Chapter 1: Introduction

1. Introduction

Broiler farming is a rapidly growing and highly demanding agricultural sector in Bangladesh. Commercial 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. Soyabean meal (SBM) serves as the major plant protein ingredient in the diets of most livestock and especially non-ruminants like poultry. Recently the prices of soybean meal are increasing day by day due to international crisis of soybean. Hundred percent of soybean meal is being imported into Bangladesh. The price increase of SBM and the cost of producing poultry meat and eggs increased significantly resulting in a decreased ability of some of the population to purchase and consume chicken meat. This has had a major impact on the livestock and poultry industries. To fulfill the protein requirement in poultry feed we have to choose the alternative products. Among the different protein source distillers dried grain with soluble (DDGS) may be the best by product to sustain poultry industry. Dried distillers grain with soluble (DDGS) are a by-product of the alcohol industry and of bioethanol production. They are obtained as a result of some stage concentration, and then, long-lasting drying of corn mash, earlier deprived of ethyl alcohol. These products are constituted by components from primary raw material, is not sensitive to fermentation (non-starch carbohydrates, protein, fat, minerals and others), and biomass of the different yeasts. DDGS are rich in protein, exogenous amino acids, vitamins, biotin and many mineral compounds, including phosphorus (Koreleski and Świątkiewicz, 2006; Thacker and Widyaratne, 2007; Min et al.,2008). Most of the distiller's dried grains are manufactured in the Northern America, mainly from maize. In Europe, DDGS is obtained from wheat and rye (Brzóska, 2009). Recently DDGS being imported to Bangladesh in huge volume to sustain the poultry industry.Many nations have investigated the use of DDGS in feed mixtures for a variety of poultry species, including livestock (Nyachoti et al., 2005; Swiatkiewicz and Koreleski ,2007; Thacker and Widyaratne,2007; Wang et al. ,2007; Swiatkiewicz and Koreleski, 2008). Many research findings showed that DDGS can replace a portion of soybean meal in a feed mixture without decreasing production results. This replacing of SBM to DDGS obviously reduces the feed cost in poultry industry. However, caution should be used in the proper balance of the diet in terms of amino acid composition and energy, as well as ensuring adequate quantities of minerals and vitamins to meet the needs of the birds.

1.2 Justification of the study

Distilled dried with Grain soluble (DDGS) is an important alternative protein and energy source ingredient in poultry nutrition because of it derived from different corn and comparatively less cost than other protein sources. Thus, incorporation of the inclusion levels of DDGS by replacing soybean meal in poultry diets might reduce feed cost. Limited studies are available regarding optimum levels of DDGS for high performing broiler in the contemporary environment in Bangladesh. Additionally, carcass quality and feed intake parameter of broiler fed diet supplemented with varying levels of DDGS by replacing SBM are scarce.

1.3 Objectives

- To estimate the effects of different levels of DDGS on feed intake, weight gain and FCR in commercial broiler.
- To measure the effects of various levels of DDGS on carcass characteristics and meat quality in commercial broiler.
- To estimate the blood lipid parameters and oxidative stability of meat of commercial broiler.
- To investigate the economics of commercial broiler rearing on feeding of DDGS.

Chapter 2: Review of Literature

2.1 Background:

Bioethanol production is increased day by day over the world. Cereals, sugar beets, and sugar cane are the primary raw materials used to make ethanol. From Almost 0.33 kg of corn grains can be gained from one kilo of corn grains and 0.32-kilogram ethanol (McAloon et al.,2000). The grains used by cereal distillers are excellent. Feeding substance for livestock Traditional distillers Grains are perishable and liquid. As a result, they DDG (dry distillers' grains) are dried grains. They are either manufactured or dried together with the soluble DDGS follows (dried distillers' grains with soluble) are manufactured. Except for nitrogen free extracts, which are fermented to alcohol, all raw material nutrients are more concentrated in DDGS. DDGS stands for primarily a source of crude protein; fat content, Minerals and fiber levels are also higher in comparison with the utilizing the raw material (Belyeaet al., 2004; Zeman and Tvrznik, 2007).

2.2 Production of DDGS

The dry grind-milling method produces the majority of corn-based ethanol (about 60%). Wet or dried corn gluten feed, corn germ meal, and corn gluten meal are the main by-products of wet milling plants. Wet and dried distillers' grains, on the other hand (University of Minnesota, 2008).

Cleaning the maize grain is typically the first step in removing foreign contaminants and contamination. A hammer mill is then used to grind the maize grain. After that, water is added to produce a slurry, and alpha-amylase enzymes are added to break down the alpha-amylase. 1-4-glucosidic this process is known as links to release dextrin, maltose, glucose, tetroses, and maltotriose. "Liquefaction".As a result, the pH (5-6) is corrected. The slurry is then jet-cooked at temperatures ranging from 90 to 165 degrees Celsius to kill microorganisms and remove lactic acid bacteria from the kernel. The jet-cooked slurry is next chilled to 32°C in preparation for the inclusion of the glucoamlyase enzyme, which converts dextrin to the simple sugar dextrose. Molecular sieves and yeast are used to ferment amylase and dextrose into ethyl alcohol (ethanol) and carbon dioxide in the fermentation process (Saccharomyces cerevisiae). Distillation is the following process, which involves extracting ethanol from the fermented mash. This procedure takes approximately 40-

60 hours to complete. The entire stillage, which contains water, protein, fat, and fiber, is centrifuged after the distillation process. The wet grains are separated from the thin stillage by centrifugation. Corn condensed distillers solubles were formed when the thin stillage evaporated and condensed. Finally, corn DDGS is made by adding a portion or all of the solubles to the distillers' wet grains, then drying them in a ring drier or rotary kiln at temperatures ranging from 127 to 621 degrees Celsius (Wright, 1987; Davis, 2001; Kelsall and Lyons, 2003; Power, 2003). The dry grind-milling method produces soluble and condensed distillers as by-products.

2.3 Chemical composition of DDGS

The nutritive value and ME content of fiber rich distillers dried grain with soluble (DDGS) produced from different grains have been documented (Thacker and Widyaratne, 2007; Adeola and, 2012; Barekatain et al., 2013 a, b). Because of grain starch present in DDGS is transformed to ethyl alcohol and CO2 during the fermentation process,the concentration of the remaining nutrients increases by about 2-3 times. In poultry diets, DDGS can provide considerable amounts of crude protein, amino acids, phosphorus, and other minerals. The biggest issue with using DGGS as a feed ingredient is the wide range of nutritional concentration and quality between different DDGS sources. Several investigations on the nutritional composition and variability of DDGS have been undertaken in recent years. Corn DDGS typically include around 27% crude protein, 8%Phosphorus, and0.7% sulfur, and are acceptable for feeding both for livestock and poultry Leaflet (2008).They discovered a wide range of nutrient content in DDGS samples, with cr ude proteinranging from 23.4 to 28.7%, fat from 2.9 to12.8%, neutral detergent fibr (NDF) from28.8 to 40.3 percent, acid detergent fibre (ADF) from 10.3 to 18.1 perce nt, ash from 3.4 to7.3 percent, lysine from 0.43 to 0.89 percent, methionine (met) fr om 0.44 to 0.55 percent, threonine from .89 to 0.1.16 and tryptophan from 0.16 to0.23 percent. Colour scores of evaluated sample s of DDGS ranged from very shiny to very dark and odor scores ranged from normal to burn. The dark colour and burnt odor were probably caused from excess heating during drying process. Lysine remains in DDGS tended to be lowest in the darkest and highest in colored DDGS, lysine content was significant (Cromwell et al., 1993). They also found that ADF concentration could be negatively correlated with nutritive value digestibility of DDGS.The availability of phosphorus in DDGS is considerably greater than in other vegetal feeds (Martinez Amezcuaet al.,2004; Lumpkins and Batal, 2005). It is especially important in feeding broiler chickens which due to a high growth are characterized by high demand for this element.More recentlySpiehs et al. (2002) evaluated the nutrient content of DDGS originating from modern ethanol plants (totally 118 samples from 10 plants). The average content of crude protein was 30.2%, crude fat -10.9%, crude fibre- 8.8%, ash -5.8%, nitrogen free extractives - 45.5%, ADF -16.2%, NDF-42.1%, lysine -0.85%, methionine-0.55%and Phosphorus - 0.89%. Particularly for lysine, methionine, and mineral contents, there was huge variation between sources. They conjointly found that crude protein, crude fat, lysine, methionine, threonine, and phosphorus levels were over than reference data, whereas dry matter and calcium levels were lower (NRC, 1994).

Because the contents of some nutrients in DDGS differed not solely between production plants however conjointly between years of production, and nutrient composition could often differ from standard reference values, a complete chemical analysis of each used source of DDGS should be performed at least once a year, according to the findings. The discrepancies in nutritional levels amongst DDGS samples could be related to variances in original grain composition, starch fermentation efficiency during ethanol production and scale up, varying amounts of soluble added back, and drying techniques (temperature and duration).For example, Belyea et al. (2004) suggested that high variation in the composition of varities samples of DDGS was not related to the composition of corn used in fermentation but rather to variations in producing techniques.Metabolizible energy for DDGS recorded by Lumpkins et al. (2004) on conventional roosters found to 2905 kcal/kg. In comparison, the total metabolizable energy (TMEn) value of DDGS recorded in NRC (1994) was 3097 kcal/kg.DDGS is a good source of phosphorus in poultry feeds. (Martinez Amezcua et al. 2004) reported that the average P value in 20 DDGS samples from different ethanol plants located in Minnesota amounted to 0.73%, which was very close to reference data (NRC, 1994). For minerals sources, the most variable in DDGS is sodium (Batal and Dale, 2003) reported a range of 0.09 to 0.44% Na in 12 samples of DDGS from the United States. The average value was 0.23%, which was markedly lower than 0.48% Na reported by NRC (1994).For this reason of high variability in sodium content of DDGS was not clear because Na is not added during any technique of ethanol production. Cells of yeast in DDGS is a rich source of vitamins (thiamine, riboflavin and others) and microelements, but it also contain other biologically important substances like nucleotides, mannanoligosacharids, inositol, glutamine and nucleic acids, which beneficial on immune responses and the health condition of animals. Results of a study on other monogastrics (young growing pigs) have suggested that DDGS at 10% dietarycan positively affect gut health bydecreasingsmall intestine and colon lesion length and prevalence and severity of lesions within the small intestine and colon in swines subjected to Lawsoniaintracellularis challenge (Whitney et al., 2006). DDGS is additionally composed of xanthophyll's; other side, (Roberson et al., 2005) recorded square measure distinction between xanthophyll content in2 samples of DDGS (29.75 vs. 3.48 mg/kg).

2.4 Use of DDGS in feed

For many years, DDGS has been approved as a feed component in broiler diets. DDGS was first used at a modest dietary inclusion level (about 5%), and was occasionally used as a source of "unidentified growth factors" that improved performance metrics. Body weight gain improved after incorporation of low levels of DDGS into the diet were observed in early broiler and turkey studies by (Day et al., 1972; Couch et al.,1957).

Later research (Waldroupet al., 1981) found that DDGS may be added to the broiler diet up to 25% without affecting body weight gain or feed conversion if the metabolizable energy level was kept constant.(Parsons et al., 1983) reported that up to 40% of soybean protein could be replaced in broiler diet by DDGS, if the lysine level was enough to support performance(Cromwell et al., 1993) reported that qualityof DDGScharacterized by darker colour hampered broiler performance, suggesting the decreasing lysine digestibility in dark colored DDGS.

Recentlysome reports on broiler chickens using DDGS obtained from new ethanol plants have been conducted.Lumpkins et al.(2004) performed two experiments to examine the use of "new generation" DDGS in broiler diets. In the first experiment they used two types of starter diets (low- or high-density diet), each containing 0 or 15% DDGS.Chicks were fed experimental feeds from 0 to 18 days of age, and within the high-density diet there were no differences in performance parameters between chicken fed 0 or 15% DDGS. In the low-density diet, chicks fed 15% DDGS had a lower feed efficiency (gain: feed) at 7 and 14 days of age. In their second experiment, isocaloric and isonitrogenous starter, grower and finisher diets containing 0, 6, 12 or

18% were used for a 42-day feeding. The authors suggested no differences in performance and carcass yield except for a decrease in body weight gain and feed conversion during the starter period, when chicken was fed 18% DDGS feed. Based upon their results the authors suggested that the safe inclusion level of DDGS was 6% in starter diets and 12 – 15% in grower and finisher diets.In a recent study (Wang et al.,2007) recorded the effect of feed formulated based on digestible amino acid levels, containing 0, 5, 10, 15, 20 or 25% DDGS, on broiler performance. They reported that inclusion up to 25% did not cause any adverse effects on the growth performance; however, chicks fed diets with 25% DDGS had poorer FCR as compared to the control group. Mixing level of 15 or 25% DDGS declined the dressing weight, and chickens fed the diet with 25% DDGS were resulted by lower breast weight (as showed as percentage of live weight).According to these results it is concluded that best quality DDGS could be used in broiler diets at levels 15 or 20% with slight negative effect on result but this might result in little loss in dressing percentage and breast meat performance.Thacker and Widyaratne (2007) used broiler feed containing 0, 5, 10, 15 or 20% wheat DDGS and examined no statistically significant differences in weight gain, feed intake and feed conversion; however, performance tended to decline at 20% inclusion of wheat DDGS in the diet. Withhigh amount of wheat DDGS in the diet decreased the Digestibility of dry matter, energy and P declined in a linear manner.

Table 1. Approximate composition of DDGS (dry matter basis).

Components	DDGS
Energy (k.cal/Kg)	2950
Dry matter (%)	89.55
Crude fiber (%)	9.17
Crude protein (%)	22-24
Ash (%)	4.99
Ether extract (%)	9.75

2.5 Inclusion level of DDGS

The lesser amount of accessible lysine in DDGS during drying process can hamper the broiler growth and efficiency. It has been reported that DDGS can be safely added to starter diets for broilers and turkeys at levels of 5%–8%, and grower-finisher diets for broilers, turkeys, and laying hens at levels of 12%–15%. DDGS has a high risk of mycotoxin effect on broiler feed and higher amount of DDGS in the diets can negatively affect the quality of pellets Wang et al (2007). Because it contains yeast protein.The crude protein is good; however, thelysine con centration is minimal.There can also be unfermented foods present.Polysaccharides derived from nonstarch sources,which can have a negative impact onlitter quality an d nutrient digestibility (Cromwell et al., 1993; Zeman and Tvrznik, 2007). DDGS has a high protein and energy content, as well as several necessary amino acids, vitamins, and minerals.DDGS's various compositions are also examined. This is a potential source of amino acid, calcium, phosphorus, and other trace minerals, despite its unpredictability. Carcass features in broilers could be investigated as a significant study, taking into account the nature of variation, inclusion levels, and their consequent effects on productive performance.

Chapter 3: Methods and Materials

3.1 Study Area

Study of feeding trail was completed at the experimental poultry shed under the Department of Animal Science and Nutrition. Proximate analysis of meat and feed, serum biochemical analysis of bird, measurements for carcass characteristics and estimation of oxidative rancidity was performed at different laboratories of the Department of Animal Science and Nutrition, Chattogram Veterinary and Animal Sciences University (CVASU), Khulshi, Chattogram,Bangladesh.

3.2 Study Period

Length of the experiment was six months. The growth trial was conducted for a period of five weeks starting from 3 September to 8 October, 2021.

3.3 Experimental Birds

Day-old unsexed broiler chicks (DOC) were purchased from Nahar Agrogroup, Chattogram, Bangladesh. All the DOC were examined for the presence of any abnormalities and chicks having no noticeable abnormalities were selected for the study. We also measure the body weight of the chicks to maintain the uniformity in size and a variation of more than 5 grams from the mean weight were excluded from the study. The live weight of the selected DOC was 36.5±3g.

3.4 Design of the experiment

Experimental birds were design to a Completely Randomized Design (CRD). A total of 96 birds were randomly distributed into four dietary treatment groups named as Control, D1, D2, and D_3 and supplemented DDGS with 0%, 10%, 20%, and 30% as replacement of soybean meal for Control, D1, D2and D3 treatment, respectively. Each treatment was further divided into three replicates having 8 birds per treatments.

3.5 Cleaning and Sanitation

Experimental house was thoroughly cleaned and washed by fresh water with caustic soda. For disinfection, phenyl solution (1% v/v) was used on the floor, ceilingand corners. Then spray, cleaning was done by using brush and clean tap water. Brooding boxes, pens and cages were disinfected in the same way. After cleaning and disinfection, the house was left one week for proper drying. Then all doors and windows were completely shut down. The shed was fumigated (Adding 35 ml of formalin to 10 g potassium permanganate per cubic meter) and closed for 24 hours. On the next day, lime powder was spread on the floor and around the shed. Footbath mixing with potassium permanganate solution (1% w/v) was kept at the entry of the poultry shed. Feeders were washed and disinfected with Timsen® solution (0.3% v/v) weekly before being used further. Drinkers were washed with potassium permanganate (1% w/v) and dried up in every morning.

3.6 Experimental Diets

Feed ingredients were purchased from Pahartali market, Chittagong, Bangladesh. During purchase, cleanliness and date of expiry were checked. Good quality, dust-free DDGS were collected from rajakhali market, Chattogram. DDGS are used as 0%, 10%, 20%, 30% soyabean meal replacing in experimental mesh diet. Four different types of rations were formulated. Each ration had two different types i.e., starter (0 to 14 days) and finisher (15 to 35 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.

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

Ingredients	Trials			
	C	D_1	D_2	D_3
Maize	52.00	55.50	50.0	54.00
Rice polish	2.50	1.00	2.50	2.50
Wheat	2.00	1.00	3.50	2.50
DDGS	0	3.20	6.40	9.60
Soybean meal	32.00	28.80	25.60	22.40
Soybean oil	3.50	2.50	2.50	2.50
Fish meal	4.00	4.00	5.31	6.20
DCP	1.69	1.52	1.50	1.50
Limestone	1.15	1.00	1.48	1.00
Vit-min. premix[2]	0.15	0.15	0.15	0.15
Common salt	0.30	0.30	0.30	0.30
Choline cl	0.06	0.06	0.06	0.06
L-Lysine[5]	0.40	0.40	0.40	0.40
DL-Methionine[4]	0.22	0.22	0.22	0.22
Enzyme	0.03	0.03	0.03	0.03
Total	100.0	100.0	100.0	100.0
Calculated chemical composition (%)				
Met. energy	3001.65	3001.10	3005.00	3011.6
Crude protein	22.09	22.18	22.05	22.01
Crude fiber	3.76	3.42	3.39	3.91
Calcium	1.28	1.18	1.26	1.12
Phosphorus	0.71	0.62	0.64	0.74
Lysine	1.37	1.38	1.36	1.43
Methionine	0.34	0.34	0.33	0.32
Cysteine	0.37	0.37	0.36	0.35

C=Control (Basal diet); D1=10% DDGS as a replacement of soyabean meal+basal diet; D2=20% DDGS as a replacement of soyabean meal+basal diet; D3=30% DDGS as a replacement of soyabean meal+basal diet; g=Gram

Table3. Ingredient and nutrient composition of the broiler grower ration (15-35 days).

Ingredients	Trails			
	C	D1	D2	D3
Maize	47.61	47.30	52.10	51.00
Rice polish	5.00	5.00	1.00	2.00
Wheat	4.00	5.00	4.00	4.00
DDGS	0	3.20	6.40	9.60
Soybean meal	32	28.80	25.60	22.40
Soybean oil	6.00	5.30	4.50	4.00
Fish meal	1.20	1.50	2.50	3.00
DCP	1.90	1.82	1.78	1.50
Limestone	1.15	1.15	1.15	1.15
Vit-min. premix	0.15	0.15	0.15	0.15
Common salt	0.30	0.30	0.30	0.30
Choline cl	0.06	0.06	0.06	0.06
L-Lysine	0.40	0.40	0.40	0.40
DL-Methionine	0.22	0.22	0.22	0.22
Enzyme	0.03	0.03	0.03	0.03
Total	100.00	100.00	100.00	100.00
Calculated chemical composition (%)				
Met. energy[7]	3108.29	3105.66	3101.88	3107.96
Crude protein	20.38	20.17	20.01	20.03
Crude fiber	3.91	3.73	3.16	3.08
Calcium	1.12	1.12	1.12	1.28
Phosphorus	0.71	0.72	0.71	0.67
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

C=Control (Basal diet); D1=10% DDGS as a replacement of soyabean meal+basal diet; D2=20% DDGS as a replacement of soyabean meal+basal diet; D3=30% DDGS as a replacement of soyabean meal+basal diet; g=Gram

3.7Vaccination and medication

All the birds were routinely vaccinated against Newcastle Disease (ND) and Infectious Bursal Disease. The vaccines were purchased from Division Livestock Office and transported in icebox to maintain the quality and function. Vaccination was performed early in the morning to reduce the stress. No medication or antibiotic was provided with the feed

Table 4. Vaccination schedule.

Age of birds	Name of diseases	Name of the vaccine	Route of administration
4th day	New Castle Disease	BCRDV (Live)	One drop in one eye
12th +18th day	Infectious Bursal Disease	IBD	One drop in one eye
21th day	New castle Disease	BCRDV (Booster)	One drop in one eye

3.8 Carcass measurement

On 5th week of the study period, two 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 removing feather, the birds were eviscerated and the feet and head were removed as the technique described by Jones (1984). During evisceration process, abdominal fat, liver, lungs, kidney, spleen, gizzard and proventriculus were carried out separately and weighed. Dressed birds were weighed to get 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. 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).

3.10Data collection

Weight gain, feed intake and FCR were recorded at weekly intervals. Carcass characteristics was recorded at 5^{th} 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 blood collection

After the feeding trail of 35days,24 birds were slaughtered for blood collection. Then separate serum and preserved at 4◦c for farther lipid profile observation. Different parameters of blood was observed farther.

3.12 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 New Multiple Range Test (Duncan, 1955). Statistical significance was accepted at $p<0.05$ for F-tests.

Photo gallery

Figure 1: First day at DOC observation

Figure 2: Feed mixing and weight of bird at different weeks

Figure 3: Meat sample collection and packaging

Figure 4: Wave length values determination for oxidative Rancidity test

Figure 5: Proximate analysis of meat and feed sample

Chapter 4: Results

The experiment was carried out to investigate the effects of various levels of DDGS as a replacement of soybean meal on the performance parameters and carcass characteristics of Ross-308 broilers. The results obtained from the present study have been presented in this chapter.

4.1 Live weight gain

The live average live weight gain at1st to 5th week is presented in Table 5 indicated a significant ($p < 0.01$) increase in the final live weight in all treatment groups compared to control where the highest (1449.4g) weight was observed in D1 group. The weekly average live weight increased in treatment groups while comparing to the control from 2nd to 5thweek, among which a significant increase was observed in 3rd($p < 0.01$) and 4th weeks ($p < 0.001$).

4.2 Average daily feed intake

The overall average daily feed intake (ADFI) presented in Table 5 showed no significant ($p > 0.05$) variation among all dietary groups throughout the study period. The lowest feed intake in D2group (54.2g) and highest daily feed intake was observed at control group C (61.95g).

4.3 Average daily weight gain

The data presented in Table 5 shows a significant ($P < 0.001$) increase in overall average daily gain (ADG) in all treatment groups compared to that of control. The highest ADG (1st to 5th week) was observed in Group D1 treatment (41.56 g/bird/day) and the lowest was obtained in control group (35 g/bird/day).

4.4 Feed conversion ratio (FCR)

The feed conversion ratio at (1st -5th week) was showed in Table 5 shows that there was a significant ($P < 0.001$) reduction in the overall FCR in all treatment groups in comparison to control. The lowest value was observed in D1 group (1.38) followed by C1 (1.77) is the highest FCR in the experiment.

Table 5. Growth performance of broiler by replacing soyabean meal with DDGS

Parameters	Treatment				SEM	P Value
	C	D_1	D_2	D_3		
1^{st} week						
Initial wt (g)	36.84	36.25	36.33	36.25	0.222	0.31
Final wt (g)	97.92	99.25	100.92	96.63	1.998	0.62
ADG (g/b/d)	8.72	9.00	9.22	8.626	0.268	0.56
ADFI(g/b/d)	9.44	8.36	9.170	8.970	0.417	0.46
FCR	1.08^{a}	0.93^{c}	0.99^{bc}	1.04^{ab}	0.025	0.02
2^{nd} week						
Initial wt (g)	97.92	99.25	100.92	96.63	1.996	0.62
Final wt (g)	221.4^{a}	267.04^{a}	244.4^{b}	227.6^{bc}	4.889	0.03
ADG (g/b/d)	17.6^{c}	23.9^{a}	20.5^{b}	18.7^{bc}	.7033	0.002
ADFI(g/b/d)	29.4^{c}	32.976^{a}	31.2^{b}	30.09^{bc}	0.331	0.001
FCR	1.66^{a}	1.37^{b}	1.5^{ab}	1.62^{a}	.0566	0.08
3^{rd} week						
Initial wt (g)	221.42^{c}	267.04^{a}	244.46^{b}	227.6^{bc}	4.889	0.004
Final wt (g)	421.043^{b}	508.37^{a}	496.91^{a}	449.46^{b}	8.155	0.001
ADG (g/b/d)	28.51^{c}	34.48^{ab}	36.06^{a}	31.69^{bc}	1.061	0.01
ADFI (g/b/d)	55.06^{b}	59.34^{a}	60.8^{a}	61.25^{a}	1.459	0.03
FCR	1.93	1.72	1.69	1.93	0.070	0.08
4^{th} week						
Initial wt (g)	421.04^{b}	508.37^{a}	496.91^{a}	449.46^{b}	8.157	0.001
Final wt (g)	677.87^{c}	850.82^{a}	772.92^{b}	687.92^{c}	20.12	0.001
ADG (g/b/d)	36.69^{b}	48.92^{a}	39.42^{b}	34.06^{b}	2.399	0.02
ADFI(g/b/d)	94.70^{a}	92.87^{a}	78.74^{ab}	73.05^{b}	3.976	0.03
FCR	2.63^{a}	1.89^{b}	1.99^{b}	2.14^{b}	.1243	0.03
5^{th} week						
Initial wt (g)	677.87^{c}	850.82^{a}	772.92^{b}	687.92^{c}	20.12	0.001
Final wt (g)	1226.96^{b}	1449.40^{a}	1279.00^{c}	1257.50^{c}	23.55	0.001
ADG (g/b/d)	78.44^{ab}	85.51^{a}	72.29^{b}	81.37^{a}	2.27	0.023
ADFI(g/b/d)	130.94^{a}	98.28^{b}	97.12^{b}	113.98^{ab}	5.83	0.031
FCR	1.69^{a}	0.99^{b}	1.15^{b}	1.20^{b}	0.06	0.014
$1\text{-}5^{th}$ week						
Initial wt (g)	36.83	36.25	36.33	36.25	0.22	0.31
Final wt (g)	1226.96^{b}	1449.40^{a}	1279.00^{b}	1257.50^{b}	27.55	0.01
ADG (g/b/d)	35.00^{b}	41.56^{a}	36.55^{b}	35.92^{b}	0.81	0.01
ADFI(g/b/d)	61.95^{a}	57.19^{ab}	54.19^{b}	55.80^{b}	1.45	0.05
FCR	1.77^{a}	1.38^{c}	1.483^{bc}	1.55^{b}	0.03	0.001

^{abc}Means with different superscripts in the same row differ significantly. Data indicated the mean value of 3 replications with 8 birds per treatment (n=24).C=Control (Basal diet); D1=10% DDGS as a replacement of soyabean meal+basal diet; D2=20% DDGS as a replacement of soyabean meal+basal diet; D3=30% DDGS as a replacement of soyabean meal+basal diet; ADG=Average daily weight gain;g/b/d=gram per day per bird; ADFI=Average daily feed intake; FCR= Feed Conversion Ratio, SEM=Standard error of means.

Table 6. Relative organ weights percentage of carcasses of broiler using DDGS in ration.

Parameters	Treatment				SEM	P Value
	C	D_1	D_2	D_3		
Dressed weight (%)	55.81	55.74	53.25	55.85	0.72	0.11
Breast meat (%)	12.78	12.24	12.37	13.11	0.35	0.39
Thigh weight (%)	10.49	9.94	10.12	10.05	0.25	0.52
Head wt (%)	2.62^{b}	2.79^{ab}	2.86^{a}	2.74^{ab}	0.05	0.07
Drumstick wt (%)	8.31	8.87	8.61	8.47	0.07	0.29
Heart wt (%)	0.58	0.53	0.61	0.62	0.03	0.37
Liver wt (%)	2.02	2.03	1.91	1.83	0.16	0.82
Gizzard wt (%)	3.56^{ab}	3.47^{ab}	3.26^{b}	3.79^{a}	0.12	0.17
Spleen wt(%)	0.09	0.08	0.07	0.10	0.01	0.17
Bursa wt (%)	0.18	0.14	0.19	0.17	0.03	0.58
Abdominal fat wt (%)	0.87	0.86	0.87	0.68	0.24	0.929

^{abc} Means with different superscripts in the same row differ significantly. Data indicated the mean value of 3 replications with 2 birds per treatment (n=6).C=Control (Basal diet); D1=10% DDGS as a replacement of soyabean meal+basal diet; D2=20% DDGS as a replacement of soyabean meal+basal diet; D3=30% DDGS as a replacement of soyabean meal+basal diet, SEM=Standard error of means.

4.5 Carcass characteristics

Dietary treatments have no notable effects on dressing percentage and weights of other carcass components, such as breast, thigh, drumstick, liver etc., except headand gizzard weight as shown in Table 6.

4.5.1Dressing percentage of broiler

Dressing percentage did not differ significantly ($p > 0.01$) within experimental birds at irrespective of the levels of DDGS supplementations (Table 6). Highest (55.85) and lowest (53.2) was recorded in D_3 and D_2 groups respectively after slaughter at 5th week.

4.5.2Breast weight (%)

Breast weight did not differ significantly ($p>0.01$) within experimental birds at irrespective of the levels of DDGS using (Table 6). Highest (13.11) and lowest (12.24) was recorded inD3 and D1groups, respectively after slaughter at5th week.

4.5.3Thigh weight (%)

Thigh weight did not differ significantly ($p> 0.01$) within experimental birds at irrespective of the levels of DDGS (Table 6). Highest (10.49) and lowest (9.94) was recorded inC1 and D_1 groups respectively after slaughter at5th week.

4.5.4Head weight (%)

Head weight did not differ significantly ($p> 0.01$) within experimental birds at irrespective of the levels of DDGS supplementations (Table 6). Highest (2.86) and lowest (2.62) was recorded inD2 and c_1 group, respectively after slaughter at5th week.

4.5.5Drumstick weight (%)

Drumstick weight did not differ significantly ($p> 0.01$) within experimental birds at irrespective of the levels of DDGS supplementations (Table 6). Highest (8.87) and lowest (8.31) was recorded in$D_2$and C_1 group respectively after slaughter at5th week.

4.5.6Heart weight (%)

Heart weight did not differ significantly ($p> 0.01$) within experimental birds at irrespective of the levels of DDGS (Table 6). Highest (0.62) and lowest (0.53) was recorded in$D_3$and D_2groups, respectively after slaughter at5th week

4.5.7Liver weight (%)

Liver weight did not differ significantly ($p> 0.01$) within experimental birds at irrespective of the levels of DDGS supplementations (Table 6). Highest (2.03) and lowest (1.83) was recorded inD1and D_3 groups, respectively after slaughter at5th week.

4.5.8Gizzard weight (%)

Gizzard weight percentage slightly differ ($p > 0.01$) within experimental birds at irrespective of the levels of DDGS supplementations (Table 6). Highest (3.79) and lowest (3.26) was recorded inD3 and D_1 groups, respectively after slaughter at5th week.

4.5.9Spleen weight (%)

Spleen weight did not differ significantly ($p > 0.01$) within experimental birds at irrespective of the levels of DDGS supplementations (Table 6). Highest (0.1) and lowest (0.07) was recorded inD_3 and D_2groups, respectively after slaughter at5th week.

4.5.10 Bursa weight (%)

Bursa weight did not differ significantly ($p > 0.01$) within experimental birds at irrespective of the levels of DDGS supplementations (Table 6). Highest (0.19) and lowest (0.14) was recorded inD2 and D_1groups, respectively after slaughter at5th week.

4.5.11 Abdominal fat (%)

Abdominal fat weight did not differ significantly ($p > 0.01$) within experimental birds at irrespective of the levels of DDGS supplementations (Table 6). Highest (0.87) and lowest (0.68) was recorded in C and D_3groups, respectively after slaughter at5th week.

Table 7. Blood parameter of bird by feeding DDGS mixing ration.

Parameters	Treatment				SEM	P Value
	C	D_1	D_2	D_3		
Cholesterol (mg/dl)	178.73	195.93	184.90	164.36	10.41	.403
HDL (mg/dl)	71.83	72.63	51.56	56.53	15.97	.733
LDL (mg/dl)	90.56	102.53	87.16	83.10	8.698	.567
TG (mg/dl)	73.80	78.87	87.42	69.96	5.41	.204

[abc] Means with different superscripts in the same row differ significantly. Data indicated the mean value of 3 replications with 8birds per treatment (n=6).C (Control group), HDL=High density lipoprotein, LDL=Low density lipoprotein, TG=Triglyceride, D1=10% DDGS as a replacement of soybean meal basal diet; D2=20% DDGS as a replacement of soybean meal basal diet; D3=30% DDGS as a replacement of soybean meal basal diet; SEM=Standard error of means.

4.6 Blood Lipid profile

The cholesterol, HDL, LDL and triglyceride level are not significantly change in compare to control group.

4.6.1 Serum cholesterol level

The result of total cholesterol level in serum is same almost in all treatment groups except D1. The lowest cholesterol level was found in D3 group.

4.6.2 Serum HDL level

The serum HDL level in different dietary levels in comparison with control shows statistically not significant differences between treatment groups with control group ($p>0.05$). The HDL level highest in C and lowest in D_2 group.

4.6.3Serum LDL level

The comparisons of concentration of LDL in serum of treatment group with control are shows that treatment D_3 had the lowest level of LDL in serum.

4.6.4Triglyceride level in serum

The level of triglyceride in serum is similar in contrast to control group. The lowest value was obtained in D_3 while the highest value was in D_2 group.

4.7Chemical composition of meat

Effects of DDGS as a replacing of soybean meal in broiler on chemical composition of meat are represented in Table 8. While assessing proximate composition of breast meat, it was observed that the crude protein increased in all treatment groups compared to control except D3. The highest percentage of crude protein was obtained in D1 (22.17) ($p < 0.01$). The changes in ether extract value is significant ($p < 0.001$) the highest value was observed in D3 treatment (1.77) lowest value in D2 treatment. The total ash content varied non-significantly.

Table8. Proximateanalysis of meat composition

Parameters	Treatment				SEM	P Value
	C	D_1	D_2	D_3		
DM (%)	24.07	24.01	23.70	23.57	0.34	0.70
CP (%)	20.66^{b}	22.17^{a}	21.95^{a}	20.09^{b}	0.25	0.01
EE (%)	0.76^{b}	0.64^{b}	0.54^{b}	1.77^{a}	0.06	0.001
ASH (%)	1.11^{a}	0.99^{ab}	1.06^{ab}	0.90^{b}	0.04	0.11

^{abc} Means with different superscripts in the same row differ significantly. Data indicated the mean value of 3 replications with 8birds per treatment (n=6). D1=10% DDGS as a replacement of soybean meal basal diet; D2=20% DDGS as a replacement of soybean meal basal diet; D3=30% DDGS as a replacement of soybean meal basal diet; SEM=Standard error of means.

4.8Oxidative stability of meat

The effects of DDGS on TBARS value of meat of broiler kept at 4°C for 3 consecutive days are demonstrated in Figure 9. No significant difference was observed on fresh meat sample in contrast to control group. The lowest average TBARS value was observed in D3 (1.58) treatment whereas the highest value was observed in control group (2.02) at 3rd day. In 5th day the TBARS value also lowest at D3 group (1.88) and highest in control group. The value of TBARS was also lowest at D3 group at 7th day and highest at control group.

Table 9. TBARS values of meat at different alternative days.

Parameters	Treatments				SEM	P Value
	C	D_1	D_2	D_3		
Fresh	1.60	1.52	1.19	1.50	0.29	0.88
Day 3	2.02^{a}	1.69^{bc}	1.80^{b}	1.58^{c}	0.06	0.01
Day 5	2.05^{a}	1.89^{b}	1.90^{b}	1.88^{b}	0.02	0.01
Day 7	3.47^{a}	3.28^{bc}	3.10^{ab}	2.81^{c}	0.08	0.01

^{abc} Means with different superscripts in the same row differ significantly. Data indicated the mean value of 3 replications with 1 bird per treatment (n=6). C=Control (Basal diet); D1=10% DDGS as a replacement of soybean meal basal diet; D2=20% DDGS as a replacement of soybean meal basal diet; D3=30% DDGS as a replacement of soybean meal basal diet; SEM=Standard error of means.

4.9Cost benefit analysis

The cost benefit analysis of the bird fed DDGS with in comparison with control is given in Table 10. The net profit varied significantly (p <0.001) among all dietary groups compared to control. The net profit per kg was highest in D1 group which was followed by control group. The lowest net profit per kg was found in control group.

Table 10. Cost benefit analysis of the bird fed supplemented diets with different percentage of DDGS.

Parameters	Treatment				SEM	P Value
	C	D_1	D_2	D_3		
Live weight(g)	1226.96^b	1449.5^a	1279^b	1257.5^b	27.55	0.01
Live weight (kg)	1.23^b	1.45^a	1.28^b	1.26^b	0.02	0.01
Feed Intake/Bird(g)	2106.34^a	1944.60^{ab}	1842.63^b	1897.46^b	49.40	0.05
Feed intake(kg)	2.11^a	1.94^{ab}	1.84^b	1.89^b	.0476	0.04
Feed Cost/Bird(TK)	96.47^a	88.28^{ab}	82.73^b	81.21^b	2.21	0.012
Chick &other cost	80.00	85.00	85.00	85.0	0	-
Total Cost(TK)	176.47^a	168.28^{ab}	162.73^b	161.21^b	2.21	0.01
Selling Price(TK)	196.31^b	231.90^a	204.64^b	201.20^b	4.40	0.01
Net Profit(Tk)	19.84^c	63.62^a	41.90^b	39.98^b	3.612	0.001
Net Profit/kg(Tk)	16.06^c	43.59^a	32.79^b	31.80^b	2.168	0.001

^{abc} Means with different superscripts in the same row differ significantly. Data indicated the mean value of 3 replications with 1 bird per treatment (n=6).C=Control (Basal diet); D1=10% DDGS as a replacement of soyabean meal+basal diet; D2=20% DDGS as a replacement of soyabean nmeal+basal diet; D3=30% DDGS as a replacement of soyabean meal+basal diet; SEM=Standard error of means.

Chapter 5: Discussion

The study investigated the effects of DDGS as a replacement of soybean meal below and above recommended levels to investigate its effects on productive performance and carcass parameters in commercial broiler for a period of 35 days.

5.1 Weight gain

Supplementation of DDGS from 1st to 5th weeks of age in broiler birds indicated that, the control group has gained the lowest body weight and in all treatment groups increased more body weight gain. Lumpkins et al. (2004) reported that inclusion of less than 15% DDGS in diets for grower and finisher broiler chickens had no negative effects. If increased DDGS body weight gain decreased slightly and observed adverse outcomes. Similarly, Wang et al. (2007) reported that DDGS could be used 15% or 20% in broiler diet with little negative effect on growth performance. Loar and Corzo (2011) had observed that increasing the level of inclusion of DDGS from 0% to 32% with 8% increment, had decreased body weight gain with increase in the level of DDGS, and recommended a level of 8% for inclusion in the diets of broiler chickens. Lukasiewicz et al. (2012) has reported that replacement of soybean meal with DDGS at 5% and 7% levels had significant effect on body weight, feed intake, and dressing percent in broiler chickens ($p<0.05$).Some reported results in the literature suggested that the inclusion of DDGS in broiler ration causes poor utilization of nutrient compared with low inclusion level of DDGS.Patience et al. (2014) reported that DON (deoxynivalenol)contaminated DDGS in animals diet effect of feeding to pigs (16 mg/kg DON) and also observed that inclusion of 25% DON-contaminated DDGS in diets decreased BW gain.

Another experiment Khose et al. (2017) proposed that the partial replacement of soybean meal with 5–10% DDGS fortified with enzyme positively affects the performance parameters which is similar to our study. The obtained results in the current study align with those of previous studies, which highlighted the synergetic effect of probiotics on growth performance (Khose et al., 2017; Iram et al., 2021).

5.2 Feed intake

In our study the feed intake increases with the decrease the DDGS ratio. Although increasing of feed intake occurs with increasing level of DDGS, the weight gain decreases. It might be due to poor nutrient utilization of DDGS. The decline in the body weight and increase DDGS based feed consumption was observed in DDGS 20% and 30% used groups**.**

5.3 Feed conversion ratio (FCR)

Feed conversion ratio is contrast to weight gain and feed consumption increased. 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. FCR in group D3 lowest than other group but all treatment group are better than control group. Similarly, Swiatkiewicz and Koreleski (2008) recommended from 5% to 8% of DDGS to the starter and from 12 to 15% DDGS to the grower and finisher for broilers.

5.4 Carcass characteristics

The present study indicates that dietary treatments have no noticeable effects on the dressing percentage and weight of other carcass components, such as breast, thigh, drumstick, wing etc. Except head weight ($p < 0.05$) and gizzard weight of carcass.Loar et al. (2012) observed significant results only for gizzard weight based on data from the weights of the large intestine, small intestine, and gizzard. As the DDGS content of the diet increased, we observed a linear increase in gizzard weight, as well as in percentage of Bursa weight. This result was most likely due to the insoluble fiber content of the DDGS which is similar to our observation.

Choi et al. (2008) reported that, DDGS supplementation up to 15% has no negative effect on meat quality of broiler. Similarly, Foltyn et al. (2012) recorded that DDGS has no effect on carcass weight and abdominal fat weight on broiler.

5.5 Serum biochemical parameters

In this study while measuring the lipid profile, no specific changes in serum cholesterol was found in treatment groups compared to control. Serum HDL and LDL level also no significantly changes with control group. Serum triglyceride level are almost similar in all treatment groups compared to control. These results also partially reflect those of Cao et al. (2012), and Santoso et al. (2018), who also found that fermented soybean meal or fermented leaves increased HDL concentrations and decreased total cholesterol, TG, and LDL concentrations. Rinttila et al. (2013) reported, Ingredient quality and digestibility are key factors in this regard, as fermentation of undigested macronutrients, particularly protein, in the hindgut can exacerbate gastrointestinal stress and disease. It has been indicated that blood biochemical analyses are a way of confirming poultry health conditions and may show possible changes in the physiological system as well as the effects of management, weather, and feeding (Damasceno et al., 2020).

5.6 Proximate analysis of meat

The proximate analysis showed that there was a significant increase in crude protein and ether extract percentage of meat in all dietary supplemented group compared to control except D3 group. The highest Crude Protein % was observed in D1 (10% DDGS) group in case of proximate analysis of meat. The highest ether% was in D3 (DDGS 30%) group. Similarly, Wang et al. (2007) reported that digestibility of DM, ME, CP are declined at linear with the increased of DDGS content. Butin control group the meat CP decreased; it may be due to environmental effect of bird rearing.

5.7 Oxidative stability of meat

The oxidative stability of meat determined by measuring TBARS value of meat showed that the TBARS value reduced in all treatment groups compared to control. The lowest value was observed in D3 group. The highest TBA value was found in control group. The TBARS values are declined in linear day by day in every group. It may be due to the chemical composition of DDGS; the 30% replacement of soybean meal with DDGS TBARS value is best in D3 treatment group.

5.8 Cost benefit analysis

The total cost varied significantly among all treatment groups with control ($P<0.001$). A significantly high net profit was obtained from all dietary group in comparison with control ($P<0.001$). Again, the highest net profit was gained from D1 group (10% replacement of SBM with DDGS) feeding with 10% replacement of soybean meal by DDGS. Due the higher growth rate and high price of broiler the net profit was high in all treatment group compare to control group.

Chapter 6: Conclusion

The study investigated the effects of DDGS supplementation on performance parameters, carcass characteristics,meat quality and economics 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 30% replacement of DDGS. These results suggested that DDGS could be safely included up to 30% as replacement of soyabean 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 soyabean meal is increased. Importantly, we observed the benefit with 10% replacement of soyabean meal by DDGS in broilers.So therefore, we believe that the results from this study will play an important role in the further development of low cost poultry meat production.

Limitations of the study

1. The sample size was only 96 birds due to resource limitations.
2. Seasonal variations were not considered due to limited study period.

Chapter 7: Recommendations and future direction

DDGS is comparatively available and cheaper than other protein sources like soyabean meal. From this study there were no significant differences in meat production or meat quality among the treatment groups of broilers with up to 30% replacement of soyabean meal with DDGS.Therefore, DDGS could be an important and economical solution for broiler production in tropical environment of Bangladesh. Inclusion of 30% DDGS meal is recommended substitution with soyabean meal.

Due to financial constraints and technical limitations, some blood parameters specially 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.

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Biography

The author, DR.Saddam Hossain, was born in Coxsbazar.He received his DVM degree from Chattogram Veterinary and Animal Sciences University. Before that, he completed his HSC from Hazera Taju Degree College, Chattogram and SSC from Kishaloya Adarsha Shikkha Niketon, Coxsbazar.During his completion of graduation, he received clinical training from Tamil Nadu Veterinary and Animal Sciences University and khon kaen university, Thailand. Currently, he is recommended as a BCS livestock cadre under the government of people of Bangladesh. He has a keen interest to research on sustainable farming, Wildlife Science, Animal welfare and emerging zoonotic diseases.