FCR | 1stwk | 1.50 | 1.69 | 1.82 | 1.74 | .03 | 0.25 |
| 2nd wk | 1.91 | 2.21 | 2.41 | 2.36 | .05 | 0.26 |
| 3rd wk | 1.76 | 2.16 | 2.16 | 2.21 | .06 | 0.12 |
| 4th wk | 1.60 | 2.28 | 2.32 | 1.98 | .08 | 0.20 |

T0=Diet without PM; T1=Diet containing 20% PM; T2=Diet containing 30% PM; T3=Diet containing 40% PM; SEM=Standard error of mean; NS=Non-significant (p<0.05); \*\*=Significant (p˂0.01); \*\*\*=Significant (p˂0.001)

**4.4 Feed Conversion Ratio**

FCR did not differ (p>0.05) within experimental birds at weekly observation with irrespective of the levels of PM supplementations (Table 4). The best (1.64) and worst (2.14) FCR was recorded in the T0 and T2 groups, respectively at 4th week.

**Table 5** Live weight (g/bird), weight gain (g/bird), feed intake (g/bird) , FCR,survivability and carcass characteristicsof the experimental broiler birds fed diets supplemented with different levels of PM at the end of 4th weeks of age.

|  |  |  |
| --- | --- | --- |
| Parameter | **Potato content (%)** | **Level of significance** |
| 0 | 20 | 30 | 40 |
| Live weight (g/broiler) | 1265.3a | 1051.5c | 1032.2d | 1124.1b | \*\* |
| weight gain (g/broiler) | 1224.8a | 1009.8c | 990.3d | 1081.9b | \*\* |
| Feed intake (g/broiler) | 2080.40d | 2170.00c | 2212.70b | 2265.91a | \*\* |
| FCR | 1.69d | 2.14b | 2.23a | 2.09c | \*\* |
| Survivability (%) | 100 | 100 | 100 | 100 | NS |
| Bodyweight (g/broiler) of slaughtered bird | 1285.5 ± 64.1 | 1047.6±18.34 | 1033.3±34.25 | 1149.5±67.36 | 0.22 |
| Thigh weight | 10.25 ± .13 | 8.95 ± .19 | 9.76 ± .15 | 9.32 ± .07 | 0.17 |
| Drumstick weight | 8.48 ± .34 | 8.09 ±.35 | 8.37 ± .78 | 8.73 ± .69 | 0.63 |
| Wing weight | 7.95 ± .79 | 7.71 ± 1.05 | 7.82 ± .51 | 8.06 ± .66 | 0.91 |
| Breast weight | 9.42 ± .56 | 9.01 ±.18 | 9.61 ± .40 | 8.98 ± .16 | 0.32 |
| Abdominal fat | .86 ± .06 | .19 ± .02 | .22 ± .03 | .19 ± .05 | 0.08 |
| Dressing % | 60.2 ± 3.55 | 55.08 ± 2.88 | 63.67 ± 6.57 | 58.14 ± .15 | 0.39 |

a,b,c,dMeans within a row with different superscripts are significantly different (P < 0.01)

NS non-significant, g gram

\*\* P < 0.01, significant at 1% level

**4.5 Carcass characteristics**

Dietary treatments have no notable effects on dressing percentage and weights of other carcass components, such as breast, thigh, drumstick, wing etc., except abdominal fat (*P* < 0.01) as shown in Table 5. Significantly low abdominal fat (~4 times lower than that of control groups) was found in all the potato meal-fed birds.

**Body weight (g/broiler) of slaughtered bird**

Body weight (g/broiler) of slaughtered bird did not differ significantly (*p>* 0.01) within experimental birds at irrespective of the levels of PM supplementations (Table 5). Highest (1285.5±64.1) and lowest (1033.3±34.25) was recorded in T0 and T2 groups, respectively after slaughter at 4th week.

**Thigh weight**

Thigh weight did not differ significantly (*p>* 0.01) within experimental birds at irrespective of the levels of PM supplementations (Table 5). Highest (10.25±.13) and lowest (8.95 ± .19) was recorded in T0 and T1 groups, respectively after slaughter at 4th week.

**Drumstick weight**

Thigh weight did not differ significantly (*p>* 0.01) within experimental birds at irrespective of the levels of PM supplementations (Table 5). Highest (8.73 ± 0.69) and lowest (8.09 ± 0.35) was recorded in T3 and T1 groups, respectively after slaughter at 4th week.

**Wing weight**

Wing weight did not differ significantly (*p>* 0.01) within experimental birds at irrespective of the levels of PM supplementations (Table 5). Highest (8.06 ± .66) and lowest (7.71 ± 1.05) was recorded in T3 and T1 groups, respectively after slaughter at 4th week.

**Breast weight**

Breast weight did not differ significantly (*p>*0.01) within experimental birds at irrespective of the levels of PM supplementations (Table 5). ).Highest (9.61 ± 0.40) and lowest (8.98 ± 0.16) was recorded in T2 and T3 groups, respectively after slaughter at 4th week.

**Abdominal fat**

Significantly low abdominal fat (~4 times lower than that of control groups) was found in all the potato meal-fed birds. (Abdominal fat (*P* < 0.01) as shown in Table 5.) Highest (.86 ± .06) and lowest (.19) was recorded in T0 and both T1 and T3 groups, respectively after slaughter at 4th week.

**Dressing %**

Dressing percentage did not differ significantly (*p>* 0.01) within experimental birds at irrespective of the levels of PM supplementations (Table 5). ).Highest (63.67 ± 6.57) and lowest (55.08 ± 2.88) was recorded in T2 and T1 groups, respectively after slaughter at 4th week.

**Chapter - V**

**DISCUSSION**

The study investigated the effects of potato meal supplementation below and above recommended levels to investigate its effects on productive performance and carcass characteristics parameters in commercial broiler for a typical period of 28 days.

**5.1 Weight gain**

Supplementation of potato meal from 1st to 4th weeks of age in broiler birds indicated that, the control group has gained the highest body weight, and it likely decreases slightly with the increasing potato meal. Some reported results in the literature suggested that the inclusion of sweet potato meal in broiler ration causes poor utilization of nutrient compared with maize-based diets (**Maphosa *et al*.,** 2003**, TEWE.,** 1991), thus leading to a lower body weight gain of bird.This might be responsible for the inversely linear fashion body weight gain with the amount of sweet potato meal (**Agwunobi *et al*.,** 1999). In contrast, some other studies, with feeding 25% potato to starter birds (**Mozafari *et al*.,** 2013), 50% sweet potato to broiler starter (**Ayuk *et al*.,,** 2009), 36 and 45% sweet potato to starter and finisher birds, respectively (**Agwunobi *et al*.,** 1999**, Turnur** ***et al*.,** 1776), reported that either potato or sweet potato in diets did not affect the body weight gain.

**5.2 Feed intake**

In our study the feed intake increases with the potato meal ratio. Although increasing of feed intake occurs with increasing level of potato meal, the weight gain decreases.it might be due to poor nutrient utilization of potato meal. The decline in the body weight and increase PM based feed consumption is similar to the results of **Maphosa** ***et al*. (2003).** Some reported results in the literature suggested that the inclusion of sweet potato meal in broiler ration causes poor utilization of nutrient compared with maize-based diets (**Maphosa *et al*.,** 2003**; TEWE.,** 1991) thus leading to a lower body weight gain of bird. The results of feed intake of birds in my study also has similarity with **Sultana** ***et al*. (2016).**

**5.3 Feed conversion ratio**

Feed conversion ratio in contrast to weight gain and feed consumption increased with increased levels of PM. Given the fact that animals in general are known to eat in order to satisfy their energy requirements first and foremost (NRC,1994),birds increase their feed intake as the energy level of diets decreased. The birds of the present studies could not increase feed intake to match energy needs. **Banser** ***et al***. (2000)suggested that the low feed intake may be due to palatability problems associated with the nature of PM which tends to dusty and less digestible. some other studies, with feeding 25% potato to starter birds (**Mozafari *et al*.,** 2013), 50% sweet potato to broiler starter (**Ayuk *et al*.,** 2009), 36 and 45% sweet potato to starter and finisher birds, respectively (**Agwunobi *et al*.,** 1999**, Turnur** ***et al*.,** 1776), reported that either potato or sweet potato in diets did not affect the feed conversion ratio.

**5.4 Carcass characteristics**

The present study indicates that dietary treatments have no notable effects on the dressing percentage and the weights of other carcass components, such as breast, thigh, drumstick, wing etc., except abdominal fat (*P* < 0.01) of carcass. These results are in agreement with those in the reported literature (**Mozafari *et al*.,** 2013) on dried cooked potato meal diets up to 35%. An important point is that the abdominal fat percentage decreases with the increasing potato meal. Since the fats in other limbs in bird is related to the abdominal fat content, it can be said that the fat contents in other limbs of meat are lower as well, compared to those of the control group. We uttered that high fibre content plays a crucial role in this regard. The significance of this result is twofold. First, the lower weight of dressing is likely due to the low content of fat. Second, the reduced fat in meat is definitely of more worth in terms of fetching higher market prices since high animal fat causes elevated blood cholesterol leading to atherosclerosis or heart failure (**AMA**., 1977)

**5.5 Limitations of the study**

5.5.1 The sample size was only 120 birds due to resource limitations.

5.5.2 Seasonal variations were not observed due to limited study period.

**Chapter - VI**

**CONCLUSION**

The study investigated the effects of potato meal supplementation on performance parameters, carcass characteristics broiler under intensive rearing system. The results in this study suggested that there were no significant differences in meat production or meat quality among the treatment groups of broiler with up to 40% replacement of corn with potato. These results suggested that potato meal could be safely included up to 40% as replacement of corn meal in diets of broiler, without causing any negative effects on the production performance. These results would encourage the farmers of the country where price of potato is lower than that of corn. Importantly, I found the benefit of a low content of fat in potato meal-fed broilers. I believe that the results from this study will play a crucial role in the further development of low-fat poultry meat.

**Chapter - VII**

**RECOMMENDATIONS AND FUTURE DIRECTION**

Potato is comparatively available and cheaper than other corn like energy sources. From this study there were no significant differences in meat production or meat quality among the treatment groups of broiler with up to 40% replacement of corn with potato. Therefore, potato meal could be an important and economical solution for low fat contained broiler production in tropical environment of Bangladesh. Inclusion of 40% potato meal is recommended substitution with maize.

Due to financial constraints and technical limitations, some blood parameters specially High Density Lipoprotein (HDL), Low Density Lipoprotein (LDL), Very Low Density Lipoprotein (VLDL), White blood cell count (WBC), calcium, phosphorus and other trace minerals both in meat and feed were not analyzed. These parameters could have vital impact on human health. The study explores new horizon for investigating those parameters with larger sample size and variable temporal pattern as future study.

**REFERENCES**

Abd-Elrazig, S. M., & Elzubeir, E. A. (1998). Effects of feeding pearl millet on laying hen performance and egg quality. *Animal feed science and technology*, *76*(1-2), 89-94.

Abd-Elrazig, S. M., & Elzubeir, E. A. (1998). Effects of feeding pearl millet on laying hen performance and egg quality. *Animal feed science and technology*, *76*(1-2), 89-94.

Abt, I., Ahmed, T., Aid, S., Andreev, V., Andrieu, B., Appuhn, R. D., ... & Bán, J. (1997). The H1 detector at HERA. *Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment*, *386*(2-3), 310-347.

Afolayan, S. B., Dafwang, I. I., Sekoni, A., & Jegede, J. O. (2013). Effect of dietary maize substitution with sweet potato meal on performance of growers (10-22 weeks) and subsequent egg production (23-35 weeks). *Asian J Poult Sci*, *7*(2), 55-64.

Afolayan, S. B., Dafwang, I. I., Sekoni, A., & Jegede, J. O. (2013). Effect of dietary maize substitution with sweet potato meal on performance of growers (10-22 weeks) and subsequent egg production (23-35 weeks). *Asian J Poult Sci*, *7*(2), 55-64.

Agwunobi, L. N. (1999). Performance of broiler chickens fed sweet potato meal (Ipomoea batatas L.) diets. *Tropical animal health and production*, *31*(6), 383-389.

Ahmed, Z. U., Begum, Z. T., Hassan, M. A., Khondker, M., Kabir, S. M. H., Ahmad, M. A. T. A., ... & Haque, E. U. (2008). Encyclopedia of flora and fauna of Bangladesh. *Asiatic Society of Bangladesh, Dhaka*.

Aina, A. B. J., & Fanimo, A. O. (1997). Substitution of maize with cassava and sweet potato meal as the energy source in the rations of layer birds. *Pertanika Journal of Tropical Agricultural Science*, *20*, 163-168.

Azimuddin, M. D., Alam, Q. M., & Baset, M. A. (2009). Potato for food security in Bangladesh. *International Journal of Sustainable Crop Production*, *4*(1), 94-99.

Beckford, R. C., & Bartlett, J. R. (2015). Inclusion levels of sweet potato root meal in the diet of broilers I. Effect on performance, organ weights, and carcass quality. *Poultry science*, *94*(6), 1316-1322.

Bhattacharya, C. B., Sen, S., & Korschun, D. (2008). Using corporate social responsibility to win the war for talent.

Dominguez-Bello, M. G., Costello, E. K., Contreras, M., Magris, M., Hidalgo, G., Fierer, N., & Knight, R. (2010). Delivery mode shapes the acquisition and structure of the initial microbiota across multiple body habitats in newborns. *Proceedings of the National Academy of Sciences*, *107*(26), 11971-11975.

Donnelly, D., & Kubow, S. (2011). Role of potato in human health. In *Colloque sur la pomme de terre. 1Y6*.

Donohue, M., & Cunningham, D. L. (2009). Effects of grain and oilseed prices on the costs of US poultry production. *Journal of Applied Poultry Research*, *18*(2), 325-337.

Dorman, F. H., & Morrison, J. D. (1961). Double and triple ionization in molecules induced by electron impact. *The Journal of Chemical Physics*, *35*(2), 575-581.

Essien, E. A. A. (2009). Growth and haematological response of broiler chicks fed graded levels of sweet potato (Ipomoea batata) meal as replacement for maize. *International Journal of Poultry Science*, *8*(5), 485-488.

Farias, E. H., Pomin, V. H., Valente, A. P., Nader, H. B., Rocha, H. A., & Mourao, P. A. (2008). A preponderantly 4-sulfated, 3-linked galactan from the green alga Codium isthmocladum. *Glycobiology*, *18*(3), 250-259.

Jones, R. (1984). A standard method for the dissection of poultry for carcass analysis. *The West of Scotland Agricultural College, Auchincruive Ayr Technical note*, (222).

Junttila, M. R., Puustinen, P., Niemelä, M., Ahola, R., Arnold, H., Böttzauw, T., & Lu, S.L.(2007). CIP2A inhibits PP2A in human malignancies.  *Cell*, *130* (1), 51-62.

Kreutzer, D. W. (2012). Renewable fuel standard, ethanol use, and corn prices. *Background, heritage foundation*, (2727).

Ladokun, O. A., Aderemi, F. A., & Tewe, O. O. (2007). Sweet potato as a feed resource for layer production in Nigeria. In *8th African Crop Science Society Conference, El-Minia, Egypt, 27-31 October 2007* (pp. 585-588). African Crop Science Society.

Lázár, A. N., Clarke, D., Adams, H., Akanda, A. R., Szabo, S., Nicholls, R. J., ... & Payo, A. (2015). Agricultural livelihoods in coastal Bangladesh under climate and environmental change–A model framework. *Environmental Science: Processes & Impacts*, *17*(6), 1018-1031.

Lee, C., Yang, W., & Parr, R. G. (1988). Development of the Colle-Salvetti correlation-energy formula into a functional of the electron density. *Physical review B*, *37*(2), 785.

Mani, S., Tabil, L. G., & Sokhansanj, S. (2006). Effects of compressive force, particle size and moisture content on mechanical properties of biomass pellets from grasses. *Biomass and bioenergy*, *30*(7), 648-654.

Maphosa, T., Gunduza, K. T., Kusina, J., & Mutungamiri, A. (2003). Evaluation of sweet potato tuber (Ipomea batatas l.) as a feed ingredient in broiler chicken diets. *Livestock Research for Rural Development*, *15*(1), 13-17.

Mohamed, F. A., & Langdon, T. G. (1974). The transition from dislocation climb to viscous glide in creep of solid solution alloys. *Acta Metallurgica*, *22*(6), 779-788.

Mozafari, O., Ghazi, S., & Moeini, M. M. (2013). The effects of different levels of edible potato (Solanum tubresum) replacing maize on performance, serum metabolite and immune system of broiler chicks. *Iranian Journal of Applied Animal Science*, *3*(3).

Munyawu, G. J., Chakoma, C., Kuwaza, C., & Mache, B. (1998). An outline of the production constrains and research needs of small-scale crop and livestock farmers in the Mashonaland East province of Zimbabwe. *Grassland Research Station, Marondera, Zimbabwe*.

National Research Council. (1998). *Nutrient requirements of swine*. National Academies Press.

Ojewola, G. S., Olojede, A. O., & Ehiri, C. G. (2006). Evaluation of Livingston potato/Rizga (Plectranthus esculentus N. Br) and Hausa potato (Solenostemon rotundifolius Poir) as energy sources for broiler chicken. *Journal of Animal and Veterinary Advances*, *5*(6), 472-477.

Oluyemi, J. A., Fetuga, B. L., & Endeley, H. N. L. (1976). The metabolizable energy value of some feed ingredients for young chicks. *Poultry Science*, *55*(2), 611-618.

Panda, A. K., Zaidi, P. H., Rama Rao, S. V., & Raju, M. V. L. N. (2014). Efficacy of quality protein maize in meeting energy and essential amino acid requirements in broiler chicken production. *Journal of applied animal research*, *42*(2), 133-139.

Shaheb, M. R. S., Begum, M. M., Ahmed, K. U., Nazrul, M. I., & Wiersema, S. G. (2016). Challenges of Seed Potato (Solanum tuberosum L.) Production and Supply System in Bangladesh-A Review. *The Agriculturists*, *13*(1), 173-188.

Sherlock, M., Reulen, R. C., Alonso, A. A., Ayuk, J., Clayton, R. N., Sheppard, M. C., ... & Stewart, P. M. (2009). ACTH deficiency, higher doses of hydrocortisone replacement, and radiotherapy are independent predictors of mortality in patients with acromegaly. *The Journal of Clinical Endocrinology & Metabolism*, *94*(11), 4216-4223.

Standifer, L. N. (1967). A comparison of the protein quality of pollens for growth-stimulation of the hypopharyngeal glands and longevity of honey bees, Apis mellifera L.(Hymenoptera: Apidae). *Insectes Sociaux*, *14*(4), 415-425.

Strain, J. J., Davidson, P. W., Bonham, M. P., Duffy, E. M., Stokes-Riner, A., Thurston, S. W., ... & Sloane-Reeves, J. (2008). Associations of maternal long-chain polyunsaturated fatty acids, methyl mercury, and infant development in the Seychelles Child Development Nutrition Study. *Neurotoxicology*, *29*(5), 776-782.

Sultana, F., Ali, M. A., & Jahan, I. (2010). Growth performance meat yield and profitability of broiler chickens fed diets incorporating cassava tuber meal. *Bioscience Biotechnology and Biochemistry*, *74*(11), 2202-8.

Sultana, F., Khatun, H., & Ali, M. A. (2016). Use of potato as carbohydrate source in poultry ration. *Chemical and Biological Technologies in Agriculture*, *3*(1), 30.

Sultana, F., Khatun, H., & Ali, M. A. (2016). Use of potato as carbohydrate source in poultry ration. *Chemical and Biological Technologies in Agriculture*, *3*(1), 30.

Tewe, O. O. (1991, October). Sweet potato utilization in poultry diets. In *Symposium on Tropical Root Crops in a Developping Economy 380* (pp. 426-437).

Tripet, F., Lounibos, L. P., Robbins, D., Moran, J., Nishimura, N., & Blosser, E. M. (2011). Competitive reduction by satyrization? Evidence for interspecific mating in nature and asymmetric reproductive competition between invasive mosquito vectors. *The American journal of tropical medicine and hygiene*, *85*(2), 265-270.

Turner, W. J., Malynicz, G. L., & Nad, H. (1976). Effect of feeding rations based on cooked sweetpotato and a protein supplement to broiler and crossbred poultry. *Papua and New Guinea agricultural journal*.

Woodson, B. T., Soose, R. J., Gillespie, M. B., Strohl, K. P., Maurer, J. T., De Vries, N., ... & Padhya, T. A. (2016). Three-year outcomes of cranial nerve stimulation for obstructive sleep apnea: the STAR trial. *Otolaryngology--Head and Neck Surgery*, *154*(1), 181-188.