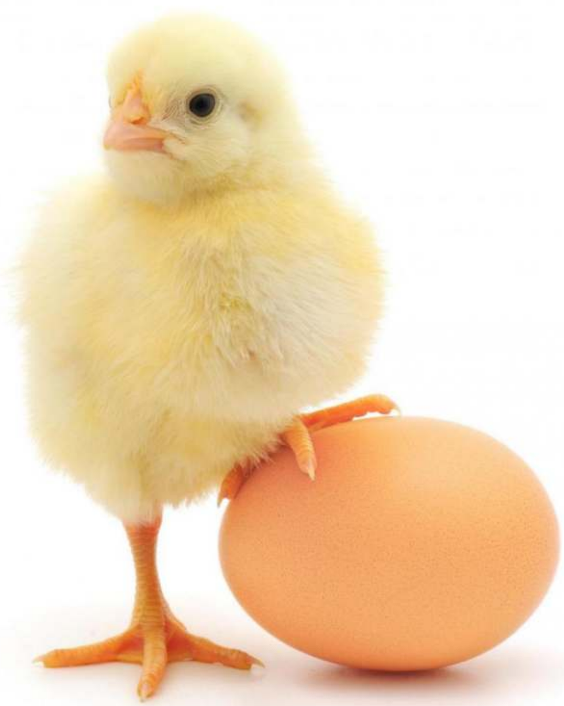
ISSN 1682-8356
ansinet.org/ijps



# INTERNATIONAL JOURNAL OF
# POULTRY SCIENCE

ANSInet
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan
Mob: +92 300 3008585, Fax: +92 41 8815544
E-mail: editorijps@gmail.com

International Journal of Poultry Science 7 (10): 990-996, 2008
ISSN 1682-8356


# Evaluation of High Levels of Distillers Dried Grains with Solubles (DDGS) in Broiler Diets[1]

Z. Wang, S. Cerrate, C. Coto, F. Yan and P.W. Waldroup[2]
Department of Poultry Science, University of Arkansas, Fayetteville AR 72701, USA

**Abstract:** A trial was conducted to evaluate high levels of distillers dried grains with solubles (DDGS) in broiler diets throughout a 49 d growing period. Diets were formulated based on digestible amino acid content to contain 0, 10, 20, 30, 40, or 50% DDGS. Diets were formulated to be optimum nutrient density commensurate with approximately 1% supplemental poultry oil. Each dietary treatment was assigned to four replicate pens with 25 commercial male broiler chicks. Starter (0-14 d) and grower (14-35 d) diets were fed as pellets with finisher (35-49 d) diets fed as mash. Bulk density (mass/volume) was determined on all the diets. Body weights and feed consumption were determined at 14, 35, 42 and 49 d of age. At the conclusion of the study, five representative birds per pen were processed to determine dressing percentage and parts yield. Generally, the bulk density of pellet or mash diets in all different growth periods decreased as DDGS inclusion rates increased, especially in mash diets. Level of DDGS had little effect on body weight at any age until up to 20% inclusion, after which body weight declined significantly. Feed intake was not significantly affected by level of DDGS during all the periods except of 0-14 d. For the whole period (0-49 d), the estimated metabolizable energy intake by chickens was less as DDGS inclusion increased. Increasing DDGS levels significantly increased calorie conversion ratio (CCR, calorie/gain ratio), especially during the period of 0-42 and 0-49 d. Dressing percentage decreased linearly with increasing DDGS levels from 0-50%. There was a significant reduction in breast meat or leg quarter yield as a percentage of live weight with increasing DDGS inclusion, while birds fed higher levels of DDGS had higher wings as percentage of live weight. These results indicate that up to 30% DDGS could be used in broiler diets if price was justified. Inclusion of high levels of DDGS reduces the bulk density and pellet quality and may be a major reason for reduced performance. Low energy density of DDGS diets is probably the limiting factor in meeting the energy needs of the chick.

**Key words:** Broilers, distillers dried grains with solubles (DDGS), pellet quality, carcass parameters, alternative feedstuff, energy intake

## Introduction

Increasing amounts of corn are being used for producing ethanol for fuel, resulting in increased price and reduced availability of corn for poultry feed. Concomitant with the production of fuel alcohol the production of distiller's dried grains with solubles (DDGS), a co-product of the dry-mill ethanol industry, has increased tremendously. The high price of corn and soybean meal encourages the use of higher levels of DDGS than has typically been used in the past.

To date, most research about "new generation" DDGS has centered on nutrient content and variability (Cromwell *et al.*, 1993; Knott *et al.*, 2004; Shurson, 2005; Robinson, 2005; Behnke, 2007), with little emphasis on factors such as pellet quality and energy density, which can influence the utilization of DDGS in broiler diets. Thus, the objective of this experiment was to evaluate the feasibility of using high levels of DDGS in broiler diets and factors influencing its utilization.

## Materials and Methods

Diets were formulated to meet nutritional standards typical of the U.S. poultry industry.[3] Total amino acid standards from the industry were converted to digestible requirements by taking 90% of the suggested value for total amino acids. Diets were formulated on an optimum density basis, using a constant 1% addition of poultry oil and maintaining nutrients in relation to dietary energy. Thus, dietary energy levels declined as the level of DDGS increased in the formula. Nutrient composition values for corn and soybean meal were based on total and digestible amino acid values suggested by a major amino acid producer[4] adjusted to the crude protein and moisture content of materials used to mix the diets. The composite database suggested by Waldroup *et al.* (2007) was used for DDGS. Diets were formulated with 0, 10, 20, 30, 40 or 50% inclusion of DDGS, allowing the computer to select the optimum nutrient density while maintaining the ratio of essential nutrients to energy. Diets were fortified with complete vitamin and trace mineral mixes obtained from a commercial poultry integrator. Composition of diets for starter (0-14 d), grower (14-35 d) and finisher periods (35-49 d) are shown in Tables 1, 2 and 3, respectively. Starter diets were pelleted on a CPM Laboratory Model pellet mill using a 1/8" die while grower diets were pelleted on a

CPM Master Model 30 hp commercial pellet mill using a 3/16" die. Because of a breakdown in the pelleting equipment, the finisher diets were in mash form. Each dietary treatment was assigned to four replicate pens of 25 males each.

Male chicks of a commercial broiler strain (Cobb 500) were obtained from a local hatchery where they had been vaccinated *in ovo* for Marek's disease and had received vaccinations for Newcastle Disease and Infectious Bronchitis post hatch via a coarse spray. New softwood shavings served as litter over concrete floors. Twenty-five chicks were assigned to each of 24 pens in a broiler house of commercial design. Each pen was equipped with two tube feeders and an automatic water font. Supplemental feeders and waterers were used during the first seven days. Temperature and airflow were controlled by automatic heaters and ventilation fans. Incandescent lights supplemented natural daylight to provide 23 hr of light daily. Care and management of the birds followed recommended guidelines (FASS, 1999).

**Measurements:** The DDGS sample was analyzed for crude protein, fat, fiber, ash, Ca, total P, Na and total amino acid content by commercial laboratories specializing in these assays and was subjected to Immobilized Digestibility Enzyme Assay (IDEA™) analysis[5] to estimate amino acid digestibility. Values were in agreement with the nutrient matrix used in formulation. All mixed diets were analyzed for crude protein, Ca, total P, Na and total amino acids by the same commercial laboratories that analyzed the DDGS sample. Bulk density (mass per unit of volume) of mixed feeds was determined by weighing a predetermined volume of feed. Body weights by pen and feed consumption during intervals were determined at 14, 35, 42 and 49 d of age. Birds that died or removed to alleviate suffering were weighed to adjust feed conversion. At the end of the study, five representative birds per pen were processed for dressing percentage and parts yield as described by Fritts and Waldroup (2006).

**Statistical analysis:** All data were subject to one-way ANOVA analysis (SAS institute, 1991). Pen means were used as the experimental unit for growth performance, while each bird served as an experimental unit for processing variables as the birds were processed in random order. Mortality data were transformed to the square root of n + 1; data are presented as natural numbers. All statements of significance were based on $P \leq 0.05$.

## Results

Starter and grower diets were in pellet form, while finisher diets were in mash form. Generally, the bulk density of the diets in all different growth phases decreased as DDGS inclusion increased (Table 4). The pelleted starter diets decreased in bulk density with any level of DDGS inclusion and remained almost constant, but with unexplainable increase in 20% DDGS. The density of pelleted grower diets also decreased gradually as DDGS increased. However, the extent to which mash finisher diets decreased in bulk density was much greater as compared to pelleted starter and grower diets. In addition, the visual pellet quality in starter and grower diets decreased as the amount of DDGS increased. This was in agreement with our previous study (Wang *et al.*, 2007a,b,c).

Varying DDGS inclusion levels significantly ($P < 0.01$) affected body weight gain, feed intake, and feed conversion but had no significant effect on mortality (Table 5). At 14 d posthatch, higher levels of DDGS numerically ($P = 0.06$) reduced the body weight. At 35, 42 and 49 d, body weight was gradually reduced as DDGS levels increased. However, supplemental DDGS had little effect on body weight at any age until up to 20% 35 or 49 d) or 30% (42 d) inclusion (Fig. 1). From the point of 20% DDGS inclusion, the linear function between body weight (kg) and every one percent of increasing DDGS level included was as follows:

$$35\text{ d: } Y = -0.0149X + 2.511\ (R^2 = 0.91)$$
$$42\text{ d: } Y = -0.0196X + 3.249\ (R^2 = 0.89)$$
$$49\text{ d: } Y = -0.0221X + 3.724\ (R^2 = 0.92)$$

Where Y = body weight (kg) and X = % DDGS.

Feed intake was not significantly affected by DDGS during all the periods except of 0-14 d. During this period, feed intake generally increased as the level of DDGS increased. No significant differences in feed intake among treatments were observed at 35, 42 and 49 d of age, even though the calculated energy content of the diets decreased as the level of DDGS increased (Fig. 2). Feed conversion was significantly increased at all ages as the level of DDGS increased in the diet, with a sharp increase after the level of 20% (Fig. 3).

Calorie conversion ratio (CCR) expressed as ME kcal/kg gain, may be a more economically important estimate of the ability of the chick to utilize diets with different energy content (Saleh *et al.*, 2004b). Estimated energy intake (kcal/bird) and CCR are shown in Table 6. Although there were significant differences in energy intake at every age period, they were not necessarily linear in relation to level of DDGS. Significant differences in CCR were observed at every age period. Except for the period of 0-14 d, the CCR remained relatively constant for diets with up to 20% DDGS but increased significantly above this level of DDGS. There was a steep increase in CCR from diets containing 30% to diets containing 50% DDGS (Fig. 4).

The effects of various levels of DDGS on processing parameters on 49 d are shown in Table 7. With increasing DDGS levels from 0-50%, dressing percentage decreased linearly. Breast yield, as percentage of live weight or carcass weight, was

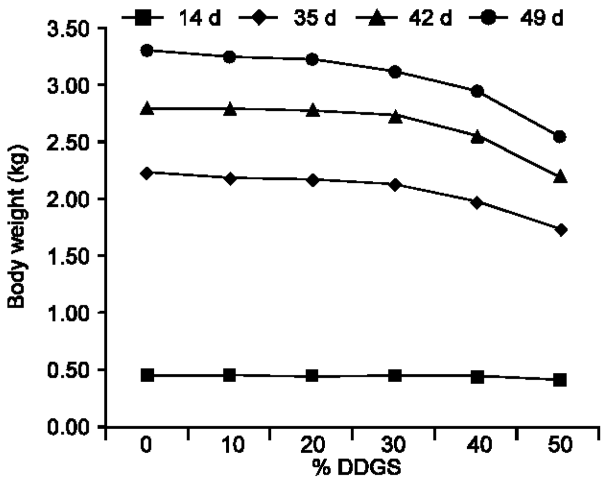



Fig. 1: Effect of varying levels of DDGS on body weight of male broilers

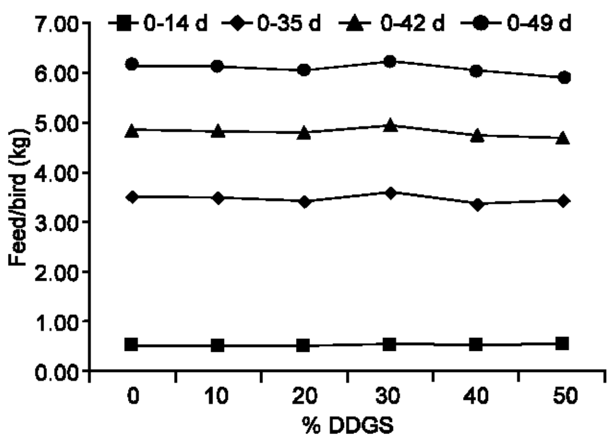



Fig. 2: Effect of varying levels of DDGS on feed intake by male broilers

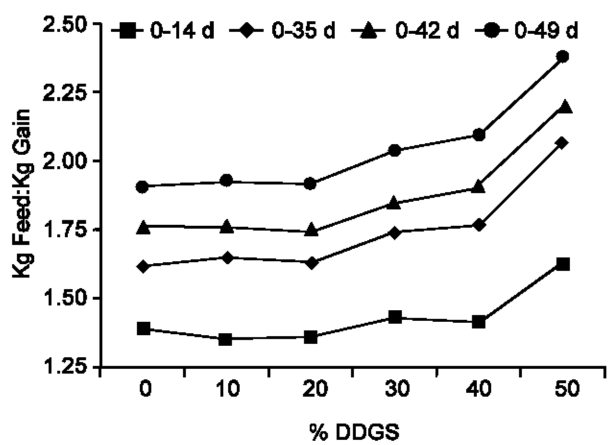



Fig. 3: Effect of varying levels of DDGS on feed conversion by male broilers.

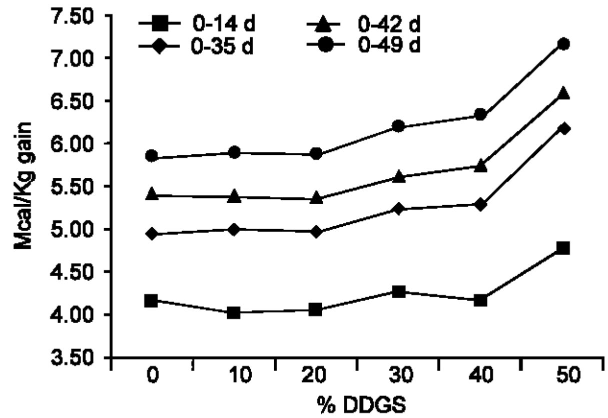



Fig. 4: Effect of varying levels of DDGS on calorie conversion (ME kcal/kg gain) by male broilers

significantly decreased as the level of DDGS increased. Leg quarter yield as a percentage of live weight tended to decline at the higher levels of DDGS but not when expressed as a percentage of carcass weight. Wing yield as a percentage of live weight was somewhat variable in relation to live weight but tended to increase as a percentage of carcass weight as the level of DDGS increased.

## Discussion

Waldroup *et al.* (1981) reported that when DDGS from beverage alcohol production was included into broiler diets with the ME content held constant, up to 25% DDGS could be used in broiler diets without reduction in body weight or feed utilization. When included in diets in which the energy content declined as the level of DDGs was increased, there was a decline in performance at DDGS levels of 15% or more. Dale and Batal (2003) suggested a maximum level of 6% DDGS from ethanol production in broiler starter diets and 12% in grower-finisher diets, while Lumpkins *et al.* (2004) stated that DDGS from modern ethanol plants could be safely used at 6% in the starter period and 12-15% in the grower and finisher periods. Dale and Batal (2003) do not indicate whether diets were formulated on total or digestible amino acid basis while Lumpkins *et al.* (2004) indicated that their diets were formulated on a total amino acid basis.

Results of the present study indicate that when formulated on digestible amino acid basis, good quality DDGS can be used in broiler diets at levels of 15-20% with little or no adverse effect on live performance, in agreement with previous studies from this laboratory (Wang *et al.*, 2007a, 2007b, 2007c) that demonstrated that good quality DDGS could be used in starter and grower broiler diets at levels of 15-20%, with even higher levels of 30% in the finisher diet. Although even higher levels of “new generation” DDGS could be used in broiler diets without any negative impact on body weight

Table 1: Composition (%) and calculated nutrient content of broiler starter diets fed 0 to 14 d with different levels of DDGS

| | DDGS inclusion levels, % | | | | | |
|---|---|---|---|---|---|---|
| Ingredient | 0 | 10 | 20 | 30 | 40 | 50 |
| Yellow corn | 58.578 | 53.835 | 49.056 | 44.313 | 39.565 | 34.786 |
| Poultry oil | 1.002 | 0.995 | 1.006 | 1.00 | 0.995 | 1.000 |
| Soybean meal (47.5%) | 36.513 | 31.147 | 25.799 | 20.433 | 15.068 | 9.706 |
| DDGS | 0.000 | 10.000 | 20.000 | 30.000 | 40.000 | 50.000 |
| Limestone | 0.730 | 0.899 | 1.067 | 1.235 | 1.403 | 1.571 |
| Defluorinated phosphate | 1.593 | 1.405 | 1.218 | 1.030 | 0.842 | 0.654 |
| Salt | 0.385 | 0.363 | 0.341 | 0.320 | 0.300 | 0.300 |
| MHA-84 | 0.194 | 0.188 | 0.182 | 0.176 | 0.170 | 0.164 |
| L-Threonine | 0.016 | 0.045 | 0.074 | 0.103 | 0.132 | 0.161 |
| L-Lysine HCl | 0.015 | 0.148 | 0.282 | 0.415 | 0.549 | 0.682 |
| Vitamin premix[1] | 0.500 | 0.500 | 0.500 | 0.500 | 0.500 | 0.500 |
| Coban 60[2] | 0.075 | 0.075 | 0.075 | 0.075 | 0.075 | 0.075 |
| BMD 50[3] | 0.050 | 0.050 | 0.050 | 0.050 | 0.050 | 0.050 |
| Mintrex P_Se[4] | 0.100 | 0.100 | 0.100 | 0.100 | 0.100 | 0.100 |
| Pel-Stik[5] | 0.250 | 0.250 | 0.250 | 0.250 | 0.250 | 0.250 |
| TOTAL | 100.000 | 100.000 | 100.000 | 100.000 | 100.000 | 100.000 |
| Crude protein, % | 21.77 | 21.70 | 21.63 | 21.56 | 21.48 | 21.41 |
| Calcium, % | 0.91 | 0.90 | 0.90 | 0.90 | 0.90 | 0.89 |
| Phosphorus, % | 0.67 | 0.67 | 0.66 | 0.66 | 0.66 | 0.65 |
| Nonphytate P, % | 0.42 | 0.42 | 0.41 | 0.41 | 0.41 | 0.41 |
| ME kcal/kg | 2993.47 | 2983.55 | 2974.30 | 2984.38 | 2954.46 | 2944.32 |
| Digestible Met | 0.53 | 0.53 | 0.52 | 0.52 | 0.52 | 0.52 |
| Digestible Lys | 1.15 | 1.15 | 1.14 | 1.14 | 1.13 | 1.13 |
| Digestible Trp | 0.24 | 0.23 | 0.21 | 0.20 | 0.18 | 0.17 |
| Digestible Thr | 0.79 | 0.79 | 0.78 | 0.78 | 0.78 | 0.77 |
| Digestible Arg | 1.43 | 1.33 | 1.23 | 1.12 | 1.02 | 0.91 |
| Digestible TSAA | 0.86 | 0.86 | 0.86 | 0.86 | 0.85 | 0.85 |
| Sodium | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 |

[1]Provides per kg of diet: vitamin A 7715IU; cholecalciferol 5511IU; vitamin E 16.53IU; vitamin $B_{12}$ 0.013mg; riboflavin 6.6mg; niacin 39mg; pantothenic acid 10mg; menadione 1.5mg; folic acid 0.9mg; choline 1000mg; thiamin 1.54mg; pyridoxine 2.76mg; d-biotin 0.066mg; ethoxyquin 125mg. [2]Elanco Animal Health division of Eli Lilly and Co., Indianapolis, IN 46825. [3]Alpharma, Inc., Ft. Lee, NJ 07024. [4]Provides per kg of diet: Mn (as manganese methionine hydroxy analogue complex) 40mg; Zn (as zinc methionine hydroxy analogue complex) 40mg; Cu (as copper methionine hydroxy analogue complex) 20mg; Se (as selenium yeast) 0.3mg. [5]Uniscope Inc., Johnstown CO 80534.

Table 2: Composition (%) and calculated nutrient content of broiler grower diets fed 14 to 35 d with different levels of DDGS

| | DDGS inclusion levels, % | | | | | |
|---|---|---|---|---|---|---|
| Ingredient | 0 | 10 | 20 | 30 | 40 | 50 |
| Yellow corn | 64.492 | 59.708 | 54.931 | 50.132 | 45.323 | 40.557 |
| Poultry oil | 1.005 | 1.002 | 0.996 | 1.000 | 1.010 | 0.998 |
| Soybean meal (47.5%) | 30.762 | 25.413 | 20.059 | 14.716 | 9.378 | 4.019 |
| DDGS | 0.000 | 10.000 | 20.000 | 30.000 | 40.000 | 50.000 |
| Limestone | 0.651 | 0.819 | 0.988 | 1.156 | 1.325 | 1.493 |
| Defluorinated phosphate | 1.471 | 1.284 | 1.096 | 0.909 | 0.721 | 0.533 |
| Salt | 0.402 | 0.400 | 0.400 | 0.400 | 0.400 | 0.400 |
| MHA-84 | 0.175 | 0.169 | 0.163 | 0.157 | 0.151 | 0.145 |
| L-Threonine | 0.022 | 0.051 | 0.080 | 0.109 | 0.138 | 0.167 |
| L-Lysine HCl | 0.045 | 0.178 | 0.312 | 0.445 | 0.578 | 0.712 |
| Vitamin premix[1] | 0.500 | 0.500 | 0.500 | 0.500 | 0.500 | 0.500 |
| Coban 60[2] | 0.075 | 0.075 | 0.075 | 0.075 | 0.075 | 0.075 |
| BMD 50[3] | 0.050 | 0.050 | 0.050 | 0.050 | 0.050 | 0.050 |
| Mintrex P_Se[4] | 0.100 | 0.100 | 0.100 | 0.100 | 0.100 | 0.100 |
| Pel-Stik[5] | 0.250 | 0.250 | 0.250 | 0.250 | 0.250 | 0.250 |
| TOTAL | 100.000 | 100.000 | 100.000 | 100.000 | 100.000 | 100.000 |
| Crude protein, % | 19.67 | 19.61 | 19.54 | 19.47 | 19.40 | 19.33 |
| Calcium, % | 0.82 | 0.82 | 0.82 | 0.81 | 0.81 | 0.81 |
| Phosphorus, % | 0.63 | 0.62 | 0.62 | 0.62 | 0.61 | 0.61 |
| Nonphytate P, % | 0.39 | 0.39 | 0.38 | 0.38 | 0.38 | 0.38 |
| ME kcal/kg | 3053.64 | 3043.06 | 3032.26 | 3021.90 | 3011.77 | 3000.75 |
| Digestible Met | 0.49 | 0.48 | 0.48 | 0.48 | 0.48 | 0.48 |
| Digestible Lys | 1.03 | 1.02 | 1.02 | 1.01 | 1.01 | 1.01 |
| Digestible Trp | 0.21 | 0.20 | 0.18 | 0.17 | 0.15 | 0.14 |
| Digestible Thr | 0.71 | 0.71 | 0.71 | 0.70 | 0.70 | 0.70 |
| Digestible Arg | 1.26 | 1.16 | 1.05 | 0.95 | 0.85 | 0.74 |
| Digestible TSAA | 0.79 | 0.79 | 0.79 | 0.79 | 0.78 | 0.78 |
| Sodium | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 |

[1]As shown in Table 1.

Table 3: Composition (%) and calculated nutrient content of broiler finisher diets fed 35 to 49 d with different levels of DDGS

| | DDGS inclusion levels, % | | | | | |
|---|---|---|---|---|---|---|
| Ingredient | 0 | 10 | 20 | 30 | 40 | 50 |
| Yellow corn | 70.799 | 66.016 | 61.191 | 56.376 | 51.555 | 44.923 |
| Poultry oil | 1.003 | 0.995 | 1.002 | 1.004 | 1.009 | 0.997 |
| Soybean meal (47.5%) | 24.645 | 19.317 | 13.996 | 8.672 | 3.350 | 0.000 |
| DDGS | 0.000 | 10.000 | 20.000 | 30.000 | 40.000 | 50.000 |
| Limestone | 0.652 | 0.820 | 0.988 | 1.157 | 1.325 | 1.503 |
| Defluorinated phosphate | 1.347 | 1.160 | 0.973 | 0.786 | 0.599 | 0.388 |
| Salt | 0.419 | 0.400 | 0.400 | 0.400 | 0.400 | 0.400 |
| MHA-84 | 0.129 | 0.123 | 0.117 | 0.111 | 0.105 | 0.072 |
| L-Threonine | 0.040 | 0.069 | 0.098 | 0.127 | 0.156 | 0.153 |
| L-Lysine HCl | 0.068 | 0.201 | 0.335 | 0.468 | 0.601 | 0.664 |
| Vitamin premix[1] | 0.500 | 0.500 | 0.500 | 0.500 | 0.500 | 0.500 |
| BMD 50[3] 0.050 | 0.050 | 0.050 | 0.050 | 0.050 | 0.050 | |
| Mintrex P_Se[4] | 0.100 | 0.100 | 0.100 | 0.100 | 0.100 | 0.100 |
| Pel-Stik[5] | 0.250 | 0.250 | 0.250 | 0.250 | 0.250 | 0.250 |
| TOTAL | 100.000 | 100.000 | 100.000 | 100.000 | 100.000 | 100.000 |
| Crude protein, % | 17.45 | 17.39 | 17.33 | 17.27 | 17.21 | 17.81 |
| Calcium, % | 0.76 | 0.76 | 0.76 | 0.76 | 0.75 | 0.75 |
| Phosphorus, % | 0.58 | 0.58 | 0.57 | 0.57 | 0.57 | 0.57 |
| Nonphytate P, % | 0.36 | 0.36 | 0.35 | 0.35 | 0.35 | 0.35 |
| ME kcal/kg | 3118.11 | 3107.64 | 3097.17 | 3086.48 | 3075.95 | 3049.90 |
| Digestible Met | 0.42 | 0.42 | 0.41 | 0.41 | 0.41 | 0.40 |
| Digestible Lys | 0.89 | 0.88 | 0.88 | 0.88 | 0.87 | 0.87 |
| Digestible Trp | 0.18 | 0.17 | 0.15 | 0.14 | 0.12 | 0.12 |
| Digestible Thr | 0.64 | 0.64 | 0.64 | 0.63 | 0.63 | 0.63 |
| Digestible Arg | 1.08 | 0.97 | 0.87 | 0.77 | 0.66 | ---- |
| Digestible TSAA | --- | 0.70 | 0.69 | 0.69 | 0.69 | 0.68 |
| Sodium | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 |
| Met,% | 0.44 | 0.45 | 0.45 | 0.45 | 0.45 | 0.44 |

[1]As shown in Table 1.

Table 4: Bulk density of starter, grower and finisher diets[1] ($g/cm^3$)

| DDGS | Starter | | Grower | | Finisher | |
|---|---|---|---|---|---|---|
| inclusion, % | Mean | SD[2] | Mean | SD | Mean | SD |
| 0 | 0.78 | 0.005 | 0.79 | 0.042 | 0.70 | 0.005 |
| 10 | 0.68 | 0.008 | 0.74 | 0.014 | 0.69 | 0.012 |
| 20 | 0.72 | 0.021 | 0.73 | 0.005 | 0.66 | 0.008 |
| 30 | 0.65 | 0.014 | 0.72 | 0.016 | 0.65 | 0.008 |
| 40 | 0.66 | 0.025 | 0.70 | 0.012 | 0.61 | 0.014 |
| 50 | 0.68 | 0.012 | 0.65 | 0.008 | 0.57 | 0.021 |

[1]Starter and grower diets in pellet form; finisher diets in mash form. [2]SD = Standard deviation

and feed conversation, some processing parameters might become worse, especially breast yield. Utilization of high levels of DDGS in broiler diets might result in some loss of dressing percentage or breast meat yield, as observed in the present study and also by Wang *et al.* (2007a, 2007b).

Physical form of the diet may also influence the acceptable level of DDGS in broiler diets. Birds attempt to consume feed to meet their metabolic energy requirement. Therefore, feed intake will increase as dietary energy content decreases until it is limited by either gut fill or other physiological limitations (Ferket and Gernat, 2006). Saleh *et al.* (2004a) pointed out that the modern broiler is eating to maximum fill rather than to meet a specific caloric need. Mraz *et al.* (1957) pointed out that neither energy value nor density of the ration was an adequate criterion of the growth-promoting value of a ration; a value based on the ratio of energy to volume was a better guide. In this study, as in previous reports from this laboratory (Wang *et al.*, 2007a; 2007b; 2007c) diets with higher levels of DDGS had a lower bulk density, which may induce the feeling of fullness before meeting their energy needs. Diets with higher levels of DDGS did not pellet as well as did diets with no DDGS. Wang *et al.* (2007a) showed that inclusion of 30% DDGS in the diet markedly reduced pellet quality. The positive relationship between pellet quality and performance of broilers has been noted by many authors (Kilburn and Edwards, 2001; Greenwood *et al.*, 2004, 2005; McKinney and Teeter, 2004).

Table 5: Effects of varying inclusion levels of DDGS on broiler chicken performance[1]

| | DDGS inclusion, % | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Items | 0 | 10 | 20 | 30 | 40 | 50 | CV, % | SEM | P value |
| Average weight, kg | | | | | | | | | |
| 14 d | 0.441 | 0.443 | 0.428 | 0.446 | 0.429 | 0.403 | 4.56 | 0.0098 | 0.0622 |
| 35 d | 2.224$^{a}$ | 2.172$^{ab}$ | 2.159$^{ab}$ | 2.123$^{b}$ | 1.961$^{bc}$ | 1.717$^{d}$ | 2.48 | 0.0256 | < 0.0001 |
| 42 d | 2.798$^{a}$ | 2.785$^{a}$ | 2.780a | 2.737$^{a}$ | 2.545$^{b}$ | 2.191$^{c}$ | 2.44 | 0.0333 | < 0.0001 |
| 49 d | 3.299$^{a}$ | 3.238$^{ab}$ | 3.216$^{ab}$ | 3.110$^{b}$ | 2.936$^{c}$ | 2.537$^{d}$ | 2.86 | 0.0437 | < 0.0001 |
| Feed conversion ratio (Feed:Gain, kg/kg) | | | | | | | | | |
| 0-14 d | 1.389$^{b}$ | 1.346$^{b}$ | 1.362$^{b}$ | 1.428$^{b}$ | 1.408$^{b}$ | 1.625$^{a}$ | 3.90 | 0.0278 | < 0.0001 |
| 0-35 d | 1.614$^{c}$ | 1.645$^{c}$ | 1.627$^{c}$ | 1.736$^{b}$ | 1.764$^{b}$ | 2.068$^{a}$ | 2.28 | 0.0198 | < 0.0001 |
| 0-42 d | 1.758$^{d}$ | 1.762$^{d}$ | 1.745$^{d}$ | 1.845$^{c}$ | 1.902$^{b}$ | 2.193$^{a}$ | 1.77 | 0.0165 | < 0.0001 |
| 0-49 d | 1.899$^{d}$ | 1.922$^{d}$ | 1.910$^{d}$ | 2.033$^{c}$ | 2.091$^{b}$ | 2.375$^{a}$ | 1.73 | 0.0176 | < 0.0001 |
| Feed intake, kg/bird | | | | | | | | | |
| 0-14 d | 0.549$^{bc}$ | 0.533$^{cd}$ | 0.521$^{d}$ | 0.570$^{ab}$ | 0.538$^{cd}$ | 0.579$^{a}$ | 3.09 | 0.0085 | 0.0008 |
| 0-35 d | 3.516 | 3.498 | 3.438 | 3.606 | 3.379 | 3.455 | 3.24 | 0.0564 | 0.1467 |
| 0-42 d | 4.839 | 4.828 | 4.806 | 4.965 | 4.751 | 4.702 | 2.81 | 0.0677 | 0.1744 |
| 0-49 d | 6.177 | 6.132 | 6.054 | 6.227 | 6.041 | 5.911 | 2.63 | 0.0802 | 0.1301 |
| Mortality, % | | | | | | | | | |
| 0-14 d | 0.00 | 0.00 | 0.00 | 0.00 | 1.00 | 0.00 | 489.90 | 0.4082 | 0.4457 |
| 0-35 d | 2.00 | 1.00 | 4.00 | 2.00 | 2.00 | 1.00 | 137.44 | 1.3744 | 0.6756 |
| 0-42 d | 3.00 | 2.00 | 4.00 | 2.00 | 4.00 | 1.00 | 108.97 | 1.4530 | 0.6341 |
| 0-49 d | 5.00 | 2.00 | 4.00 | 2.00 | 4.00 | 1.00 | 86.07 | 1.2910 | 0.2578 |

[1]Means of four pens of 25 males each. [abcd]Means in row with common superscript do not differ significantly ($P \leq 0.05$)

Table 6: Effects of varying inclusion levels of DDGS on energy consumption and calorie conversion ratio of broiler chicken[1]

| | DDGS inclusion, % | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Items | 0 | 10 | 20 | 30 | 40 | 50 | CV, % | SEM | P value |
| Energy intake, kcal/bird | | | | | | | | | |
| 0-14 d | 1.641$^{ab}$ | 1.589$^{bc}$ | 1.547$^{c}$ | 1.701$^{a}$ | 1.589$^{bc}$ | 1.706$^{a}$ | 3.05 | 24.83 | 0.0010 |
| 0-35 d | 10.743$^{ab}$ | 10.612$^{abc}$ | 10.502$^{abc}$ | 10.876$^{a}$ | 10.145$^{c}$ | 10.334$^{bc}$ | 3.19 | 168.04 | 0.0658 |
| 0-42 d | 14.870$^{ab}$ | 14.737$^{ab}$ | 14.744$^{ab}$ | 15.069$^{a}$ | 14.364$^{bc}$ | 14.139$^{c}$ | 2.73 | 200.18 | 0.0427 |
| 0-49 d | 19.043$^{a}$ | 18.797$^{a}$ | 18.622$^{a}$ | 18.964$^{a}$ | 18.331$^{ab}$ | 17.828$^{b}$ | 2.70 | 251.38 | 0.0280 |
| Calorie conversion ratio (ME kcal:kg gain) | | | | | | | | | |
| 0-14 d | 4156$^{bc}$ | 4.014$^{c}$ | 4.051$^{bc}$ | 4.263$^{b}$ | 4.157$^{bc}$ | 4.785$^{a}$ | 3.89 | 82.56 | < 0.0001 |
| 0-35 d | 4932$^{c}$ | 4.991$^{c}$ | 4.970$^{c}$ | 5.236$^{b}$ | 5.296$^{b}$ | 6.186$^{a}$ | 2.05 | 54.02 | < 0.0001 |
| 0-42 d | 5403$^{d}$ | 5.382$^{d}$ | 5.354$^{d}$ | 5.600$^{c}$ | 5.749$^{b}$ | 6.594$^{a}$ | 1.64 | 46.46 | < 0.0001 |
| 0-49 d | 5854$^{d}$ | 5.890$^{d}$ | 5.875$^{d}$ | 6.190$^{c}$ | 6.343$^{b}$ | 7.161$^{a}$ | 1.55 | 48.12 | < 0.0001 |

[1]Means of four pens of 25 males each. [abcd]Means in row with common superscripts do not differ significantly ($P \leq 0.05$)

Table 7: Effect of various levels of DDGS on processing parameters at 49 d

| | DDGS inclusion, % | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Variables | 0 | 10 | 20 | 30 | 40 | 50 | SEM | CV,% | P-value |
| Average body weight, kg | 3.297$^{a}$ | 3.233$^{ab}$ | 3.215$^{ab}$ | 3.091$^{bc}$ | 2.986$^{c}$ | 2.818$^{d}$ | 0.0597 | 7.94 | <0.0001 |
| Dressing percentage, % | 75.78$^{a}$ | 75.31$^{ab}$ | 74.68$^{bc}$ | 74.05$^{cd}$ | 73.61$^{d}$ | 71.38e | 0.3441 | 1.91 | <0.0001 |
| Breast % of live weight | 22.39$^{a}$ | 21.07$^{b}$ | 21.14$^{b}$ | 20.06$^{bc}$ | 19.32$^{c}$ | 18.18$^{d}$ | 0.3936 | 7.99 | <0.0001 |
| Wings % of live weight | 7.83$^{c}$ | 8.23$^{ab}$ | 8.08$^{abc}$ | 8.21$^{ab}$ | 8.34$^{a}$ | 7.96$^{bc}$ | 0.1097 | 5.58 | <0.0001 |
| Leg quarter % of live weight | 23.74$^{a}$ | 22.82$^{ab}$ | 22.42$^{b}$ | 22.51$^{b}$ | 22.35$^{b}$ | 22.46$^{b}$ | 0.3567 | 6.47 | 0.0404 |
| Breast % of carcass | 29.53$^{a}$ | 27.96$^{b}$ | 28.31$^{ab}$ | 27.07$^{bc}$ | 26.24$^{cd}$ | 25.46$^{d}$ | 0.4699 | 7.07 | <0.0001 |
| Wings % of carcass | 10.34$^{c}$ | 10.93$^{ab}$ | 10.82$^{b}$ | 11.10$^{ab}$ | 11.33$^{a}$ | 11.15$^{ab}$ | 0.1507 | 5.68 | <0.0001 |
| Leg quarter % of carcass | 31.34 | 30.32 | 30.02 | 30.40 | 30.37 | 31.49 | 0.4916 | 6.61 | 0.1465 |

[1]Means of four replicate groups of five males each. [abcd]Means in row with common superscript do not differ significantly ($P < 0.05$).

In conclusion, the inclusion of up to 20% DDGS of known composition can be used in broiler diets formulated on a digestible amino acid basis with little or no loss in performance. Higher levels can be used but performance declines more rapidly than expected at levels of 30% or more. Dressing percentage and breast meat yield appear to be very sensitive to inclusion of DDGS, even at levels of 20% in the diet. Further research is needed to examine the possible reasons for loss in breast meat yield and reduction in dressing percentage in diets high in DDGS. Ability to produce a durable pellet may be one of the greatest factors limiting the use of high levels of DDGS in diets for broilers.

## Acknowledgements

The assistance of Ajinomoto Heartland Lysine LLC in amino acid analysis and Novus International for IDEA analysis is gratefully acknowledged. This project was supported in part by the Novus International-Walton Foundation endowed professorship.

## References


Behnke, K.C., 2007. Feed manufacturing considerations for using DDGS in poultry and livestock diets. Proc. 5th Mid-Atlantic Nutrition Conference, Timonium MD.

Cromwell, G.L., K.L. Herkelman and T.S. Stahly, 1993. Physical, chemical and nutritional characteristics of distillers dried grains with solubles for chicks and pigs. J. Anim. Sci., 71: 679-686.

Dale, N. and A. Batal, 2003. Nutritional value of distillers dried grains and solubles for poultry, Pages: 1-6 in:19th Annual Carolina Nutrition Conference, Research Triangle Park, NC.

FASS, 1999. Guide for the care and use of agricultural animals in agricultural research and teaching. 1st rev. ed. Federation of Animal Science Societies, Savoy IL.

Ferket, P.R. and A.G. Gernat, 2006. Factors that affect feed intake of meat birds: A review. Int. J. Poult. Sci., 5: 905-911.

Fritts, C.A. and P.W. Waldroup, 2006. Modified phosphorus program for broilers based on commercial feeding intervals to sustain live performance and reduce total and water-soluble phosphorus in litter. J. App. Poult. Res., 15: 207-218.

Greenwood, M.W., K.R. Cramer, R.S. Beyer, P.M. Clark and K.C. Behnke, 2005. Influence of feed form on estimated digestible lysine needs of male broilers from sixteen to thirty days of age. J. Appl. Poult. Res., 14: 130-135.

Greenwood, M.W., P.M. Clark and R.S. Beyer, 2004. Effect of feed fines level on broilers fed two concentrations of dietary lysine from 14-30 days of age. Int. J. Poult. Sci., 3: 446-449.

Kilburn, J. and H.M. Edwards, Jr., 2001. The response of broilers to the feeding of mash or pelleted diets containing maize of varying particle sizes. Br. Poult. Sci., 42: 484-492.

Knott, J., J. Shurson and J. Goihl, 2004. Variation in particle size and bulk density of distiller's dried grains with solubles (DDGS) produced by "new generation" ethanol plants in Minnesota and South Dakota. Available at website: www.ddgs.umn.edu.

Lumpkins, B.S, A.B. Batal and N.M. Dale, 2004. Evaluation of distillers dried grains with solubles as a feed ingredient for broilers. Poult. Sci., 83: 1891-1896.

McKinney, L.J. and R.G. Teeter, 2004. Predicting effective caloric value of nonnutritive factors: I. Pellet quality and II. Prediction of consequential formulation dead zones. Poult. Sci., 83: 1165-1174.

Mraz, F.R., R.V. Boucher and M.G. McCartney, 1957. The influence of the energy: volume ratio on growth response in chickens. Poult. Sci., 36: 1217-1221.

Robinson, H.P., 2005. Ethanol industry co-products: milling process, nutrient content and variation. J. Anim. Sci., 83: 49.

Saleh, E.A., S.E. Watkins, A.L. Waldroup and P.W. Waldroup, 2004a. Consideration for dietary nutrient density and energy feeding programs for growing large male broiler chickens for further processing. Int. J. Poult. Sci., 3: 11-16.

Saleh, E.A., S.E. Watkins, A.L. Waldroup and P.W. Waldroup, 2004b. Comparison of energy feeding programs and early feed restriction on live performance and carcass quality of large male broilers grown for further processing at 9-12 weeks of age. Int. J. Poult. Sci., 3: 61-69.

SAS Institute, 1991. SAS® User's Guide: Statistics. Version 6.03 Edition. SAS Institute, Inc., Cary, NC.

Shurson, G.C., 2005. Issues and opportunities related to the production and marketing of ethanol by-products. USDA Agricultural Outlook Forum, Washington D.C. Feb. 24.

Waldroup, P.W., J.A. Owen, B.E. Ramsey and L.L. Whelchel, 1981. The use of high levels of distillers dried grains plus solubles in broiler diet. Poult. Sci., 60: 1479-1484.

Waldroup, P.W., Z. Wang, C. Coto, S. Cerrate and F. Yan, 2007. Development of a standardized nutrient matrix for corn distillers dried grains with solubles. Int. J. Poult. Sci., 6: 478-483.

Wang, Z., S. Cerrate, C. Coto, F. Yan and P.W. Waldroup, 2007a. Use of constant or increasing levels of distillers dried grains with solubles (DDGS) in broiler diets. Int. J. Poult. Sci., 6: 501-507.

Wang, Z., S. Cerrate, C. Coto, F. Yan and P.W. Waldroup, 2007b. Utilization of distillers dried grains with solubles (DDGS) in broiler diets using a standardized nutrient matrix. Int. J. Poult. Sci., 6: 470-477.

Wang, Z., S. Cerrate, C. Coto, F. Yan and P.W. Waldroup, 2007c. Effect of rapid and multiple changes in levels of distillers dried grain with solubles (DDGS) in broiler diets on performance and carcass characteristics. Int. J. Poult. Sci., 6: 725-731.


[1]Published with approval of the Director, Arkansas Agricultural Experiment Station, Fayetteville AR 72701. Mention of a trade name, proprietary product, or specific equipment does not constitute a guarantee or warranty by the University of Arkansas and does not imply its approval to the exclusion of other products that may be suitable.


[2]To whom correspondence should be addressed. Waldroup@uark.edu

[3]Agri-Stats, Fort Wayne IN.

[4]Ajinomoto Heartland Lysine LLC, Chicago IL.

[5]Novus International, St. Louis MO.