EFFECT OF DDGS AS A REPLACER OF SOYBEAN MEAL ON SONALI CHICKEN

A THESIS

BY

KAMOL CHANDRA DAS
Registration No. 1705453
Semester: January–June, 2019

MASTER OF SCIENCE (M.S.)

IN

POULTRY SCIENCE

DEPARTMENT OF DAIRY AND POULTRY SCIENCE
HAJEE MOHAMMAD DANESH SCIENCE AND TECHNOLOGY UNIVERSITY, DINAJPUR - 5200

JUNE 2019

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A Thesis

Submitted to the Department of Dairy and Poultry Science
Hajee Mohammad Danesh Science and Technology University, Dinajpur in
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Approved as to style and content by

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DEPARTMENT OF DAIRY AND POULTRY SCIENCE
HAJEE MOHAMMAD DANESH SCIENCE AND TECHNOLOGY UNIVERSITY, DINAJPUR - 5200

JUNE 2019

Dedicated to

My

Beloved Parents

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The Author

ABSTRACT

The experiment was conducted to evaluate the efficacy of DDGS on production performance and reduce the feed cost of sonali chicken. A total of 150 one day old chicks were purchased from Najim Poultry Feed and Hatchery Limited. After 7 days of brooding the chick were randomly divided into five treatment groups namely (T_0, T_1, T_2, T_3 and T_4) having three replication in each treatment group. Brooded chick was randomly separated into replication wise in separate pen for rearing 9 weeks. Each treatment group contain 30 birds where as each replication contain 10 birds. Experimental birds in T_1, T_2, T_3 and T_4 were provided DDGS @ 5%, 10%, 15% and 20% while T_0 was provided only normal feed. The results of this study was indicated that final live weight gain and feed efficiency of birds was significantly ($p<0.05$) higher that received @5% DDGS compared to control T_0group. This result also indicated that body weight gain, feed intake and feed efficiency were increased at dose rate using 5% DDGS formulated feed. Data obtained feed cost, lowest was seen in DDGS treated group T_1 and highest in untreated group. Net profit obtained maximum was found in T_1 (35.02±3.42Tk.) then T_2 (31.01±1.73Tk.), T_0 (23.98±1.71Tk.), T_3 (21.98±2.87Tk.) and T_4 (19.10±4.88) respectively. Based on the result of present study it may be concluded that DDGS is a good source to reduced feed cost and it has significant effect on body weight gain and feed efficiency of sonali chicken. The result of this study suggests that supplementation of 5% DDGS can be used for the production of sonali chicken. The results suggest that better growth performance could be achieved in sonali chicken supplemented with DDGS formulated feed.

Keyword: Dried Distillers Grains with Solubles (DDGS), Sonali chicken, growth performance, reduction feed cost.

CONTENTS

CONTENTS (Contd.)

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

CHAPTER I

INTRODUCTION

Bangladesh is an agro-based developing country and the growth and sustainability of agricultural production are prerequisite for attaining the rate of overall growth of the economy. Livestock is an important sub-sector of agriculture. Poultry is one of the major components of livestock sub-sectors that committed to supply cheap sources of good quality nutritious animal protein to the nation. Around 22 core poultry are remaining in Bangladesh (DLS, 2016). This subsector has created direct, indirect employment opportunity including support services for about 6 million people. The sector accounts for 14% of the total value of livestock output and is growing rapidly. It is found that poultry meat alone contributes 37% of the total meat production in Bangladesh. Poultry contributes about 22-27% of the total animal protein supply in the country.

Dried Distillers Grains with Solubles (DDGS) is a corn co-product obtained during the dry-milling process of corn to produce ethanol after the fermentation of corn starch by selected yeasts. Dried distillers grains with solubles has been available for poultry for many decades primarily from the beverage industry.

High feed ingredient prices around the world are causing animal nutritionists to search for lower cost alternative feed ingredients to minimize the cost of food animal production. U.S. dried distiller's grain with solubles (DDGS) is an excellent, lower cost alternative feed ingredient that continues to be produced in large quantities by the dry-grind fuel ethanol industry.

It has been recognized that DDGS are a valuable source of energy, amino acids, water soluble vitamins, and minerals for poultry (Jensen, 1978, 1981; Parsons and Baker, 1983; Wang *et al.,* (2007b). The production and supply of ethanol DDGS continues to increase (Renewable Fuels Association, 2011) encouraging the use of DDGS in poultry diets.

In the past, moderate quantities of DDGS were produced and sold locally. The majority of DDGS produced by the beverage industry was fed to beef and dairy cattle operations. Air act amendment in 1990, which promoted the use of ethanol blend at ten percent with gasoline increased production of ethanol, and as a result the availability of DDGS (Adam, 2008, Zurong, 2008).

After a dramatic increase in corn prices and dicalcium phosphate, the poultry industry has been working to reduce feed costs of production. Utilizing alternative feed ingredients and exogenous enzymes are not a new concept in the poultry industry. Alternative feed ingredients and exogenous enzymes have proven to be cost saving. On average, the addition of exogenous enzymes to poultry diets has allowed producers to save as much as $3 per metric ton (Clark, 2009). Nutritionists continue to test the best combinations of alternative feed ingredients and feed additives to optimize production. The goal of exogenous enzyme supplementation is to improve nutrient digestibility of low quality feeds, diminish anti-nutrient factors, reduce nutrient losses in excreta, as well as reduce feed costs (Costa *et al.*, 2008). Because distillers grains by-products are high in fiber (NSP) enzymes in diets containing DDGS can partly remove the negative effect of high fiber content

In 2009, the U.S. production of distiller's grains for livestock exceeded 25 million metric tons (Renewable Fuels Association, 2011). The poultry industry consumes around 9% of the total DDGS; whereas, swine utilizes near 10% of the DDGS, with the majority (80%) fed to ruminants (Renewable Fuels Association, 2011) Feeding greater of DDGS could have a significant impact on feed costs for poultry producers due to higher availability of DDGS for livestock usage, and the current price fluctuations of feed ingredients, corn and soybean meal (Schilling *et al.*, 2010).

It a very attractive, partial replacement for some of the more expensive, traditional energy (corn), protein (soybean meal), and phosphorus (mono- or dicalcium phosphate) used in animal feeds. When DDGS is added to properly formulated feeds, it results in excellent animal health, performance, and food product quality. These attributes, and others, have made DDGS one of the most popular feed ingredients for use in animal feeds around the world.

The use of cereal grains to obtain ethanol has given rise to important changes in the worldwide feedstuffs market, on one hand raising the price of raw materials and in consequence feed prices, while on the other hand providing new raw materials or co-products mainly corresponding to the non-starchy grain fraction, as the starch is hydrolysed and fermented to produce ethanol. Although dry mill ethanol plants produce a great variety of co-products, corn DDGS are the most important marketed worldwide for the use of raw materials in feed formulation and preparation. Some 48% is for beef cattle feed, 32% for dairy cattle, 11% for swine, 8% for poultry and 1% for other species (US Grains Council, 2012; Renewable Fuels Association, 2012). DDGS is an acceptable ingredient for use in poultry diets and can be safely added in poultry ration. When DDGS will be available in Bangladesh, it will reduce the feed cost. So using DDGS on poultry ration may be more profitable in Bangladesh.

Objectives

Therefore the present study was conducted aimed at the following objectives

- To evaluate the growth performance and alternative feed source (DDGS) of sonali chicken.
- To reduce the feed cost of sonali chicken.

CHAPTER II

REVIEW OF LITERATURE

2.1 DDGS Production

The ethanol industry which is one the earliest developing sectors in the United States. With recent incentives from the government to produce alternative and efficient fuel from grain sources, ethanol plant construction increased around the U.S. and more specifically in the Midwest (Reilly, 1979). Ethanol production in 2010/2011 is predicted to grow to 13.00 billion gallons compared to 2.1 billion gallons were produced in 2002 as declared by U.S. Department of Energy (RAF, 2011). In addition, Dooley (2008) reported expansion in ethanol production because of the 2007 Energy Independence and Security Act mandate to increase to 15 billiongallons of starch based ethanol by 2015. This has resulted in a rapid growth in DDGSproduction, with an expectation of more than 30 million tons of DDGS to be produced by 2011 (RFA, 2011).

Most of the ethanol produced in the U.S. originates from corn as the feedstock. Corn usage has increased from 6% in 2000 to 24% in 2008 to produce ethanol and it is expected to range from 30 to 35 percent over the next decade (Westcott, 2009). In addition, over 98% of the fermentation by-products available today are from fuel ethanol production using corn grain as the stock material (University of Minnesota, 2008a). The USDA-ERS 2010 report, reported that 4.7 billion bushels were used to produce ethanol in the United States in 2009. Ruminant animals use the majority of ethanol by-products in their diets as wet distillers grains (WDGS) however, an estimated of 3.2 million metric tons of corn DDGS are available for use in both ruminant and non-ruminant diets (University of Minnesota, 2008a).

Curzaynz-Leyva *et al.,* (2019) suggests that dried corn distillers grains with solubles (DDGS) can partially replace grains and forages in diets for ruminants. The objective of this research was to evaluate the effect of replacing grains and soybean meal with DDGS (0%, 15%, 30% and 45%) in the diet of lambs. Thirty-two native lambs were used (initial bodyweight = 28.6 ± 2.19 kg) in a completely randomized design. Initial body weight was a co-variable, and the means were compared with the Tukey test. The dry matter intake was significantly higher in DDGS containing diet than in the control treatment. The daily weight gain was higher in the diets with 15% of DDGS compared with the control. Dry matter digestibility was lower by 7% with 45% of DDGS. The hot and cold carcass weights were significantly higher by 8% in DDGS treatments compared to the control. The inclusion of increasing levels of DDGS in the diet of fattening lambs increased their dry matter intake, improved carcass weight, and did not adversely affect carcass characteristics.

There are two distinguished methods for processing corn to produce ethanol, wet-milling or dry grind-milling (Davis, 2001; Dooley, 2008). The majority of corn based ethanol (around 60%) is produced by dry grind-milling while, the remaining (40%) is produced by wet milling ethanol plants. The wet milling plants produce wet or dried corn gluten feed, corn gluten meal and corn germ meal as the primary by-products. The by-products of the dry grind-milling process are wet and dried distillers grains with solubles, modified "wet cake", and condensed distillers (University of Minnesota, 2008a). Both the world oil crises in 1970's and clean air legislation have contributed much to expanding the dry milling industry (Davis, 2001).

A brief overview of ethanol production using the conventional dry grind-milling process to produce corn Dried Distillers Grains with Solubles (DDGS) is presented in Figure 1. In general, the first step is cleaning the corn grain to reduce contamination, and foreign materials. Then, washed corn grain is ground using a hammer mill. After that water is added to the corn to make a slurry, in which alpha-amylase enzymes are added, to break the alpha 1-4-glucosidic linkages releasing dextrin, glucose, maltose, maltotriose, and tetroses in a process called "liquefaction". As a result, the pH (5-6 pH) is adjusted. Then the slurry is jet-cooked at temperatures ranging from 90° to 165°C (194° to 329°F) to remove lactic acid bacteria, and to reduce or eliminate microorganisms that may be present in the kernel. Then, the cooked slurry is cooled down to 32°C (90° F) to prepare for the addition of glucoamlyase enzyme that converts dextrin into the simple sugar dextrose. Dextrose and amylase are then fermented into ethanol (ethyl alcohol) and carbon dioxide using yeast (*Saccharomyces cerevisiae*), and using a molecular sieves, the ethanol is removed from the resulting "fermented mash" through distillation. The fermentation process is completed in 40-60 hours. After the ethanol is distilled off the fermented mash, the whole stillage (water, protein, fat and fiber) is centrifuged to separate the wet grains (or wet cake) from the thin stillage. Solubles (or syrup) are produced from the thin stillage through evaporation and condensation to form corn condensed distillers solubles (CDS). Corn DDGS is finally produced at this step by adding a portion or all of the solubles to the wet cake followed by drying in a rotary-kiln or a ring drier at temperatures ranging between 127° and 621°C (260° and 1,150°F) (Wright, 1987; Davis, 2001; Kelsall and Lyons, 2003; Power, 2003).

On average, one bushel of corn (with an average weight of 25.4 kg (56 lbs)) fermented in a dry, grind-milling, ethanol plant, produce approximately 10.22 liters (2.7 gallons) of ethanol, 8.16 kg (18 lbs) of DDGS and 8.16 kg (18 lbs) of carbon dioxide (Davis, 2001). This means less corn starch and the nutrient contents of corn DDGS is concentrated by a factor of three compared to its original corn grain (Shurson *et al.,* 2005). Dried distillers grains with solubles contain all the nutrients contained in corn grain except the starch, which has been removed; DDGS on average contains approximately 27% crude protein, 10% oil, and 0.8% phosphorus (Bregendahl, 2008). Since the majority of ethanol plants use the dry grind-milling process, corn DDGS or WDGS are the major by-products available for livestock. The official AAFCO (2007) definition for DDGS is: "Distillers Dried Grains with Solubles is the product obtained after the removal of ethyl alcohol by distillation from yeast fermentation of a grain or a grain mixture by condensing and drying at least ¾ of the solids of the resultant whole stillage by methods employed in the grain distilling industry." Depending on the ethanol plant, there may be a number of variations on the production process. For example, some plants remove the oil-rich germ and fiber rich hulls prior to fermentation to improve ethanol yield, while others exclude the jet-cooking process, or remove the oil from the thin stillage. These different processing techniques may result in different by-products (Bregendahl, 2008). In addition, sorghum, a blend of corn with barley, or wheat may be used in the ethanol plant to make ethanol and distillers grains with solubles, which basically depends on the geographical location, cost, and availability of these grains relative to corn (Shurson *et al.,* 2005). Most ethanol plants add all of the condensed solubles produced to the grains fraction, while others may include less solubles to the grains fraction before drying (Shurson and Noll, 2005). Some ethanol plants use solubles as a fuel source for the ethanol plant. This may affect the nutrient composition of the resulting by-product produced (Shurson *et al.,* 2005; Bregendahl, 2008).

With the increase of ethanol production in the U.S., millions of metric tons of DDGS are available for livestock feed (Noll *et al.,* 2007). It is estimated that DDGS production will reach 30 million metric tons by the year 2010 (Shurson, 2003). This encourages the use of DDGS at a higher percentage than has typically been used in the past. In addition, with increasing corn prices, the interest in using DDGS in poultry diets has also escalated. In order to understand the variation and the nutrient characteristics of DDGS and the impact of new processing conditions on nutritional quality of DDGS, it is important to review the product and its nutrient value to poultry.

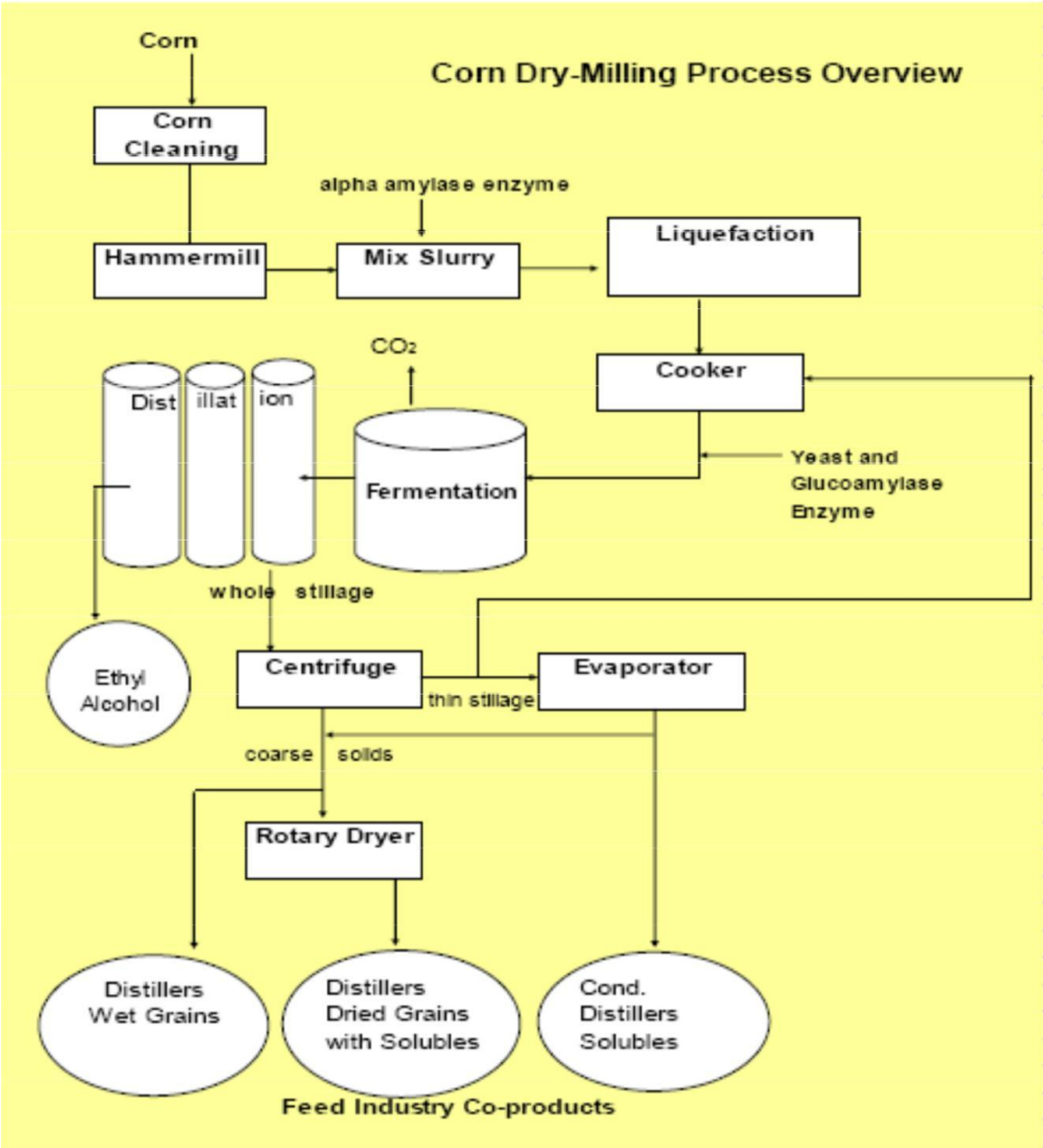


Figure 2.1: Corn Dry-Milling Process Overview

Table 2.1: Distillers dried grains with soluble ingredients composition (Dakota Gold® BPX™)*

Item	Value (as fed basis)	Analyzed**
Dry matter, %	90.5	89.9
Crude protein, %	27.0	27.1
Crude fat, %	10.3	10.8
Crude fiber, %	6.4	
Metabolizable energy (ME), kcal/kg	2800	
ADF%	8.2	
NDF%	24.1	
Phosphorus, %	0.85	
Sodium, %	0.22	
Arginine, %	1.31	
Lysine, %	0.97	
Methionine, %	0.51	
Cystine, %	0.86	
Leucine, %	3.02	
Isoleucine, %	0.97	
Phenylalanine	1.31	
Threonine	0.96	
Tryptophan	0.21	
Valine	1.30	
Serine	1.07	

Waldroup *et al.*, 2007.

*Data obtained from Poet Nutrition (September, 2008).

http://www.dakotagold.com/products/dakotagold.asp.

** Analyzed sample at Non-ruminant lab, University of Nebraska-Lincoln.

2.2 DDGS Nutrient Value and Digestibility for Poultry

Waldroup *et al.,* (2007) published an excellent review of published data and developed a standardized nutrient matrix for corn DDGS for poultry. First, they determined a weighted average of proximate analysis and amino acid values from 5 published sources (Spiehs *et al.,* 2002; Fiene *et al.,* 2006; Parsons *et al.,* 2006; Fastinger *et al.,* 2006; and Batal and Dale, 2006).

2.3 Water Adsorption Properties of DDGS

Limited information exists regarding the water adsorption properties (hygroscopicity; ability to attract moisture) of DDGS. However, the U.S. Grains Council sponsored a broiler field trial in Taiwan, where moisture content of DDGS was monitored during storage at a commercial feed mill from March 16 to June 10, 2004. A random sample of DDGS was obtained weekly from storage at the feed mill and analyzed for moisture over a 13- week storage period. Moisture content of DDGS increased from 9.05% at the beginning of the storage period to 12.26% at the end of the 13-week storage period. As expected, crude protein concentration did not change in DDGS, and no aflatoxin was present initially or at the end of the storage period. Therefore, it appears that under humid climatic conditions, DDGS will increase in moisture content during long-term storage.

Moisture appears to be a major factor affecting DDGS flow ability during storage and transport, in which storage moisture, temperature, relative humidity, particle size, and time variations may interact to determine flow characteristics. Ganesan *et al.,* (2008) conducted a study to develop sorption isotherms for DDGS with varying soluble levels, in order to provide facility designers and operators with relevant storage and transport information. They determined equilibrium moisture content of DDGS with four different soluble levels (10, 15, 20, and 25% on a dry basis) using a static gravimetric method at 10°C, 20°C, 30°C, and 40°C over four equilibrium relative humidity levels of 60, 70, 80, and 90%. They observed that the sorption capacity of DDGS increased with increasing temperature and solubles level, and followed a type III isotherm, which is commonly observed in high-sugar foods. The equilibrium moisture content for DDGS containing 10, 15, 20, and 25% solubles (dry basis) ranged from 8.61 to 47.07% (dry basis), 11.58 to 83.49% (dry basis), 13.72 to 90.70% (dry basis), and 15.03 to 132.01% (dry basis), respectively. These researchers applied 9 models to fit the isotherm data, but learned that no common model could accurately predict the sorption isotherms of DDGS with various soluble levels. As a result, they developed a new equilibrium moisture content model (Ganesan-Muthu-Rosentrater model) that included solubles level in DDGS as one of the effects along with temperature and moisture content. This model, along with a new modified exponential 2 model, produced the best fits for DDGS with varying soluble levels, and can be used to predict equilibrium moisture sorption behavior of DDGS under a variety of storage conditions (Ganesan *et al.,* 2007b).

2.4 Nutrient Value of DDGS for Poultry

2.4.1 Phosphorus availability

Phosphorus availability is relatively high in DDGS when fed to poultry. However, to further enhance phosphorus availability in DDGS, Martinez-Amezcua *et al.,* (2005) conducted two experiments to evaluate the effectiveness of OptiPhos® phytase and citric acid for improving phosphorus availability in DDGS. Based on the tibia ash responses from OptiPhos and citric acid supplementation compared with those from KH_2PO_4 in these experiments, OptiPhos® phytase and citric acid released from 0.04 to 0.07% more phosphorus from DDGS which indicates that both OptiPhos® phytase and citric acid increase the availability of phosphorus in DDGS. In a follow-up study, Martinez-Amezcua *et al.,* (2006) conducted 3 experiments to determine the effectiveness of OptiPhos® phytase and citric acid for releasing the phosphorus that is not bioavailable in DDGS. Results showed that phosphorus bioavailability in DDGS was 67% and supplemental phytase and citric acid could release from 0.04 to 0.07% phosphorus from DDGS and increased the bioavailability of phosphorus in DDGS from 62 to 72%. These results suggest that phytase and citric acid increase the bioavailability of phosphorus in DDGS, but phytase at 1,000 FTU/kg had no consistent effect on improving AME_n and amino acid digestibility.

2.5 Effect of DDGS on Layers

There has been a significant amount of recent research conducted on the use of high quality corn DDGS in layer diets confirming that it is an excellent partial replacement for corn, soybean meal and inorganic phosphate and supports excellent layer performance and egg quality. Early research results reported by Matterson *et al.,* (1966) showed that DDGS could be added to laying hen diets at levels of 10 to 20%, accounting for about 30% of the total dietary protein, without synthetic lysine supplementation, and had no effect on egg production. Harms *et al.,* (1969) reported that adding 10% DDGS to a layer diet to replace a portion of the dietary protein did not affect egg production or egg weight. Jensen *et al.,* (1974) reported that feeding diets containing DDGS resulted in an improvement in interior egg quality (Haugh units), but it was not a consistent response. Lumpkins *et al.,* (2005) were the first to evaluate the use of high quality, corn DDGS in layer diets. They fed Hy-line W-36 laying hens high energy (2,871 kcal TME_n/kg) and low energy (2,805 kcal TME_n/kg) diets, with and without 15% DDGS from 22 to 42 weeks of age. The DDGS used in this study had color values of L* = 58.52, a* = 6.38, and b* = 20.48. There were no significant differences in egg production for layers fed the 0 and 15% DDGS high energy diets during the entire 22- week experiment, but egg production of hens fed the 15% DDGS diet was consistently lower through 32 wk of age (**Figure 2.2**). When adding 15% DDGS to the low energy diet, egg production was reduced from 26 to 34 weeks of age, but there was no difference after 34 weeks of age (**Figure 2.3**). There were no differences in egg weights, specific gravity and shell breaking strength, feed conversion, body weight, or mortality between the four dietary treatments throughout the entire experiment. There was no difference in Haugh units between dietary treatments from 25 to 31 weeks of age. At 43 weeks of age, layers fed the low energy, 15% DDGS diet had lower Haugh units compared to hens fed the high energy, 15% DDGS diet. Furthermore, feeding the 15% DDGS diets had no appreciable effect on egg yolk color. Based upon these results, the researchers concluded that DDGS is a very acceptable feed ingredient in layer diets and the maximal dietary inclusion level of DDGS should be 10 to 12% in high energy commercial diets, but lower dietary inclusion rates may be necessary in lower energy diets

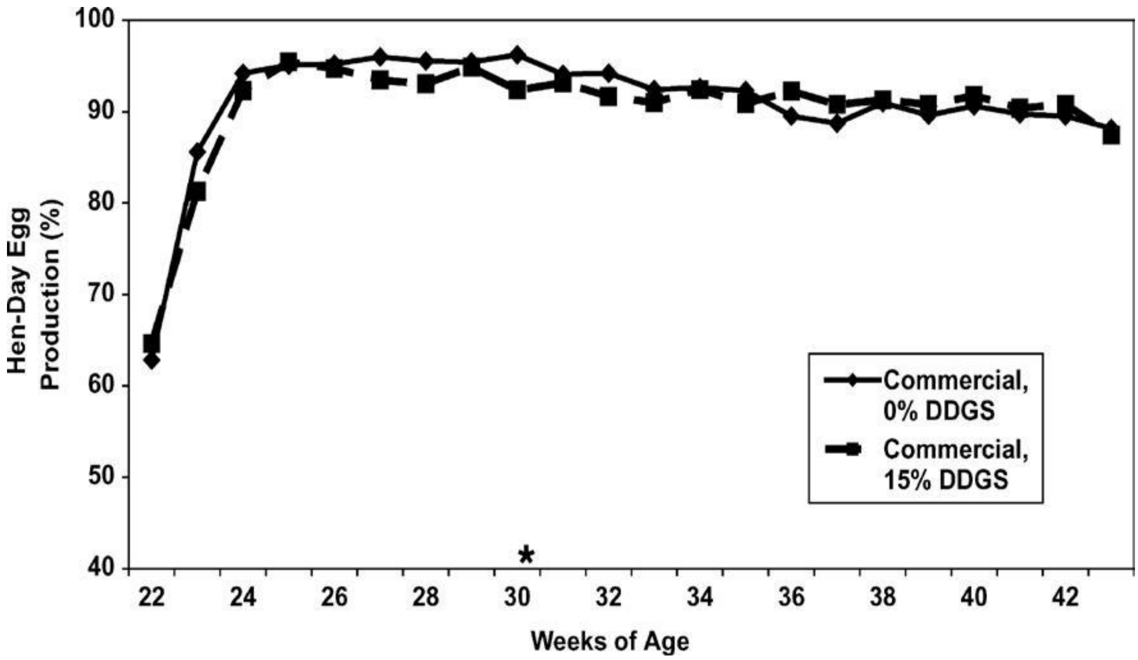


Figure 2.2: Effects of feeding DDGS in high energy density, commercial diets to laying hens on hen-day egg production

*A significant (*P*< 0.05) difference between the 2 treatments

Lumpkins *et al.*, (2005)

Use of DDGS in Poultry Diets

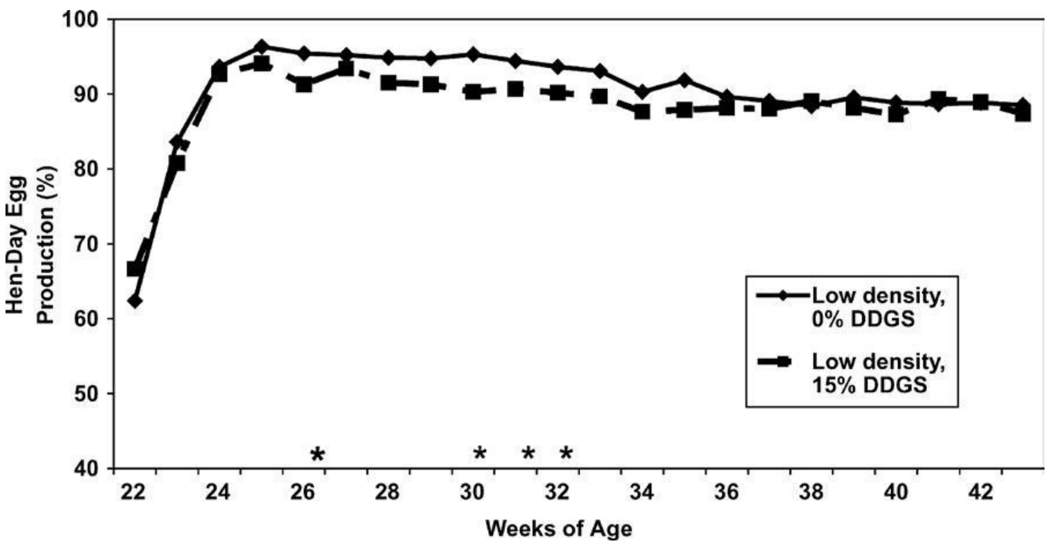


Figure 2.3: Effects of feeding DDGS in low energy density diets to laying hens on hen-day egg production

*A significant (*P*< 0.05) difference between the 2 treatments

Lumpkins *et al.*, (2005)

Similarly, Roberson *et al.*, (2005) conducted two experiments where diets containing 0, 5, 10, or 15% DDGS were fed to laying hens to determine if egg production parameters or yolk color are affected. In the first experiment, a source of golden colored corn DDGS was added to diets fed from 48 to 56 weeks of age and then a brown colored DDGS source was added to diets from 58 to 67 weeks of age. Egg production measurements were not different at most ages. However, as dietary level of DDGS increased, there was a linear decrease in egg production (52-53 weeks of age), egg weight (63 weeks of age), egg mass (51 and 53 weeks of age), and specific gravity (51 weeks of age). Egg yolk color increased linearly as dietary level of DDGS increased throughout the experiment. In experiment 2, egg yolk redness (a*) increased linearly as dietary DDGS level increased. These results showed that egg yolk color becomes more red within one month of feeding diets containing 10% DDGS or more of a golden colored DDGS, and that egg yolk color becomes more red by two months of feeding diets containing 5% DDGS. These researchers concluded that feeding layer diets containing up to 15% DDGS did not affect egg production, but the variable results in experiment 1 suggest that a level less than 15% DDGS should be used.

Cheon *et al.,* (2008) conducted a layer feeding trial for 10 weeks to investigate the effects of adding light-colored DDGS at levels of 0, 10, 15, and 20% to iso-protein, iso-caloric layer diets on laying performance, egg quality and yolk fatty acid composition. Adding up to 20% DDGS to layer diets had no effect on feed intake, laying rate, total egg mass, mean egg weight and feed conversion. Furthermore, color and breaking strength of eggshell were not affected when feeding increasing levels of DDGS in the diet. In addition, albumin height and Haugh units were not affected by adding up to 20% DDGS to the diet. As expected, yolk color was significantly increased when DDGS was added to the diet. The oleic acid content decreased, and linoleic acid increased in egg yolk as increasing levels of DDGS were added to the diet, but the amount of saturated fatty acids in the yolk was not affected by DDGS supplementation. Results of this study conducted in Korea, suggest that light colored DDGS (L* 56.65) could be used at levels up to 20% in layer diets without any negative effects on laying hen performance, and provide economic benefits to the Korean poultry industry.

The effect of reducing the level of fodder phosphate in layer diets containing corn or rye DDGS on performance, egg shell quality and tibia and humerus bone quality were studied in an experiment by Swiatkiewicz and Koreleski (2007). Feeding diets containing 20% corn DDGS had no effect on laying performance or egg shell and bone quality. When diets containing 20% rye DDGS were fed, layer performance and feed conversion were reduced. Reducing fodder phosphate levels in layer diets containing DDGS, did not affect performance or egg shell thickness, density and strength, elasticity and stiffness of the tibia and humerus bones. These results indicate that the amount of fodder phosphate level can be reduced in diets containing 20% corn DDGS without negative effects on performance, egg shell quality or bone characteristics.

Recently, Masa'deh *et al.,* (2011) fed diets containing 0, 5, 10, 15, 20, or 25% DDGS to laying hens from 24 to 46 weeks (phase 1) and 47 to 76 weeks (phase 2) to evaluate egg production responses for a full production cycle. Diets were formulated to be isocaloric (2,775 and 2,816 kcal/kg of ME) and isonitrogenous (16.5 and 16.0% crude protein) in phases 1 and 2, respectively. Results showed that adding up to 25% DDGS in layer diets had no negative effects on feed intake, egg production, Haugh units, or specific gravity, and improved egg yolk color at the higher inclusion rates. Including DDGS at levels greater than 15% during phase 1 decreased egg weight, but not during phase 2. Nitrogen and phosphorus retention was increased and excretion was decreased when hens were fed the 25% DDGS diets.

Gupta *et al.,* (2017) investigated the biological experiment that was undertaken with (4x2) factorial CRD in 45 wk old CARI Sonali layers (n=120) assigned to eight treatments (i.e. 2 control + 6 test diets) having 15 replicates with one layer in each replicate for ten weeks (45th -54th week of age). Eight experimental diets (D1 to D8) were prepared by incorporating rice dry distiller grain with soluble (DDGS) without and with enzyme at 0, 5, 7.5 and 10% level. Weighed amount of respective diet was offered to individual birds daily. All diets had been kept isocaloric and isonitrogenous in nature. Findings of this experiment revealed that consistent decreased values of egg cholesterol were observed at higher inclusion levels of DDGS in combination with enzyme, however significantly ($P<0.01$) increased the hematological, serum protein profile and have lowering effect on serum lipid profile, which was found better effect after dietary addition of enzyme. There was no detrimental effect on sensory attributes of egg.

2.6 Dietary enzyme supplementation in DDGS diets

Refer to Chapter 24 of this Handbook for a detailed summary of "Use of Enzymes in DDGSDiets for Poultry and Swine". In a study conducted by Swiatkiewicz and Korelski

(2005), 132brown Lohman hens (from 26 to 38 weeks of age) were fed 0, 5, 10, 15, or 20% corn or rye DDGS to determine the effects on laying performance and egg quality. Diets containing 20% DDGS were either not supplemented or supplemented with enzyme preparations that had xylanase and beta–glucanase activity. Dietary levels of corn DDGS had no effect on laying rate, feed conversion, Haugh units, eggshell percent and eggshell breaking strength, but egg yolk color was significantly increased. Feeding diets containing 5, 10 or 15% of rye DDGS did not affect laying performance and egg quality, but feeding the 20% rye DDGS diet decreased egg production. However, the addition of xylanase and beta-glucanase to the 20% rye DDGS diet improved egg laying rate.

In a subsequent study, Swiatkiewicz and Korelski (2006) fed laying hens isocaloric and isonitrogenous diets containing 0, 5, 10, 15 or 20% DDGS, and diets containing 20% DDGS supplemented with non-starch polysaccharide hydrolyzing enzymes and additional amounts of synthetic lysine and methionine. In the first phase of production (26 to 43 weeks of age), dietary DDGS level had no effect the laying rate, daily egg weight, feed intake and feed conversion. In the second phase of the cycle (44 to 68 weeks of age), there were no differences in egg production response criteria among groups fed diets containing 0, 5, 10 and 15% DDGS, but feeding 20% DDGS reduced laying rate and daily egg weight. However, when non-starch polysaccharide hydrolyzing enzymes were added to the diet, laying rate and performance improved when feeding the 20% DDGS diet. Dietary level of DDGS had no effect on albumen height, Haugh units, eggshell thickness, density and breaking, or sensory properties of boiled eggs, but egg yolk color score significantly improved when DDGS was added to the diet.

Gady *et al.*, (2008) determined the apparent metabolizable energy (AME) content of corn DDGS and the effect of adding a fungal non-starch polysaccharide hydrolyzing enzyme produced by *Penicillium funiculosum* (Rovabio^{TM} Excel) on DDGS energy digestibility in layers. They fed dietscontaining 10 or 20% corn DDGS in corn and wheat based diets. The AME value obtained with the control corn-wheat based diet was similar to the expected value (3,089 vs. 3,106 kcal/kg DM). The corn DDGS AME value averaged 2,452 kcal/kg DM, and the AME of the control diet was only increased by 34 kcal/kg DM by enzyme supplementation. This increase was less than expected, and may be explained by the lower feed intake of the layer hens fed with the enzyme-treated diet compared to the control diet (99.5 vs. 104.4 g/hen/day). Feed conversion and egg weights were similar and not affected by adding corn DDGS to the diets. The improvement in energy digestibility by enzyme supplementation was greater for diets containing 10 and 20% corn DDGS (43 and 58 kcal/kg DM, respectively), which indicates that adding this enzyme product will improve energy utilization in corn-wheat based diets containing corn DDGS.

2.7 Effects of DDGS on molting

Hong *et al.*, (2007) conducted a study to induce molting using DDGS and a non-salt diet to compare the effect of feeding-molting and fasting-molting treatments on performance, egg quality and visceral organ weights of laying hens. They used 108 White Leghorn hens (62 weeks of age) with egg production of over 80% and average body weight of 1.08 kg in this study. The dietary treatments consisted of: control (non-molt treatment), feeding-molting treatment (DDGS and non-salt diet), and fasting-molting treatment. Egg production decreased for 18 days to 0% in the feeding-molting group and for 17 days to 0% in the DDGS-non-salt feeding-molting group. Egg production stopped for 6 days in the fasting-molting group. Egg production restarted after 12 and 16 days in the feeding - molting and fasting-molting groups, respectively. Except for egg yolk quality, egg quality was improved for all molting treatments. Liver, heart and oviduct weights of laying hens decreased with all molting treatments. These results indicate that the feeding-molting treatment (DDGS and non-salt diet) could replace the fasting-molting treatment and reduce animal welfare concerns due to fasting during the molting process.

Mejia *et al.*, (2010) fed 36, 45, and 54 grams/day of DDGS in a non-feed withdrawal molt program compared to feeding similar daily intakes of corn and found that postmolt egg production (5 to 43 weeks) was higher for hens fed the DDGS molt diets compared to those fed the corn diets. No consistent differences were observed for egg mass, egg specific gravity, feed efficiency, or layer feed consumption among the molt treatments for the postmolt period. These researchers concluded that limit feeding corn or DDGS in a non-feed withdrawal program will result in long-term post-molt performance comparable to ad libitum feeding of a corn-soybean hull diet.

2.8 Effects on manure nutrient content and gas emissions

Ammonia (NH_3) emissions are a major concern for the U.S. poultry industry. Roberts *et al.,* (2007a,b) conducted studies to determine if increasing dietary fiber and reducing dietary crude protein would decrease NH_3 emissions from laying- hen manure. They fed diets containing 2 levels of crude protein (normal and reduced) and 4 dietary fiber sources (corn-soybean meal based control diet, diets containing either 10% corn DDGS, 7.3% wheat middlings, or 4.8% soybean hulls to provide equal amounts of additional neutral detergent fiber). The crude protein levels of the reduced crude protein diets were approximately 1 percentage unit lower than those of the normal crude protein diets, and all diets were formulated on a digestible amino acid and isoenergetic basis.

Adding corn DDGS, wheat middlings, or soybean hulls to the diet reduced the 7 day cumulative manure NH_3 emission from 3.9 g/kg of DM manure for the control, to 1.9, 2.1 and 2.3 g/kg of DM manure, respectively, and also reduced the daily NH_3 emission rate. These results show that adding 10% corn DDGS, 7.3%wheat middlings, or 4.8% soybean hulls are effective in reducing NH_3 emissions from laying-hen manure, but reducing the crude protein content by 1 percentage unit did not affect NH_3 emissions.

Hale (2008) compared the effects of feeding a standard industry diet vs. feeding a diet containing 10% DDGS on manure pH, solids content and ammonia emissions. Manure ammonia emissions were reduced by anaverage of 16.9% over the period of the study, manure pH was reduced by 0.25 SU, and manure solids content was increased by 2.36% when feeding the diet containing 20% DDGS. Wu-Haan *et al.,* (2010) showed that feeding 20% DDGS to laying hens reduces ammonia and hydrogen sulfide emissions with no adverse effects on hen performance.

2.9 Feeding DDGS to Broilers

Distillers dried grains with soluble (DDGS) from corn contain relatively large amounts of polyunsaturated fatty acids and some yeast components, which may increase oxidative stress and alter immune function, respectively, when fed to broilers. Min *et al.,* (2015) conducted the study was undertaken to assess the effects of distillers dried grains with soluble (DDGS) on broilers under immunosuppressive challenge. One-day-old male broiler chickens (300) were assigned to 2 treatments with 6 replicates pretreatment. Birds were fed diets formulated to contain 0, 15% corn-based DDGS, respectively. The experimental diets were fed for 6 weeks in 2 phases. On day 21, serum IgA, IgG content and malondialdehyde (MDA), glutathione peroxidase (GSH-Px), total superoxide dismutase (T-SOD), and total antioxidant activity (T-AOC) capacity were analyzed. Chickens were then randomly allotted to 1 of 4 treatment groups: negative control (NC) corn-soybean meal diet without dexamethasone (DEX) challenge, positive control (PC) corn-soybean meal diet with (DEX) challenge, 15% DDGS without DEX challenge (D), 15% DDGS with DEX (D+DEX). Based on these results, dietary DDGS did not influence ADG, ADFI and F:G of 21 d, 28 d and 42 d chicks ($P > 0.05$), however, DEX affected ADG and F:G of 28 d chicks remarkably ($P < 0.05$). Relative weights of liver, abdominal fat, spleen, thymus, and bursa were influenced by DEX challenge on d 28 ($P < 0.05$). DDGS reduced serum T-AOC, T-SOD, whereas increased IgA, IgG and MDA of 21-day-old broilers significantly ($P < 0.05$). Dietary DDGS also reduced liver T-SOD of 21-day-old broilers significantly ($P < 0.05$). Based on real-time PCR, 28 d chicks fed DDGS had a greater relative abundance of mRNA encoding IL-4 and IL-6 ($P < 0.05$), whereas DEX decreased the expression of GPX, IL-6, IL-10 ($P < 0.05$). Thus, 15% dietary DDGS inclusion has the beneficial effects on immune functions for broilers to some degree.

Dinani *et al.*, (2018) conducted to evaluate the effect of feeding rice distillers dried grains with solubles (rDDGS) and rice gluten meal (RGM) combination as a replacement of soybean along with exogenous enzyme supplementation on the intestinal morphometry and microbiology of broiler chicken at 21 days of age. Following a 2x3 factorial design, the experimental diets were: T1 (no rDDGS/RGM/enzyme), T2 (no rDDGS/RGM, with multienzymes), T3 (12.5% rDDGS, 15% RGM, no enzyme), T4 (12.5% rDDGS, 15% RGM, with protease enzyme), T5 (10% rDDGS, 12.5% RGM, no enzyme) and T6 (10% rDDGS, 12.5% RGM, with protease enzyme). Each treatment was allocated 5 replicates of broiler chicken with 8 birds in each. The feeding of the dietary combination of 12.5% rDDGS and 15% RGM significantly ($p<0.05$) decreased the villus height (VH), crypt depth (CD), VH: CD ratio and villus width compared to the control and other rDDGS & RGM combination. The microbiological parameters revealed that TVC in crop and jejunum were increased significantly ($P<0.05$) in12.5% rDDGS & 15% RGM as compared control. It was concluded that the simultaneous inclusion of rDDGS and RGM in broiler chicken ration with or without enzyme supplementation had adverse effects on the intestinal histomorphometry and microbiology.

Shim *et al.,* (2018) investigated the effects of feed form and distiller's dried grain with solubles (DDGS) on meat quality and fatty acids profile of broiler chickens. A total of 720 broilers (Ross 308; average BW [body weight] 541±5.7 g) were randomly allotted to six treatments. Birds were fed three different feed forms (mash; SP, simple pellet; EP, expanded pellet) and DDGS (0 or 200 g kg^{-1}) in a 3×2 factorial arrangement. The addition of DDGS and EP to the diet resulted in increased shear force of breast meat. Moreover, DDGS inclusion in the diet reduced the concentration of stearic acid and behenic acid in thigh meat. Pelleting (SP and EP) of the diets increased palmitic acid content in the thigh, whereas the linolenic acid content decreased. The breast mass was higher with EP and SP diets than with the mash diet. Feed processing led to increased pectoralis muscle and drum mass compared to mash-fed chickens. In conclusion, our results demonstrated that EP decreased thigh linolenic acid and meat shear force. In addition, DDGS supplementation in broiler hampers meat quality by increasing the shear force.

Abd El-Hack *et al.*, (2019) suggests that Dried Brewers grains (DBG), a brewery by-product that, may offer a suitable cheap replacer for traditional feedstuffs (e.g., corn and soybean meal). A variety of essential nutrients are present in BDG which are required in feed formulation for poultry. It is composed of around 20% crude proteins, 6% ether extract, 15% crude fiber and 4% ash. Besides, it is fairly rich in essential amino acids; 0.9% lysine, 0.4% methionine, 0.4% tryptophan, 1.2% phenylalanine, 1.1% threonine as well as 1.6% valine. As a result, the concentrations of protein and amino acids are greater in BDG than in maize. However, the use of BDG in poultry feeds has some constraints such as high moisture and fiber contents. The high moisture content of wet brewers' grains (about 80%) increases its bulkiness. So, efficient sun-drying is recommended to avoid nutrient losses of the by-product. Due to presence of high fiber content in BDG, it is mainly used as a cattle feed. But, there are also many studies, which explored the use of BDG in poultry diets. The present review article highlights the nutritional value of BDG as an untraditional feedstuff in broiler diets and its impacts on growth performance.

Kim *et al.,* (2016) conducted the study were to determine the maximum inclusion rates of a low fat distillers dried grains with solubles (LF-DDGS) in broiler diets fed during the finisher I phase (28 to 42 d) and the finisher II phase (43 to 56 d) and the subsequent effects on live performance and carcass characteristics. These ages were specifically chosen to determine effects of feeding LF-DDGS to broilers grown to heavy weights (>3.0 kg). Experimental diets were formulated to contain 0, 8, 16, 18, 24, or 30% LF-DDGS for finisher I phase and 0, 18, 16 and 24% LF-DDGS for finisher II phase. Diets were formulated to be isocaloric and to meet or exceed the minimum nutrient requirements. Birds were fed common diets until d 27 or 41 and experimental diets were fed until d 42 and d 56, respectively. Upon completion of the experimental periods, all birds and feed were weighed to determine body weight, body weight gain, feed consumption and feed conversion ratio for the experimental periods. On d 43 and 57, after an overnight fast, 6 birds per pen were tagged, weighed and processed to determine hot carcass weight and abdominal fat pad. After a period of chilling, carcasses were deboned to determine breast and tender weights. For the Finisher I period, body weight gain (BWG) was significantly ($P<0.05$) decreased and FCR was significantly increased for birds fed diets containing 30% LF-DDGS. At 43 d, carcass yield was found to be significantly decreased ($p<0.05$) for birds fed 30% LF-DDGS when compared to birds fed no LF-DDGS. For the Finisher II period, there were no significant effects of LF-DDGS inclusion on live performance and resulting carcass parameters. These results indicate that finishing broilers (28 to 56 d) can tolerate up to 24% LF-DDGS in the later phases of production without any detrimental effects on live performance and carcass parameters.

Researchers have consistently observed positive performance and meat quality results when DDGS is added to broiler diets. Results from an early study by Day *et al.,* (1972) showed that weight gain of broilers was increased when low levels of DDGS (2.5 and 5%) were added to the diet compared to broilers fed the control diet. Later, Waldroup *et al.,* (1981) demonstrated that DDGS can be added to broiler diets at levels up to 25% to achieve good performance if dietary energy level is held constant.

Studies involving the use of high quality corn DDGS have confirmed, and even suggested that higher dietary DDGS can be used effectively. Lumpkins *et al.,* (2004) conducted two experiments to evaluate dietary energy and protein density and DDGS inclusion rate in broiler diets. In the first experiment, two dietary nutrient densities (high= 22% protein, 3050 kcal ME_n/kg and low = 20% protein, 3000 kcal ME $_n$/kg) contained either 0 or 15% DDGS. Chicks were fed experimental diets from 0 to 18 days of age. Weight gain and feed conversion were the highest for chicks fed the high density diet compared to the low density diet, but performance was not different between chicks fed the 0 or 15% DDGS diets within diet nutrient density level.

In the second experiment, Lumpkins *et al.*, (2004) fed chicks isocaloric and isonitrogenous diets containing 0, 6, 12, or 18% DDGS for a 42-day feeding period. Adding 18% DDGS in the diet reduced weight gain during the starter (0 to 16 d) period, and there was a slight numerical decrease in weight gain when 12% DDGS was added to the diet. However, there was no difference in weight gain between dietary DDGS level during the grower and finisher periods. Overall weight gain (0 to 42d) of chicks fed the 18% DDGS diets was reduced compared to the other DDGS feeding levels because of the reduced weight gain during the starter period. The amino acid profile in soybean meal is more suitable to meet the amino acid requirements of broilers than corn protein sources. Since the percentage of protein provided by corn protein increased from 4.6 to 8.6% when 18% DDGS was added to the diet, and the percentage of protein supplied by soybean meal decreased, it is likely that lysine was deficient and resulted in reduced growth rate and gain efficiency. Feed intake was not affected by dietary DDGS level throughout the experiment. Gain efficiency was reduced when feeding the 18% DDGS diet during the starter period, and there was a numerical decrease in gain efficiency when 12% DDGS was added to the diet. However, there were no differences in gain efficiency between any of the DDGS feeding levels during the grower and finisher period and throughout the 42-d experimental feeding period. Feeding diets containing 0, 6, 12, or 18% DDGS had no effect on carcass yield. These researchers concluded that high quality DDGS is an acceptable ingredient in broiler diets and recommended a 6% maximum dietary inclusion rate in the starter period and 12 to 15% DDGS in grower and finisher phases of broiler production.

2.10 Turkeys

Noll (2004) summarized results from three trials where diets containing up to 12% DDGS were fed to market toms during the grower-finisher period, and found no difference in body weight gain and feed conversion compared to the control corn-soybean meal-meat meal diets. A subsequent study by Noll and Brannon (2005) showed that up to 20% DDGS can be included in turkey tom grower or finisher diets but when high protein levels are fed, diets containing 15% DDGS can improve growth performance. Roberson (2003) conducted two experiments using Large White female turkeys to evaluate the effects of increasing dietary DDGS level on growth performance. In the first experiment, corn-soybean meal diets containing 0, 9, 18, or 27% DDGS were fed to growing turkeys from 56 to 105 days of age. Body weight linearly decreased with increasing level of DDGS in the diet at 105 days of age. However, feed conversion improved from 77 to 105 days of age as dietary DDGS level increased. Roberson (2003) noted that the incidence of pendulous crops increased for birds fed diets with high levels of DDGS. In the second experiment, diets containing 0, 7, or 10% DDGS were fed in the grower period, with half of the birds fed the 10% DDGS in the grower period fed 7% DDGS in the finisher period. There were no differences among dietary treatments for body weight gain or feed conversion in this experiment. He concluded that DDGS can be effectively included at 10% of growing-finishing diets for turkey hens if the proper nutrient values for DDGS are used.

2.11 Ducks

The U.S. Grains Council sponsored a recent study conducted at the I-lan Branch of the Livestock Research Institute in Taiwan, where researchers evaluated the effects of feeding diets containing corn dried distiller's grains with solubles on the production performance and eggChapter 19. Use of DDGS in Poultry Diets quality of brown Tsaiya duck layers (Huang *et al.*, 2006). After 14 weeks of age up to 50 weeks of age, ducks were randomly assigned to one of four dietary treatments containing 0, 6, 12, or 18% DDGS. Diets were isocaloric and isonitrogenous and contained 2750 kcal/kg ME and 19% CP. Results from this study suggested that adding DDGS at levels up to 18% of the diet for laying ducks had no significant effect on feed intake, feed conversion, or quality of the egg shell. When laying ducks were fed the 18% DDGS diet egg production rate increased in the cold season. Egg weight tended to be higher by including 12% or 18% of DDGS in the diets. Yolk color was linearly improved with increasing amounts of DDGS in the laying duck diets. The xanthophylls in DDGS can be well utilized by the laying ducks. When DDGS was used in duck laying diets, fat percentage of yolk and linoleic acid content of yolk was increased. DDGS can be efficiently used in the diets of duck layers to improve the yolk characteristics without influencing the productive performance.

2.12 Effect of DDGS on Japanese Quail

El-Abd (2017) conducted that effect of replacing yellow corn (YC) by distillers dried grains with Solubles (DDGS) was studied on Japanese quail chicks performance. One hundred and eighty unsexed one- day old chicks, distributed at random equally into 3 groups each in 3 replicates. Treatments were: control with 0% DDGS, T1 containing 50% of YC as DDGS and T2 containing 100% of YC as DDGS. The experiment lasted for 42 days and all chicks had free access to feed and water. Average feed intake (FI), daily gain (BWG) and feed conversion efficiency (FCR) were determined. Data showed that, chicks fed100 % and 50% of YC as DDGS had higher BWG at 42 days, higher FI and better FCR compared to the control diet. Also, T1 and T2 had the highest globulin concentrations and total plasma protein, than the control diet. No significant effect of DDGS levels on carcass characteristics. Digestibility of crude protein was affected significantly ($p<0.005$) with increasing DDGS level. In conclusion, use of DDGS at 100% of YC showed the higher results compared to the other treatments. Therefore, DDGS could be successfully replaced 100% of YC in diet of Japanese quail.

CHAPTER III

MATERIALS AND METHODS

3.1 Experimental site

The experiment was conducted at the Poultry farm under the Department of Dairy and Poultry Science of HSTU, Dinajpur 5200 during the period from 08 May 2019 to 9 July 2019. Commercial sonali chick was used as experimental birds for a period of 9 weeks to find out the effects of partial replacement of soyabean by DDGS on sonali chicken.

3.2 Experimental birds

One hundred twenty vigorous day- old sonali chicks were procured from Najim Poultry Feed and Hatchery Limited, Setabgonj, Dinajpur.

3.3 Layout of the experiment

The experiment was conducted in completely randomized design (CRD)**.** The chicks were randomly distributed to four dietary treatment groups T_0, T_1, T_2, and T_3, T_4 having three replications in each treatment. The chicks were reared in separated pens according to treatments and replications, each dietary treatment group contain of 30 birds. The layout of the experiment is shown in the following table materials.

Table 3.1: Layout of the experiment

Dietary Treatment	No. of chicks in each replication			Total number of chicks in each treatment
	R_1	R_2	R_3	
T_0	10	10	10	30
T_1	10	10	10	30
T_2	10	10	10	30
T_3	10	10	10	30
T_4	10	10	10	30
Total				150

Where,

T_0: Control group,

T_1: 5% DDGS

T_2: 10% DDGS

T_3: 15% DDGS and

T_4: 20% DDGS

3.4 Preparation of the experimental house

HSTU poultry farm was used for rearing experimental birds to evaluate the growth performance, carcass characteristics and alternative feed source of sonali chicken. Experiment shed was constructed with compartment of housing for ten birds. Each compartment was 54x42 inches size. The shed was constructed by metal wire and wooden materials. At first, the experimental house was properly washed and cleaned by using tap water. Ceiling, walls, and floor were thoroughly cleaned and subsequently disinfected with bleaching powder, then the room was kept closing for two weeks. After that, the house was again disinfected with virocid solution 1ml/3liter water. At the same time, all feeders, waterers and other necessary equipment were also properly cleaned, washed and disinfected with Timsen solution. After proper drying, the house was used for this study.

3.5 Collection of DDGS and preparation of ration

DDGS were brought from Najim Poultry Feed and Hatchery Limited to determine the growth performance, carcass characteristics of sonali chicken.

After collection, level of DDGS were used as 0%, 5%, 10%, 15%, 20% in ration on sonali chicken.

3.6 Experimental diet

The experimental diet was provided into two phases (Sonali-starter and Sonali-grower), starter was provided 0 to 20 days and grower was days 21 to last day of experiment. Only a bag of Sonali-starter of experimental diet was purchased from local market in Dinajpur, namely company (Nourish poultry and hatchery limited). Then, the rest of the feed named Sonali-grower was made by own to keep free from external antibiotics. All the ingredients were taken at proper rate according to their standard composition. All the treatments were provided through feed during experimental period.

Table 3.2: Nutrient Composition of Sonali Starter

Chemical composition	Starter (Upto 0-21 days)
Moisture (%)	11-12
Crude protein (%)	21
Crude fiber (%)	5
Crude fat (%)	-
Calcium (%)	1
Available phosphorus (%)	0.5
ME (Kcal/Kg)	2850

Table 3.3: Ingredients amount of formulated ration of Sonali Grower with their chemical Composition

Ingredients (Kg)	Treatment				
	T_0	T_1	T_2	T_3	T_4
Maize	56.5	55.5	51.5	51	48.5
Soybean	26.5	22	20	16	13.5
Rice Polish	9	10	11	10.5	10
DDGS	0	5	10	15	20
Propec	4	4	4	4	4
Soybean Oil	1.5	1	1	1	1.5
DCP	0.5	0.5	0.5	0.5	0.5
Oyster Shell	0.85	0.85	0.85	0.85	0.85
Limestone	0.75	0.75	0.75	0.75	0.75
Salt	0.40	0.40	0.40	0.40	0.40
Total	**100**	**100**	**100**	**100**	**100**
Chemical composition of Sonali Grower					
ME (Kcal/Kg)	2952.26	2995.71	2970.82	2970.43	2982.68
Crude Protein (%)	20.75	20.19	20.50	20.075	20.075
Crude Fiber (%)	2.905	3.03	3.22	3.306	3.425
Calcium (%)	1.0255	1.0154	1.0156	1.0005	0.916
Phosphorus (%)	0.6017	0.583	0.644	0.543	0.53
Lysine (%)	1.128	0.995	0.933	0.8128	0.754
Methionine (%)	0.3653	0.5621	0.3194	0.292	0.283

*** Added vitamin-mineral premix @ 250gm, Lysine @ 50gm, Methionine @ 50gm, Toxin Binder @ 150gm, Anti-Salmonella @ 150gm, Enzyme @ 50gm, Emulex @ 50gm and Maduramysin @ 50gm per 100 kg feed.

3.7 Routine Management

The birds were reared to similar care and management in all treatment groups throughout the experimental period. The following management practices were followed whole experimental period.

3.8 Litter Management

Fresh and dried rice husk was used as litter at a depth of 2-3 inch. After 5 weeks, old litter was totally removed and new litter was provided as same depth. The litter was stirred one time per day from four weeks upto the last day of experimental period.

3.9 Floor Space

Each pen was 4.5×3.5 sq. ft. allocated for feeding, watering, and housing for 9 experimental birds.

3.10 Brooding Management

Brooding is the first management of day old chick. In brooding period, electric brooder was used to provide suitable heat in chick for maintaining their body temperature. The brooder was hanged just above the bird level at the center of chick guard. Before entrance of day old chicks, fresh dried litter was provided at a depth 3 inches then covered by newspaper. Pre-heating the brooding space and temperature adjusted at 33 ± 2^0C. After entrance, day old chicks were provided vitamin C and glucose, one-hour later feed was provided. At first day temperature was maintained 33 ± 2^0C then gradually decreased 1^0C per day. Temperature and humidity were recorded by using clinical thermometer and hygrometer.

3.11 Lighting Management

The birds were exposed to 23 hours of lighting and 1-hour dark period throughout the experimental period.

3.12 Feeding and drinking

Provide adlibitum feed and water through the experimental period.

Table 3.4: Vaccination

Name of Vaccine	Name of diseases	Age (Days)	Route of administration
IB+ND	Infectious Bronchitis & New Castle	5^{th}	One drop in one eye
IBD	Gumboro	10^{th}	One drop in one eye
IBD	Gumboro	17^{th}	Through drinking water
ND	New Castle	22^{nd}	Through drinking water
ND	New Castle	42^{nd}	Through drinking water

Vaccine, prepared by Intervet International, Netherland, was applied as per recommendation of the manufacturer.

3.13 Sanitation

Drinkers were washed daily in the morning and feeders were cleaned weekly before being used. Strict sanitary measures were followed during the experimental period.

3.14 Temperature and relative Humidity measure

Temperature (°C) was recorded by clinical thermometer and relative humidity (%) was recorded by digital hygrometer three time daily.

3.15 Debeaking

Debeaking of the birds was done successfully by electric debeaker at the age of 42-45 days to reduce cannibalism.

3.16 Slaughtering of the Birds

Prior to slaughtering the birds were fasted for 10 hours, but water was provided adlibitum. Two birds were randomly selected in each replication for slaughtering. The live weight of birds was taken individually before slaughtering. At the time of slaughtering, the birds were secured by holding both shanks with one hand and both wings with other hand by the help of an assistant to prevent struggling. Slaughtering was done by Halal method with a sharp knife. Complete bleeding was accomplished by raising the bird approximately 45^0C so that the caudal part will be elevated than the head. After complete bleeding removal were done shank, head and skin. Finally evisceration was done manually to separate liver, spleen, heart, gizzard, and to measure meat yield.

3.17 Calculation

1. Total weight gain in (kg): This was computed as a group by subtracting the initial weight from the final weight.

Total gain in weight = Final weight – Initial weight

2. Dressing percentage: The dressing percentage of sonali chicken was calculated as follows:

$$\text{Dressing (\%)} = \frac{\text{Dressed weight}}{\text{Body weight}} \times 100$$

3. Total feed consumption (kg): The amount of feeds consumed by the birds from the start until the end of the experiment (70 days). This was computed by adding the total feeds offered after the total left- over have been subtracted.

Total feed consumption = Total feed offered – Total left over

4. Feed efficiency: This was obtained per treatment by dividing the total feed consumed by the total gain in weight. Feed efficiency is computed for the whole duration of the experiment (70 days).

$$\text{Feed efficiency} = \frac{\text{Total feed consumed}}{\text{Total gain in weight}}$$

5. Total cost of the total feed consumed: This was obtained by multiplying the cost of feed per kilogram to the total feed consumed.

Cost of the total feed consumed = Cost of feed per kilogram × Total feed consumed

6. Feed cost per kg gain of sonali chicken: The feed cost per kilogram of gain in weight was computed as the price of feeds per kilogram multiplied by the total gain in weight.

$$\text{Feed cost per kilogram gain} = \text{Price of feeds 1 kg} \times \frac{\text{Total feed consumed (kg)}}{\text{Total weight gain (kg)}}$$

7. Mortality rate (%):

$$\text{Mortality rate (\%)} = \frac{\text{No. of dead chickens}}{\text{Total no. of birds housed}} \times 100$$

8. Cost of production: This includes the cost of stocks, feeds, commercial antibiotics, vitamins, electricity and materials used.

9. Gross income: This was obtained as a group by multiplying the sum of the final weight of the birds by the price per kilogram of live weight.

Gross Income = Total weight (kg) of the birds (as a group) × Price per kilogram

10. Net income: This was obtained by subtracting the cost of production from the gross income.

Net income = Gross income – Cost of production

3.18 Data collection and record keeping

The following records were kept during the experimental period: Initial DOCs weight and after brooding weight of chicks. Weekly Body weight gain and feed intake was recorded replication wise in each treatment group at last day of week. Mortality was recorded daily if death occurred. The different meat yield parameters like, carcass, drum stick, breast meat, head, heart, liver, spleen, gizzard and shank weight for individual birds were recorded after slaughtering. Temperature and relative humidity was recorded three times daily.

3.19 Statistical analysis

The data of feed consumption, growth performance, carcass characteristics and bacterial count were recorded and analyzed by SPSS version-22 software by using one way ANOVA according to the principles of Completely Randomized Design (CRD). All values were expressed as Mean±SEM and significance was determined when ($P<0.05$) mean was compared among the treatment groups by using Duncan test.

CHAPTER IV

RESULTS AND DISCUSSION

This experiment was conducted to evaluate the efficacy of DDGS on production performance in terms of weekly body weight gain, final live weight gain, feed intake and feed efficiency of Sonali chicken. DDGS has been safely used in Asia for hundreds of years. There are no established contraindication of DDGS in use says drugs.com. This experiment was held under the department of Dairy and Poultry Science, Faculty of Veterinary and Animal Science, HSTU, Dinajpur.

Day old chicks were randomly divided into 5 groups (T_0, T_1, T_2, T_3 and T_4) after 21 days for assessing the efficacy of DDGS formulated ration on sonali birds.

4.1 Weekly Body weight gain

At the start of the experiment, the average body weight of the birds did not differ significantly among the treatment groups. In (Table 4.1) showed that after 7 days of brooding, initial body weight of chicks in different dietary treatment was similar. The live weight of birds in 4^{th}, 6^{th}, 7th and 9th weeks did not significantly ($P<0.05$) vary among the treatment groups. The efficacy of supplementation of DDGS @ 5%, 10%, 15% and 20% on sonali feed upto 10^{th} weeks showed increased live weight gain compared to the control (T_0) group. At 10^{th} weeks the highest values was found in T_1 (798.58±19.36g) in DDGS group that was received @ 5% DDGS and the lowest values was found in T_0 (752.82±10.49g) that received only feed. Within the DDGS group respective treatment @ 5%, 10%, 15% and 20% in feed and live weight was found (798.58±19.36 g), (781.82±10.33g), (727.27±17.02g) and (718.18±28.11g). The result of this study clearly showed that 5% DDGS increase live weight upto 10 weeks of age. Live weight of 5th, 8th and 10th weeks significantly ($p<0.05$) differed among the treatment groups. Live weight gain was significantly ($p<0.05$) highest in T_1 and T_2 group compared to T_0, T_3 and T_4 group. However the inclusion level of 5% DDGS was showed maximum live weight (798.58±19.36 g) and minimum live weight was showed (718.18±28.11g g) in T_4 treatment group at the terminal stage of experiment. Within treatment group 20% DDGS was represented lowest live weight gain whereas, 5% treatment group represent highest live weight gain. It is clearly stated that 5% DDGS help to increase live weight of sonali chicken. The significant effect of DDGS on body weight gains were found higher in T_1, T_2group compared to T_0, T_3, T_4 group (Table 1).Similarly, Folytn *et al.*, (2013) reported that heavier body weight found by using 6% DDGS on broiler chicken feed groups, which is in agreement with the findings of the present study. Kaya and Şahin (2013) reported significant increase in the live weight of broiler chicken compared with control group. The present study supported with Swiatkiewicz and Korelski (2008) conducted a scientific literature review on the benefits of feeding DDGS to poultry and concluded that DDGS is an acceptable ingredient for use in poultry diets and can be safely added at levels of 5-8% in starter diets for broilers and turkeys, and 12-15% in grower-finisher diets for broilers, turkeys, and laying hens.

4.2 Body weight gain

In (Table 4.1) initial body weight of sonali chicks fed on different dietary treatments was similar ($p>0.05$). Final live weight gain was statistically significant ($p<0.05$) among the different treatment group. The highest body weight gain was attained in birds that received DDGS 5% of feed. However, treatment group T_1 was significantly ($p<0.05$) higher body weight gain compared to control group T_0. Within DDGS group treatment T_1 was significant ($p<0.05$) compare to treatment group T_2, T_3 and T_4. The result of this study was indicated that DDGS 5% (T_1) of feed induces highest body weight gain compared to other group at the end of feeding trial. This result agree with Kaya and Şahin (2013) reported that, DDGS supplementation to the broiler diets up to 15% improved body weight gain, weekly gain in weight, feed consumption and feed efficiency. Mortality rate was not affected in the current experiment. Disimilar results were obtained by Wang *et al.*, (2007b, 2008) and also similar with Youssef *et al.*, (2008), that they had used the diets with 30% and 15% DDGS, respectively.

Table 4.1: Effect of supplementation of DDGS formulated ration on weekly body weight of sonali chicken

Age in weeks	T_0	T_1	T_2	T_3	T_4	Level of significant
4th	238.36±3.01	217.27±15.76	225.15±2.74	212.73±6.30	201.15±4.95	0.073(NS)
5th	300.12±3.71^{cd}	308.18±4.34^{a}	302.54±4.68^{b}	281.15±10.92^{d}	277.21±1.26^{d}	0.014 *
6th	369.21±10.97	389.33±12.50	362.67±4.50	370.54±11.04	356.30±7.71	0.247(NS)
7th	393.48±15.02	441.06±19.03	417.73±6.56	407.12±2.18	408.34±6.45	0.130 (NS)
8th	507.03±5.37^{c}	546.43±14.69^{a}	541.15±9.44^{b}	505.76±9.39^{d}	493.52±13.43^{d}	0.023 *
9th	613.03±8.44	623.94±36.32	650.30±17.06	596.36±10.33	588.18±14.61	0.275(NS)
10th	752.82±10.49^{cd}	798.58±19.36^{a}	781.82±10.33^{b}	727.27±17.02^{d}	718.18±28.11^{d}	0.04 *

The mean values with different superscript (a to d) within the same row differs significantly, at least ($p<0.05$). All values indicate Mean±Standard Error of mean.

NS means statistically not significant, *Means significant at 5% level of significance ($P<0.05$).

4.3 Feed intake

In (Table 4.2) shows that the cumulative feed intake of sonali chicken in different dietary treatment during experimental periods was statistically similar ($p>0.05$). However, the lowest feed intake (2147.7±.079g) was found T_1 group. The birds of T_4 group showed higher feed intake (2234.7±.005g) compared to others groups. Kaya and Şahin (2013) reported that, DDGS supplementation to the broiler diets up to 15% improved body weight gain, weekly gain in weight, feed consumption and feed efficiency. Mortality rate was not affected in the current experiment which is in agreement with the findings of the present study. Disimilar with results were obtained by Wang *et al.,* (2007b, 2007c and 2008) and also similar with Youssef *et al.,* (2008), that they had used the diets with 30% and 15% DDGS respectively

4.4 Feed efficiency

Difference in feed efficiency of different treatment groups during the experimental period statistically significant ($P<0.05$). The birds of T_1 groups containing 5% DDGS converted feed to meat most efficiently. The feed efficiency of T_1 treatment groups was statistically significant ($P<0.05$) with T_0 group. T_1 and T_2 treatment group was also significantly higher than T_0 treatment group. From (Table 4.2) feed efficiency was higher at the level of 5% (T_1) DDGS formulated feed. Highest feed efficiency (2.69±0.07) was found in T_1 groups and lowest feed efficiency (3.12±0.12) was found in T_4 groups. The second highest feed efficiency (2.78±.04) was found in T_2 groups. It was found that 5% of DDGS induced higher feed efficiency on sonali chicken. But Youssef *et al.,* (2008) reported that 10-15% DDGS as a protein source could be included without negative effects on broilers' weight gain and feed intake, however especially FCR values decline, which is in agreement with the findings of the present study. Shim *et al.,* (2011) showed that DDGS can be a good alternative ingredient in diets for broilers at levels up to 24% of the diet when diets are formulated on digestible amino acids basis which is disagreement with the findings of the present study.

Table 4.2: Effect of DDGS on feed intake, feed efficiency and mortality of Sonali chicken

Parameters	T_0	T_1	T_2	T_3	T_4	Level of significant
Feed intake(g)	2189.0±.006	2147.7±.079	2174.0±.002	2186.7±.004	2234.7±.005	0.67(NS)
Weight gain(g)	752.7±.010	798.7±.020	781.7±.010	727.3±.169	718.2±.033	0.09(NS)
Feed efficiency	2.91 ± 0.04^{bc}	2.69 ± 0.07^{a}	$2.78\pm.04^{ab}$	3.01 ± 0.07^{c}	3.12 ± 0.12^{d}	.013*
Mortality	0	0	0	0	0	

The mean values with different superscript (a to d) within the same row differs significantly, at least ($p<0.05$). All values indicate Mean±Standard Error of mean.

NS means statistically not significant, *Means significant at 5% level of significance ($P<0.05$)

4.5 Cost benefit analysis of production

Production cost of sonali chicks in this study are presented in (Table 4.3). Spending on feed, chick, vaccine, medicine, litter, DDGS formulated ration, miscellaneous (labour, electricity, transport cost) were constituted cost/chick live weight. Lowest total production cost per chick weight gain was (100.69±.13Tk.) found in T_1 group and highest was found in (103.98±.20 Tk.) in T_0 group. Total feed cost per chick in different dietary treatment was found non-significant ($p>0.05$). However, the total feed cost was lowest in the group that received 5% DDGS whereas increased total feed cost in T_0 group without DDGS. The highest profit (35.02±3.42Tk.) was found in T_1 group and lowest (19.10±4.88Tk.) was found in T_4 group. DDGS formulated ration group net profit higher was found in T_1 (35.02±3.42Tk) then T_2 (31.01±1.73Tk), T_0 (23.98±1.71Tk), T_3 (21.98±2.87Tk) and T_4 (19.10±4.88Tk), respectively.

This study result showed that supplementation with DDGS formulated ration was more profitable than control group. The study has revealed that supplemented with DDGS had higher body weight gain, weekly gain in weight, feed consumption and feed efficiency, Kaya and Şahin (2013). It is concluded that supplementation 5% DDGS caused significant increase in live body weight and improvement in weekly gain in weight and feed-efficiency as compared to that of control group of poultry. This results are in line with those reported by Folytn *et al.,* (2013) that heavier body weight found by using 6% DDGS on broiler chicken fed groups which is in agreement with the findings of the present study.

Swiatkiewicz and Korelski (2008) conducted a scientific literature review on the benefits of feeding DDGS to poultry and concluded that DDGS is an acceptable ingredient for use in poultry diets and can be safely added at levels of 5-8% in starter diets for broilers and turkeys, and 12-15% in grower-finisher diets for broilers, turkeys, and laying hens.

Table 4.3: Cost benefit analysis of different dietary treatment

Parameters (Tk.)	T_0	T_1	T_2	T_3	T_4	Level of significant
Chick cost/chick	16	16	16	16	16	NS
Litter cost/chick	5	5	5	5	5	NS
Vaccine + medicine cost/chick	10	10	10	10	10	NS
Miscellaneous cost/ chick	5	5	5	5	5	NS
Feed cost/ kg	31.05	30.12	30.30	30.00	29.96	NS
Feed cost/ chick	67.98±.20	64.69±.13	65.87±.06	65.60±.10	66.93±.15	NS
Total cost/ chick	103.98±.20	100.69±.13	101.87±.06	101.60±.10	102.93±.15	NS
Selling price Tk./kg	170	170	170	170	170	NS
Selling price Tk./chick	127.95±1.76	135.72±3.39	132.88±1.75	123.58±2.92	122.06±4.77	.04*
Net profit Tk./bird	23.98±1.71	35.02±3.42	31.01±1.73	21.98±2.87	19.10±4.88	.03*

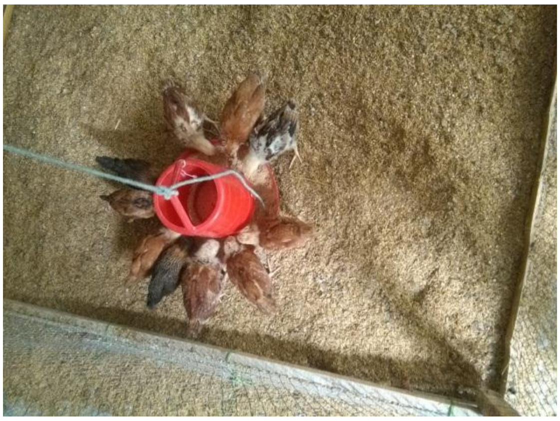
The mean values with different superscript (a to b) within the same row differs significantly, at least ($p<0.05$). All values indicate mean ± Standard error of mean

NS=Non significant, *statistically significant ($P<0.05$)

Brooding

Experimental Shade

Preparation of Feed with DDGS



Feeding

Offering feed

Taking Weight of Bird

Figure 4.1: Some Picture of my Experimental Site

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted to evaluate the efficacy of DDGS on production performance and reduce the feed cost of sonali chicken. A total of 150 one day old chicks were purchased from Najim Poultry Feed and Hatchery Limited. After 7 days of brooding the chick were randomly divided into five treatment groups namely (T_0, T_1, T_2, T_3 and T_4) having three replication in each treatment group. Experimental birds in T_1, T_2, T_3 and T_4 were provided DDGS @ 5%, 10%, 15% and 20% while T_0 was provided only normal feed. At the terminal stage of experiment the cumulative body weight gain of different treatment groups was T_0 (752.82±10.49g), T_1 (798.58±19.36g), T_2 (781.82±10.33g), T_3 (727.27±17.02g) and T_4 (718.18±28.11g), respectively. Birds that received DDGS 5% was gained highest (798.58±19.36g) body weight in T_1 and lowest was found (752.82±10.49g) in T_0 group compared to control group.

The feed intake among different treatments were non-significant ($p>0.05$). The cumulative maximum feed intake was observed in treated T_0 group (2189.0±.006g) and minimum in DDGS treatment group T_1 (2147.7±.079g). All treatment groups showed significant difference ($p>0.05$) to control groups. Feed efficiency of different treatment was statistically significant ($p<0.05$) compared to T_0 control group. Respective feed efficiency was found T_0 (2.91±.04), T_1 (2.69±0.07), T_2 (2.78±.04), T_3 (3.01±0.07) and T_4 (3.12±0.12). But DDGS treated group (T_1) converted feed to meat most efficiently compared to T_2, T_3, T_4 and T_0 treatment, respectively.

Data obtained feed cost, lowest was seen in DDGS treated group T_1 and highest in untreated group. Net profit obtained maximum was found in T_1 (35.02±3.42Tk.) then T_2 (31.01±1.73Tk.), T_0 (23.98±1.71Tk.), T_3 (21.98±2.87Tk.) and T_4 (19.10±4.88), respectively. Based on the result of present study it may be concluded that DDGS is a good source to reduced feed cost and it has significant effect on body weight gain and feed efficiency of sonali chicken. The result of this study suggests that supplementation of 5% DDGS can be used for the production of sonali chicken. The results suggest that better growth performance could be achieved in sonali chicken supplemented with DDGS formulated feed. Therefore, more studies are required to determine cost effective doses and form of use of DDGS.

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APPENDICES

Appendix I: Daily temperature (^{0}C) was recorded by clinical thermometer at 7 AM, 2 PM and 7 PM

Sl. No	Date	7 AM	2 PM	7 PM
1	08-05-2019	27	35	29
2	09-05-2019	30	36	29
3	10-05-2019	29	35	30
4	11-05-2019	27	35	29
5	12-05-2019	31	36	30
6	13-05-2019	30	34	29
7	14-05-2019	28	34	29
8	15-05-2019	30	35	29
9	16-05-2019	29	34	28
10	17-05-2019	29	35	28
11	18-05-2019	29	35	29
12	19-05-2019	29	35	30
13	20-05-2019	27	34	28
14	21-05-2019	27	34	28
15	22-05-2019	30	36	31
16	23-05-2019	28	35	29
17	24-05-2019	28	35	29
18	25-05-2019	27	34	29
19	26-05-2019	28	33	27
20	27-05-2019	28	33	27
21	28-05-2019	28	33	27
22	29-05-2019	29	34	29
23	30-05-2019	29	34	28
24	31-05-2019	29	34	28
25	01-06-2019	28	33	27
26	02-06-2019	30	35	29
27	03-06-2019	29	34	28

Appendix I: Daily temperature (^{0}C) was recorded by clinical thermometer at 7 AM, 2 PM and 7 PM (Contd.)

Sl. No	Date	7 AM	2 PM	7 PM
28	04-06-2019	28	33	27
29	05-06-2019	28	33	27
30	06-06-2019	28	33	27
31	07-06-2019	27	34	28
32	08-06-2019	27	34	28
33	09-06-2019	29	34	28
34	10-06-2019	28	33	27
35	11-06-2019	28	33	27
36	12-06-2019	28	33	28
37	13-06-2019	27	32	28
38	14-06-2019	28	32	27
39	15-06-2019	28	32	28
40	16-06-2019	27	33	28
41	17-06-2019	28	33	29
42	18-06-2019	29	35	30
43	19-06-2019	30	35	29
44	20-06-2019	28	33	29
45	21-06-2019	28	33	29
46	22-06-2019	27	32	28
47	23-06-2019	28	32	27
48	24-06-2019	28	32	27
49	25-06-2019	28	33	27
50	26-06-2019	29	34	28
51	27-06-2019	29	34	27
52	28-06-2019	27	33	28
53	29-06-2019	27	33	28
54	30-06-2019	28	34	29
55	01-07-2019	28	34	29
56	02-07-2019	29	33	28

Appendix I: Daily temperature (^{0}C) was recorded by clinical thermometer at 7 AM, 2 PM and 7 PM (Contd.)

Sl. No	Date	7 AM	2 PM	7 PM
57	03-07-2019	28	33	27
58	04-07-2019	28	33	28
59	05-07-2019	28	32	27
60	06-07-2019	28	32	27
61	07-07-2019	29	33	27
62	08-07-2019	29	33	28
63	09-07-2019	28	33	28
64	10-07-2019	28	34	29
65	11-07-2019	28	33	30
66	12-07-2019	28	34	29
67	13-07-2019	29	33	28
68	14-07-2019	28	32	29
69	15-07-2019	28	33	29
70	16-07-2019	28	33	29

Appendix II: Chemical composition and cost of different feed ingredients

Sl. No.	Ingredients	Cost/kg Tk.	ME (Kcal/kg)	CP %	CF %	EE %	Ca %	P %	Lysine %	Methi-onine %
1	Maize	18	3320	9	2	4	.01	.25	.26	.19
2	Soyabean meal	40	2330	46	5	1.5	.25	.66	2.89	.63
3	DDGS	30	2500	29.5	6.4	10.08	-	-	.73	.50
4	Rice polish	20	3100	12	5	12	.06	1.30	.60	.25
5	Propac	115	2860	60	-	8.1	6.37	2.7	3.38	1.7
6	Oil	90	8800	-	-	99	-	-	-	-
7	Limestone	10	-	-	-	-	38	-	-	-
8	Oystershell	14	180	-	-	-	33	.06	-	-
9	DCP	50	-	-	-	-	24	12	-	-
10	Salt	16	-	-	-	-	-	-	-	-

Appendix III: Weekly Feed Intake per Bird

Treatment	4^{th} Week	5^{th} Week	6^{th} Week	7^{th} Week	8^{th} Week	9^{th} Week	10^{th} Week
T_0R_1	170.00	197.20	237.50	268.20	314.10	339.50	364.80
T_0R_2	181.80	201.30	243.60	270.90	302.30	343.60	364.30
T_0R_3	170.00	199.70	235.90	272.70	301.80	337.70	368.20
T_1R_1	163.60	194.20	232.70	262.70	303.20	333.70	355.40
T_1R_2	172.70	192.40	236.10	264.60	298.80	335.90	355.50
T_1R_3	170.00	191.80	235.20	265.90	299.80	335.30	361.80
T_2R_1	179.00	198.80	253.40	265.40	299.30	335.10	363.00
T_2R_2	179.10	192.10	237.30	267.80	300.40	340.90	363.90
T_2R_3	177.20	191.50	235.20	269.00	306.10	337.30	365.50
T_3R_1	170.00	198.20	239.50	267.30	308.90	338.50	363.70
T_3R_2	170.00	199.10	240.90	270.90	303.70	343.60	365.40
T_3R_3	179.00	200.00	235.40	271.70	307.30	339.10	365.70
T_4R_1	192.70	206.10	241.80	271.80	307.90	345.20	371.80
T_4R_2	188.20	198.00	244.30	272.80	308.60	346.80	375.30
T_4R_3	179.10	206.00	240.50	282.70	315.50	349.10	376.60

Appendix IV: Weekly Body Weight per Bird

Treatment	4^{th} Week	5^{th} Week	6^{th} Week	7^{th} Week	8^{th} Week	9^{th} Week	10^{th} Week
T_0R_1	237.82	301.09	369.64	411.36	504.73	596.36	731.82
T_0R_2	233.45	293.27	388.00	405.45	517.27	623.64	763.18
T_0R_3	243.82	306.00	350.00	363.64	499.09	619.09	763.45
T_1R_1	243.82	314.36	412.73	474.55	562.55	654.55	796.36
T_1R_2	218.73	299.82	385.27	440.00	559.64	677.27	833.64
T_1R_3	189.27	310.36	370.00	408.64	517.09	640.00	765.73
T_2R_1	224.55	306.00	370.00	429.09	537.27	650.00	774.09
T_2R_2	230.18	308.36	363.64	417.73	559.09	680.00	802.27
T_2R_3	220.73	293.27	354.36	406.36	527.09	620.91	769.09
T_3R_1	201.82	262.18	369.09	405.91	501.82	590.91	700.91
T_3R_2	212.73	281.27	352.18	411.36	523.64	616.36	759.09
T_3R_3	223.64	300.00	390.36	404.09	491.82	581.82	721.82
T_4R_1	198.55	278.18	368.73	420.91	519.09	615.45	768.18
T_4R_2	194.18	274.73	342.18	399.55	487.82	583.64	715.45
T_4R_3	210.73	278.73	358.00	404.55	473.64	565.45	670.91