Chapter 19

Use of DDGS in Poultry Diets

Introduction

A considerable amount of research has been conducted on the effects of feeding DDGS to poultry. Corn DDGS is an excellent feed ingredient for use in layer, broiler, duck and turkey diets and contains approximately 85% of the energy value in corn, has moderate levels of protein and essential amino acids, and is high in available phosphorus. Layer and broiler diets can easily contain up to 10% DDGS with little, if any formulation adjustments for energy and amino acids. 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. However, these are conservative dietary inclusion rates assuming that diets are not formulated on a digestible amino acid basis.

Recent research studies (Shim et al. 2011; Loar et al., 2010; Masa'deh et al. 2011) have shown that DDGS can be added to poultry diets at even higher dietary inclusion rates (e.g. 20%) as long as accurate nutrient profiles specific to the DDGS source are used, and diets are formulated on a digestible amino acid basis.

Nutrient Value of DDGS for Poultry

The nutrient composition and digestibility/availability values for DDGS use in poultry diet formulation are described in detail in Chapter 4 “Nutrient Composition and Digestibility of DDGS: Variability and In Vitro Measurement” in this handbook. Additional information on in vitro measurements for amino acid digestibility and phosphorus availability for poultry are described in more detail in this section.

Amino acid digestibility and measurement in DDGS

Pahm et al. (2009) conducted a study to compare the concentration of standardized digestible (SDD) lysine and relative bioavailable lysine in 7 sources of corn DDGS, and to evaluate in vitro methods (reactive lysine and color score) to predict the concentration of SDD lysine and bioavailable lysine in DDGS. Results showed that the average SDD lysine and relative bioavailability values of lysine were 61.4 and 69.0%, respectively. There were no differences between the concentration of SDD lysine and the concentration of bioavailable lysine in 5 of 7 sources of DDGS. The concentration of SDD lysine was highly correlated ($r^2 = 0.84$) with the concentration of reactive lysine in DDGS. High Hunter L* scores were correlated with higher ($r^2 = 0.90$) concentration of bioavailable lysine in DDGS. These researchers concluded that the concentration of SDD lysine in DDGS does not overestimate the concentration of bioavailable lysine for poultry and values for reactive lysine can be used to estimate the concentration of
SDD lysine, whereas Hunter L* color scores can be used to estimate the concentration of bioavailable lysine in DDGS.

Adedokun et al. (2008) determined standardized ileal amino acid digestibility of 5 plant-based ingredients (2 samples of corn DDGS - light and dark colored DDGS; canola meal, corn, and soybean meal) in 5 to 21-d old broiler chicks and turkey poults. After standardization, standardized ileal amino acid digestibility increased with age when chicks were fed DDGS and corn, but not soybean meal or canola meal. In turkey poults, the apparent ileal amino acid digestibility values increased with age for all feed ingredients except the dark DDGS and canola meal, but after standardization, there was no effect of age on amino acid digestibility, except for corn. Results from this study suggest that with the exception of corn, standardization of amino acid digestibility with ileal endogenous amino acid flow from birds fed a nitrogen free diet or a high digestible protein diet was not different for most plant feedstuffs.

Fastinger et al. (2006) evaluated 5 sources of corn DDGS, which varied in darkness of color for amino acid and energy content, color score, TMEn, apparent amino acid digestibility, and true amino acid digestibility using a precision-fed rooster assay. The total lysine content of the DDGS sources ranged from 0.48 to 0.76%, and the darkest DDG source had the lowest lysine content. Apparent and true lysine digestibility was approximately 30 and 15 percentage units lower, respectively, for the dark-colored DDGS source than in the other 4 DDGS sources, and average apparent and true digestibility of the essential amino acids were 10 and 8 percentage units lower for the darkest colored DDGS source, respectively, than the other 4 DDGS sources. The TMEn content of the darkest DDGS source was also lower than the other 4 DDGS sources. These results suggest that when the color score of a DDGS source was measured to have L* between 28 and 34, the amino acid availability and true metabolizable energy content is reduced, particularly for lysine. Dark-colored DDGS is often overheated during the drying process, causing reduced total lysine content, lysine digestibility, and TMEn content.
IDEA™ is a patented enzyme-based assay which is commercially available for rapid prediction of amino acid digestibility of poultry feed ingredients (soybean meal, meat and bone meal, poultry by-product meal, and feather meal; Schasteen et al., 2005). In order to determine the applicability of IDEA™ to predict the amino acid digestibility of DDGS, a study was conducted using 28 DDGS samples to compare amino acid digestibility estimates from IDEA™ to the true amino acid digestibility determined in the precision-fed cecrectomized rooster assay. True lysine digestibility varied among DDGS samples from 59.1% to 83.6% with an average of 70.3%. There was a strong correlation between IDEA™ estimates and true lysine digestibility determined in roosters ($r^2 = 0.88$), but the correlation between IDEA™ and true digestibility for other amino acids was poor ($r^2 < 0.5$). Results from this study showed that in vivo lysine digestibility varies greatly among DDGS sources, with less variability among other amino acids, and that IDEA™ provides good prediction of in vivo poultry digestibility of lysine in DDGS, but not for other amino acids.

**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 Opti-phos and citric acid supplementation compared with those from $\text{KH}_2\text{PO}_4$ 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.

**Feeding DDGS to Chicken 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\textsubscript{n}/kg) and low energy (2,805 kcal TME\textsubscript{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 1). 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). 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 1. Effects of feeding DDGS in high energy density, commercial diets to laying hens on hen-day egg production\textsuperscript{1}**

![Graph showing egg production](image)

\*A significant ($P < 0.05$) difference between the 2 treatments
\textsuperscript{1}Lumpkins et al. (2005)

**Figure 2. Effects of feeding DDGS in low energy density diets to laying hens on hen-day egg production\textsuperscript{1}**
A significant ($P < 0.05$) difference between the 2 treatments. 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.

**Dietary enzyme supplementation in DDGS diets**

Refer to Chapter 24 of this Handbook for a detailed summary of “Use of Enzymes in DDGS Diets for Poultry and Swine”. In a study conducted by Swiatkiewicz and Korelski (2005), 132 brown 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™Excel) on DDGS energy digestibility in layers. They fed diets containing 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.

**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.

**Effects on manure nutrient content and gas emissions**
Ammonia (NH\textsubscript{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\textsubscript{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\textsubscript{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\textsubscript{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\textsubscript{3} emissions from laying-hen manure, but reducing the crude protein content by 1 percentage unit did not affect NH\textsubscript{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 an average 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.

**Feeding DDGS to Broilers**

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\textsubscript{a}/kg and low = 20% protein, 3000 kcal ME\textsubscript{a}/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 (Table 1).
Table 1. Effect of feeding 15% DDGS in high and low nutrient density broiler diets on weight gain and gain efficiency

<table>
<thead>
<tr>
<th>Response criteria</th>
<th>High density, 0% DDGS</th>
<th>High density, 15% DDGS</th>
<th>Low Density, 0% DDGS</th>
<th>Low Density, 15% DDGS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wt. gain (day 7), g/d</td>
<td>133</td>
<td>134</td>
<td>130</td>
<td>124</td>
</tr>
<tr>
<td>Wt. gain (day 14), g/d</td>
<td>401\textsuperscript{a}</td>
<td>399\textsuperscript{a}</td>
<td>376\textsuperscript{b}</td>
<td>362\textsuperscript{b}</td>
</tr>
<tr>
<td>Wt. gain (day 18), g/d</td>
<td>556\textsuperscript{a}</td>
<td>555\textsuperscript{a}</td>
<td>523\textsuperscript{b}</td>
<td>518\textsuperscript{b}</td>
</tr>
<tr>
<td>Gain:feed (day 7)</td>
<td>956\textsuperscript{a}</td>
<td>991\textsuperscript{b}</td>
<td>898\textsuperscript{c}</td>
<td>854\textsuperscript{d}</td>
</tr>
<tr>
<td>Gain:feed (day 14)</td>
<td>938\textsuperscript{a}</td>
<td>936\textsuperscript{a}</td>
<td>874\textsuperscript{b}</td>
<td>847\textsuperscript{c}</td>
</tr>
<tr>
<td>Gain:feed (day 18)</td>
<td>782\textsuperscript{a}</td>
<td>772\textsuperscript{a}</td>
<td>712\textsuperscript{b}</td>
<td>705\textsuperscript{b}</td>
</tr>
</tbody>
</table>

\textsuperscript{a,b,c,d} Means within rows with different superscripts are different (P < 0.05).

\textsuperscript{1} adapted from Lumpkins et al., 2004

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 (Table 2), 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 (Table 2). 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.
Table 2. Effect of feeding 0, 6, 12, and 18% DDGS in isocaloric and isonitrogenous diets to broilers over a 42 day feeding period on diets on weight gain and gain efficiency 1

<table>
<thead>
<tr>
<th>Response criteria</th>
<th>0% DDGS</th>
<th>6% DDGS</th>
<th>12% DDGS</th>
<th>18% DDGS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wt. gain (d 0 to 16), g/d</td>
<td>414a</td>
<td>416a</td>
<td>399ab</td>
<td>387b</td>
</tr>
<tr>
<td>Wt. gain (d 17 to 31), g/d</td>
<td>1,052</td>
<td>1,055</td>
<td>1,049</td>
<td>1,039</td>
</tr>
<tr>
<td>Wt. gain (d 0 to 42), g/d</td>
<td>2,314a</td>
<td>2,289a</td>
<td>2,291a</td>
<td>2,243b</td>
</tr>
<tr>
<td>Gain:feed (d 0 to 16)</td>
<td>746a</td>
<td>739a</td>
<td>715ab</td>
<td>702b</td>
</tr>
<tr>
<td>Gain:feed (d 17 to 31)</td>
<td>597</td>
<td>600</td>
<td>604</td>
<td>599</td>
</tr>
<tr>
<td>Gain:feed (d 0 to 42)</td>
<td>566</td>
<td>554</td>
<td>565</td>
<td>554</td>
</tr>
</tbody>
</table>

a,b Means within rows with different superscripts are different (P < 0.05).

1adapted from Lumpkins et al., 2004

Several additional studies have been conducted to evaluate the use of DDGS at various dietary inclusion rates in broiler diets (Shim et al., 2008; Choi et al., 2008; Wang et al, 2007 a, b, c, Wang et al., 2008 a, b, c; Youssef et al., 2008; Min et al., 2008; and Moran and Lehman, 2008).

Shim et al. (2011) fed corn-soybean meal diets containing 0, 8, 16, and 24% DDGS and poultry fat as a supplemental energy source. Diets were formulated on a digestible amino acid basis using crystalline amino acids. Body weight gain was improved at the end of the starter phase (d 18) when birds were fed DDGS compared to the control diet, and weight gain and feed:gain were similar among dietary DDGS levels at 42 days. Fat pads, breast meat yield, and carcass quality were not different among dietary DDGS levels. These results show 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.

Additional research by Youssef et al. (2008) fed diets containing 0, 5, 10 or 15% DDGS from 12 to 35 days of age and showed no significant effects of increased DDGS levels on feed intake, weight gain, excreta quality or digestibility of protein and organic matter. Feed conversion tended to decrease when 15% DDGS was fed. Digestibility of DDGS protein was estimated to be 77%. Results from this study suggest that DDGS can be used as an effective protein source in finishing broiler diets at levels up to 10-15%.

Choi et al. (2008) confirmed the findings by Youssef et al. (2008) and showed that adding up to 15% DDGS in broiler diets had no effect on growth performance, color scores and firmness of breast and thigh muscles, but the unsaturated fatty acid content of meat and yellowness of the shank increased by the addition of DDGS to the diet. They concluded that DDGS can be added up to 15% of the diet to decrease the feed cost by partially replacing some of the corn and soybean meal, without any negative effect on growth performance and meat quality.

Wang et al., (2007 a,b,c; 2008 a,b,c) conducted a series of studies which showed that feeding diets containing up to 30% DDGS may support satisfactory growth performance as long as diets are formulated on a digestible amino acid basis. However, reduced bulk density, pellet quality, and inadequate crystalline amino acid supplementation in the diet may cause reductions in growth performance at dietary DDGS levels greater than 15-20%. Furthermore carcass yield
and breast meat yield may be reduced when feeding DDGS levels greater than 15 to 20% of the diet. When diets contain 15% DDGS and are formulated on a digestible amino acid basis, abrupt removal of this level of DDGS did not adversely affect performance of broilers.

Min et al. (2008) conducted an experiment to determine the effects of feeding 0, 15, or 30% DDGS with or without 0 or 5% glycerin on growth performance and meat yield. Diets were formulated on a digestible amino acid basis and were fed as pellets. The results of this study demonstrate that 15% DDGS of known nutritional quality can be utilized in diets for growing broilers with no negative effects on growth performance and meat yield if the diets are formulated on a digestible amino acid basis and meet the nutritional requirements of broilers. Higher dietary levels of DDGS may be acceptable, but feed conversion may be reduced unless pellet quality can be improved. Dressing percentage was reduced, as reported in previous studies, when higher levels (>15%) of DDGS is added to the diet, but it appears that adding 5% glycerin as a source of energy provides satisfactory growth and meat yield.

Moran and Lehman. (2008) showed that the inclusion of combined amylase-phytase-protease-xylanase into broiler feeds without antimicrobials over an 8 week feeding period resulted in positive responses in growth performance, skinless boneless meat yield and skeletal integrity, regardless of alfalfa meal and DDGS inclusion and whether metabolizable energy and available phosphorus were below the requirements.

Corzo et al. (2009) conducted a study to evaluate the effects of feeding 0 or 8% DDGS on broiler breast and thigh meat quality. No differences were observed between the DDGS and control treatment for color (CIE L*, a*, b*), ultimate pH, cooking loss, shear values, and acceptability of texture. However, birds fed the control diet had a slightly higher preferred flavor and overall acceptability compared to broilers fed DDGS. Chicken breasts from both treatments received scores of "like moderately" on the hedonic scale, and consumers who liked the chicken breasts "moderately" or "very much" (over 50% of the panelists) could not differentiate between the 2 treatments. There was a slight variation in fatty acid composition between treatments with muscle from birds fed the DDGS diet having a greater percentage of linoleic acid and total polyunsaturated fatty acids, suggesting that it may be more susceptible to lipid oxidation. In general, these data show that feeding an 8% DDGS diet results in high-quality breast and thigh meat with minimal product differences.

Most recently, Loar et al. (2010) evaluated the effects of feeding 0 or 8% DDGS in the starter diet (0 to 14 days) and 0, 7.5, 15, 22.5, or 30% DDGS in grower diets (14 to 28 days). Feed conversion and mortality rates were not affected by dietary inclusion rate of DDGS, but growth rate can be negatively affected by feeding diets containing 15% or more DDGS. However, Shim et al. (2011) fed diets containing isonutritional diets containing 0, 8, 16, and 24% DDGS and showed that broilers fed diets containing 8% DDGS or more had increased growth rate compared to those fed 0% DDGS during the 0 to 18 day starter period. However, body weights were almost identical among DDGS feeding levels at day 42. Pellet durability index was reduced when DDGS was added to the diets but it did not affect growth performance. These results indicate that broilers perform well when fed properly balance diets containing up to 24% DDGS with no negative effects on carcass or meat quality.
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.

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 egg 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 24% DDGS. Regardless of dietary DDGS level, yielded high quality breast meat. Thigh meat quality was similar among birds fed diets containing 0 to 12% DDGS, but high dietary inclusion rates resulted in thigh meat that was more susceptible to oxidation.
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.

Summary

Current recommended maximum dietary inclusion levels for corn DDGS are 15% for broilers, turkeys, layers, and ducks, but higher levels of corn DDGS can be used successfully with appropriate diet formulation adjustments for energy and amino acids (Wang et al., 2007a,b,c; 2008a,b,c; Noll et al., 2004; Waldroup et al., 1981). When formulating diets containing corn DDGS, digestible amino acid values should be used especially for lysine, methionine, cystine, and threonine. Diets should also be formulated by setting minimum acceptable levels for tryptophan and arginine due to the second limiting nature of these amino acids in corn DDGS protein.

References

Chapter 19. Use of DDGS in Poultry Diets


Moran, E.T., and R. Lehman. 2008. Response to combined amylase-phytase-protease-xylanase supplementation when 8 week broiler males had received corn-soybean meal feeds devoid of antimicrobials with/without alfalfa meal and/or DDGS. Poult. Sci. 87(Suppl. 1):158.


Chapter 19. Use of DDGS in Poultry Diets


Wang, Z., S. Cerrate, C. Coto, F. Yan, F. Perazzo, A. Abdel-Maksoud, and P. Waldroup. 2008a. Evaluation of distillers dried grains with solubles (DDGS) in broiler diets formulated isocaloric at typical industry levels or formulated for optimum density with constant 1% poultry oil. Poultry Science 87(Suppl. 1):112.

Wang, Z., S. Cerrate, C. Coto, F. Yan, F.P. Costa, A. Abdel-Maksoud, and P.W. Waldroup. 2008b. Evaluation of corn distillers dried grains with solubles in broiler diets formulated to be isocaloric at industry energy levels or formulated to optimum density with constant 1% fat. International J. Poult. Sci. 7: 7, 630-637.


