International Journal of Poultry Science 6 (10): 725-731, 2007
ISSN 1682-8356

Effect of Rapid and Multiple Changes in Level of Distillers Dried Grain with Solubles (DDGS) in Broiler Diets on Performance and Carcass Characteristics[1]

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Abstract: This study was conducted to evaluate the use of moderate to high levels of DDGS in broiler diets and to evaluate the effects of rapid and multiple changes in level of DDGS during the growth period. Diets were formulated to contain 0, 15, or 30% DDGS with diets formulated on the basis of digestible amino acids to meet levels typical of the U.S. broiler industry. Groups of birds were fed diets with these three levels of DDGS on a constant basis from 0 to 42 d of age. Other groups were fed 0 and 15% or 0 and 30% DDGS on alternate week basis, with one group starting with diets containing no DDGS and other groups starting with diets containing 15 or 30% DDGS. Four pens of 25 male broilers were fed each of the dietary treatments. At the conclusion of the study five representative birds per treatment were processed to determine dressing percentage and carcass yield. Birds fed diets containing 15% did not differ significantly in live performance or carcass characteristics from birds fed diets with no DDGS, whether fed on a continuous basis or alternated weekly between 0 and 15% DDGS. Birds that were continuously fed diets with 30% DDGS had significantly reduced body weight and feed intake at 35 and 42 d compared to birds fed the control diet with no DDGS and had reduced breast meat yield. When birds were fed diets with 0 or 30% DDGS alternating on a weekly basis live performance was approximately midway between that of birds fed diets with 0 or 30% continuously and similar to that of birds fed 15% DDGS on a constant basis, but breast meat yield tended to be reduced. The results of the study demonstrated the effective use of diets with 15% DDGS when formulated on a digestible amino acid basis and showed that abrupt removal of this level of DDGS did not adversely affect performance of broilers. Further studies are suggested to quantify reasons for reduced performance when fed diets containing 30% DDGS.

Key words: Broilers, distiller's grains, ethanol byproduct, alternative ingredients

Introduction

The principle reason for broiler producers to select dietary ingredients is economy, because feed represents approximately 70% of the live production cost. In feed formulation, nutritionists consider a wide range of ingredients and attempt to develop feed formulas that provide the desired level of nutrients at minimum cost. In formulating diets the nutritionist must consider not only cost and nutrient content of the ingredient, but also the quantity available for use and consistency of supply. An ingredient that has received considerable attention recently is distillers dried grains plus solubles (DDGS). DDGS, a byproduct from beverage alcohol production and more recently from production of fuel alcohol, is an acceptable feed ingredient for poultry diets (Couch *et al*., 1970; Jensen, 1978, 1981; Potter, 1966; Runnels, 1966, 1968; Scott, 1965, 1970; Waldroup *et al*., 1981; Parsons and Baker, 1983; Lumpkins *et al*., 2004; Wang *et al*., 2007a, 2007b). With the expansion of ethanol plants, the supply of DDGS is increasing rapidly and poultry nutritionists are making increasing use of it in their diets. One of the concerns about using relatively high levels of this product is the possible effects on performance that might occur if the supply was erratic or price differentials eliminated it from a diet after previously been fed at high levels. Therefore, this study was conducted to evaluate the possible effects of rapidly changing back and forth from diets with no DDGS to diets with medium or high levels of DDGS.

Materials and Methods

Diet formulation: Diets were formulated to meet nutritional standards typical of the U.S. poultry industry (Agri-Stats, Fort Wayne IN) to contain 0, 15, or 30% DDGS. Diets were formulated on a digestible amino acid basis, utilizing 90% of current industry total amino acid levels in relation to dietary energy. Metabolizable energy and crude protein values typical of the U.S. industry were specified. Amino acid minimums were expressed for digestible Lys, TSAA and Thr as these are commercially available in supplemental form. No other amino acid minimums were specified in formulation. Because of the reported variation in sodium content of DDGS (Spiehs *et al*., 2002; Batal and Dale, 2003; Parsons *et al*., 2006) a minimum level of 4.0 g/kg of sodium chloride was specified in addition to a minimum sodium content of 0.25% for all diets. Requirements for calcium and available phosphorus were similar to industry average values.

Table 1: Suggested nutrient matrix for DDGS based on weighted averages of published data[1]

Nutrient	Amount	Actual
Dry matter %	89.36	90.12
Crude protein %	26.45	27.92
Fat %	10.08	9.42
Fiber %	6.99	6.47
TME_n, kcal/lb	1293	Nd
Calcium %	0.07	0.05
Phosphorus %	0.77	0.82
Available phosphorus %	0.48	Nd
Potassium %	0.85	1.05
Sodium %	0.20	0.18
Arginine %	1.09	1.12
Histidine %	0.68	0.68
Isoleucine %	0.96	1.13
Leucine %	3.00	2.77
Lysine %	0.73	0.83
Methionine %	0.50	0.55
Cystine %	0.54	0.52
Phenylalanine %	1.31	1.24
Threonine %	0.96	0.95
Tryptophan %	0.21	Nd
Valine %	1.30	1.43
Serine %	1.07	1.44
Dig Arginine % (88.9%)[2]	0.93	0.99
Dig Histidine %	0.58	Nd
Dig Isoleucine % (85.3%)	0.78	0.96
Dig Leucine % (91.0%)	2.70	2.52
Dig Lysine % (76.1)	0.50	0.63
Dig Methionine % (88.6%)	0.43	0.48
Dig Cystine % (82.0%)	0.42	0.43
Dig Phenylalanine %	1.15	Nd
Dig Threonine % (78.7%)	0.72	0.75
Dig Tryptophan % (88.4%)	0.18	Nd
Dig Valine % (83.8)	1.05	1.20
Dig Serine %	0.88	Nd

[1]Data source: Waldroup *et al*. (2007), [2]Values in parenthesis are digestibility estimates based on IDEA analysis (Novus International, St. Louis MO)

Total and digestible amino acid values for corn and soybean meal were based on values suggested by a leading amino acid producer (Ajinomoto Heartland Lysine, Chicago IL) adjusted to the moisture and crude protein content of the products used in the formulation of the diets. Nutrient values used for DDGS are shown in Table 1 and were a composite of reported values (Waldroup *et al*., 2007). A blended animal protein was added to all diets at 5%, a level typical of animal protein usage in the U.S. poultry industry. Diets were maintained isocaloric and isonitrogenous. All diets were fortified with complete vitamin and trace mineral mixes. Composition of the diets is shown in Table 2 while the calculated analysis of diets is shown in Table 3. Starter diets were crumbled, while grower and finisher diets were pelleted.

Using the diets with three different levels of DDGS, eight dietary treatments were compared. These included 1) feeding no DDGS for the entire period; 2) feeding 15% DDGS for the entire period; 3) feeding 30% DDGS for the entire period; 4) alternating between 0 and 15% DDGS beginning with 0% DDGS; 5) alternating between 0 and 15% DDGS beginning with 15% DDGS; 6) alternating between 0 and 30% DDGS beginning with 0%; and 7) alternating between 0 and 30% DDGS beginning with 30%. Each of the dietary treatments was fed to four replicate pens of 25 birds each.

Housing and management: Male chicks of a commercial broiler strain (Cobb 500[3]) 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 randomly assigned to each of 28 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 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[4] to estimate amino acid digestibility. 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 and were found to be in good agreement with calculated values. 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 and 42 d of age. Birds that died were weighted 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 analyses: All the data were subject to one-way ANOVA analysis (SAS institute, 1991). Significant differences among means were separated using Duncan's multiple-range test option of the general linear model procedure. Pen means of growth performance were used as an experimental unit, while each bird as an experimental unit for processing variables as the birds were processed in random order. Mortality data were transformed to $\sqrt{n+1}$ for analysis; data are shown as natural numbers. All statements of significance were based on $p \leq 0.05$.

Table 2: Composition (g/kg) of diets with different levels of DDGS

Ingredient	Starter 0-14 d			Grower 14-35 d			Finisher 35-42 d		
DDGS	0.00	150.00	300.00	0.00	150.00	300.00	0.00	150.00	300.00
Yellow corn	591.02	511.34	431.65	650.00	570.65	490.97	715.23	636.27	556.60
Soybean meal	311.06	234.65	158.24	252.76	176.29	99.87	189.55	113.00	36.58
Poultry oil	17.09	21.05	25.02	18.13	21.98	25.95	18.03	21.74	25.70
Pro-Pak[1]	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00
Defl. phos	8.52	5.82	3.11	7.30	4.59	1.88	6.01	3.30	0.60
Limestone	6.49	9.01	11.53	5.68	8.19	10.71	5.68	8.20	10.72
Salt	4.00	4.00	4.00	4.15	4.00	4.00	4.33	4.00	4.00
MHA-84	1.53	1.46	1.39	1.34	1.27	1.20	0.85	0.78	0.71
L-Lysine HCl	0.31	2.26	4.22	0.60	2.56	4.52	0.84	2.80	4.76
L-Threonine	0.23	0.66	1.09	0.29	0.72	1.15	0.48	0.91	1.33
Vitamin premix[2]	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Pel-Stik[3]	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
Mintrex P_Se[4]	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Coban 60[5]	0.75	0.75	0.75	0.75	0.75	0.75	0.00	0.00	0.00
BMD 50[6]	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
TOTAL	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00

[1]H.J. Baker and Bro., 595 Summer Street, Stamford, CT 06901-1407, [2]Provides per kg of diet: vitamin A 7715 IU; cholecalciferol 5511 IU; vitamin E 16.53 IU; vitamin B_{12} 0.013 mg; riboflavin 6.6 mg; niacin 39 mg; pantothenic acid 10 mg; menadione 1.5 mg; folic acid 0.9 mg; choline 1000 mg; thiamin 1.54 mg; pyridoxine 2.76 mg; d-biotin 0.066 mg; ethoxyquin 125 mg, [3]Uniscope Inc., Johnstown CO 80534, [4]Provides per kg of diet: Mn (as manganese methionine hydroxy analogue complex) 40 mg; Zn (as zinc methionine hydroxy analogue complex) 40 mg; Cu (as copper methionine hydroxy analogue complex) 20 mg; Se (as selenium yeast) 0.3 mg; Novus International, St. Louis MO, [5]Elanco Animal Health division of Eli Lilly and Co., Indianapolis, IN 46825, [6]Alpharma, Inc., Ft. Lee, NJ 07024

Table 3: Calculated nutrient content of diets with different levels of DDGS. Values in bold are at minimum specified level

	Starter 0-14 d			Grower 14-35 d			Finisher 35-42 d		
Nutrient	0% DDGS	15% DDGS	30% DDGS	0% DDGS	15% DDGS	30% DDGS	0% DDGS	15% DDGS	30% DDGS
ME kcal/lb	1400.00	1400.00	1400.00	1430.00	1430.00	1430.00	1460.00	1460.00	1460.00
CP, %	22.44	22.44	22.44	20.31	20.31	20.31	18.01	18.01	18.01
Met %	0.58	0.58	0.59	0.53	0.54	0.54	0.46	0.47	0.47
Lys %	1.32	1.33	1.34	1.18	1.19	1.20	1.02	1.03	1.04
Trp %	0.27	0.25	0.22	0.24	0.21	0.19	0.20	0.18	0.15
Thr %	0.93	0.94	0.96	0.84	0.86	0.87	0.76	0.77	0.78
Ile %	0.95	0.90	0.86	0.84	0.79	0.75	0.72	0.67	0.63
His %	0.62	0.61	0.60	0.57	0.55	0.54	0.50	0.498	0.47
Val %	1.13	1.12	1.11	1.02	1.02	1.01	0.90	0.90	0.89
Leu %	2.05	2.13	2.21	1.89	1.97	2.04	1.71	1.79	1.87
Arg %	1.53	1.38	1.24	1.34	1.19	1.05	1.13	0.99	0.85
TSAA %	1.01	1.02	1.03	0.93	0.94	0.95	0.82	0.83	0.84
Dig Met %	0.54	0.54	0.54	0.50	0.50	0.50	0.43	0.43	0.43
Dig Lys %	1.18	1.18	1.18	1.06	1.06	1.06	0.91	0.91	0.91
Dig Thr %	0.81	0.81	0.81	0.73	0.73	0.73	0.66	0.66	0.66
Dig TSAA %	0.89	0.89	0.89	0.82	0.82	0.82	0.72	0.72	0.72
Ca %	0.93	0.93	0.93	0.85	0.85	0.85	0.79	0.79	0.79
Available P %	0.43	0.43	0.43	0.40	0.40	0.40	0.37	0.37	0.37
Sodium %	0.25	0.26	0.27	0.25	0.26	0.27	0.25	0.25	0.26

Table 4: Dietary bulk density (g/cm³)

DDGS inclusion, %	Diet	Mean	SD
0	Starter	0.74	0.012
15	Starter	0.72	0.017
30	Starter	0.72	0.007
0	Grower	0.76	0.001
15	Grower	0.75	0.003
30	Grower	0.72	0.016
0	Finisher	0.76	0.018
15	Finisher	0.77	0.005
30	Finisher	0.73	0.010

Results and Discussion

Increasing the level of DDGS in the diet resulted in a reduction in weight:volume ratio (Table 4). As all diets in the present study were formulated to be isocaloric, this reduction was associated with a lower energy:volume ratio as defined by Mraz *et al*. (1957). Similar effects of bulk density on performance have been observed by Shelton *et al*. (2005). Although pellet quality was not quantitatively assessed the visual pellet quality decreased as the level of DDGS increased. Diets with 15% DDGS pelleted reasonably well and were similar to

Table 5: Effect of constant or variable levels of distillers dried grains plus solubles (DDGS) on live performance of male broilers (means of four pens of 25 birds)

% DDGS by week						Body weight (kg)			Feed intake (kg/bird)			Feed:Gain Ratio		
1	2	3	4	5	6	14 d	35 d	42 d	1-14 d	1-35 d	1-42 d	1-14 d	1-35 d	1-42 d
0	0	0	0	0	0	0.403[ab]	2.115[a]	2.771[a]	0.583	3.472[a]	4.775[a]	1.459	1.643	1.724
15	15	15	15	15	15	0.415[a]	2.062[abc]	2.658[ab]	0.590	3.396[a]	4.718[ab]	1.422	1.648	1.775
30	30	30	30	30	30	0.386[b]	1.864[d]	2.440[c]	0.594	3.241[b]	4.495[b]	1.539	1.742	1.845
0	15	0	15	0	15	0.417[a]	2.079[ab]	2.738[ab]	0.595	3.472[a]	4.858[a]	1.428	1.671	1.775
15	0	15	0	15	0	0.412[a]	2.056[abc]	2.705[ab]	0.590	3.424[a]	4.851[a]	1.434	1.665	1.793
0	30	0	30	0	30	0.404[ab]	2.002[bc]	2.608[b]	0.584	3.436[a]	4.744[a]	1.452	1.718	1.821
30	0	30	0	30	0	0.415[a]	1.987[c]	2.676[ab]	0.580	3.427[a]	4.817[a]	1.399	1.726	1.801
					P diff	0.04	<.001	0.001	0.90	0.04	0.04	0.17	0.29	0.36
					SEM	0.008	0.026	0.041	0.011	0.048	0.077	0.034	0.035	0.036
					CV	3.22	2.58	3.09	3.33	2.82	3.24	4.68	4.17	4.01

Table 6: Effect of constant or variable levels of distillers dried grains plus solubles (DDGS) on dressing percentage and parts yield of male broilers (mean of 20 birds)

% DDGS by week						Dressing Percentage (%)	Based on body weight			Based on carcass weight		
							Breast	Wings	Leg quarters	Breast	Wings	Leg quarters
1	2	3	4	5	6		%			%		
0	0	0	0	0	0	71.33	19.63[a]	7.81	20.73	27.51[a]	10.96[b]	29.08
15	15	15	15	15	15	71.05	19.30[ab]	7.86	21.10	27.13[ab]	11.07[b]	29.71
30	30	30	30	30	30	70.06	17.83[c]	8.06	21.05	25.44[c]	11.50[a]	30.06
0	15	0	15	0	15	70.32	18.76[abc]	7.66	20.95	26.64[ab]	10.89[b]	29.82
15	0	15	0	15	0	71.04	19.15[ab]	7.95	20.76	26.94[ab]	11.19[ab]	29.22
0	30	0	30	0	30	70.98	18.47[bc]	7.95	20.88	26.02[bc]	11.19[ab]	29.43
30	0	30	0	30	0	71.01	18.65[abc]	8.00	21.30	26.25[bc]	11.27[ab]	30.01
					P diff	0.13	<.0001	0.13	0.40	0.005	0.02	0.11
					SEM	0.36	0.049	0.36	0.20	0.39	0.13	0.29
					CV	2.25	8.17	2.25	4.23	6.61	5.16	4.41

that of the control diet with no DDGS; however, diets with 30% DDGS pelleted extremely poorly and had numerous fines even though a pellet binder was added to the diets. Due to the fermentation of the corn starch by selected yeasts and enzymes to produce ethanol, DDGS is not well gelatinized. Pelleting increases the bulk density of feed ingredients and improves flowability as compared to mash feed (Briggs, 1999). This increase in bulk density as DDGS levels increased was consistent with our previous experiments (Wang *et al*., 2007a, 2007b). 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).

The effects of constant or varying levels of DDGS on live performance is shown in Table 5. When fed on a constant basis, there were no significant differences in body weight, feed intake, or feed conversion between birds fed diets with no DDGS and those fed diets with 15% DDGS. In addition, there were no significant differences in these parameters when birds were fed 0 or 15% DDGS on alternate weeks during the study, as compared to those fed diets with no DDGS or fed diets with 15% DDGS on a constant basis. Birds fed a constant level of 30% DDGS had significantly lower body weight and less feed intake at 35 and 42 days than did birds fed diets with no DDGS and were numerically lighter at 14 d. When birds were fed diets with 0 or 30% DDGS on alternate weeks during the study, their body weight at 14 d did not differ significantly from that of birds fed diets with no DDGS while at 35 and 42 d their body weights were somewhat intermediate between that of birds fed no DDGS and those fed 30% DDGS on a constant basis and did not differ significantly from that of birds fed 15% DDGS on a constant basis. At 35 d both groups fed 0 and 30% DDGS on an alternate basis differed significantly from those fed the control diets with no DDGS while at 42 d those birds that were started on 30% DDGS and alternatively fed diets with no DDGS did not differ significantly from birds fed the control diet. Feed intake of birds fed 0 or 30% on an alternate basis did not differ significantly from that of birds fed 0 or 15% DDGS on a constant basis. Although numerical differences were observed among the various treatments there were no significant differences, indicating that one of the major problems with the high level of DDGS was associated with reduction in feed intake. There were no significant effects of dietary treatments on mortality (data not shown).

The effects of constant or varying levels of DDGS on dressing percentage and parts yield of broilers is shown in Table 6. There were no significant differences in dressing percentage or leg quarter yield of broilers related to dietary treatments. Breast meat yield was significantly affected by dietary treatment, whether expressed as a percentage of live weight or as percentage of dressed carcass weight. There were no significant differences in breast weight, either as percentage of live weight or dressed weight, between birds fed diets with no DDGS, 15% DDGS on a constant basis, or birds fed diets with 0 or 15% DDGS on an alternate weekly basis. Breast meat yield was significantly reduced on either as percentage of live weight or dressed carcass weight when birds were fed diets with 30% DDGS on a constant basis. Breast meat yield as a percentage of live weight of birds fed diets alternating between 0 and 30% DDGS was numerically reduced, with a significant difference in breast meat yield between birds fed diets with no DDGS and those fed diets with 0 or 30% DDGS on an alternate basis ending with 30% DDGS. Birds that were fed alternatively diets with 0 or 30% DDGS and which received the diet with 0% DDGS during the final week did not differ significantly in breast yield from those consistently fed the diet with no DDGS. When breast meat yield was expressed as a percentage of dressed weight, however, breast meat yield of birds fed 0 and 30% on an alternate basis was significantly lower than that of birds fed the diet with no DDGS regardless of the level fed during the final week. The adverse effects of 30% DDGS on breast meat yield was consistent with the observations from a previous study in our laboratory (Wang *et al*., 2007b). Wing yield as a percentage of live weight was not significantly affected by dietary treatment, but when expressed as a percentage of carcass weight it tended to be higher as a percentage of carcass weight when breast meat yield was adversely affected.

The results of the present study indicate that diets with 15% DDGS, formulated on a digestible amino acid basis, can be effectively used in broiler diets providing the DDGS is equivalent in nutrient value to the standardized nutrient matrix and the diets are formulated on a digestible amino acid basis. Feeding diets with 30% DDGS consistently during the growth period will result in adverse performance, probably related to the poor pellet quality resulting from such diets. These results are in agreement with Waldroup *et al*. (1981) who 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 without reduction in body weight or feed utilization. When included in diets in which the energy content was allowed to decline as the level of DDGS was increased, there was a decline in performance at DDGS levels of 15% or more.

In contrast, Dale and Batal (2003) suggested a maximum level of 6% DDGS from ethanol production in 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 to 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 diets were formulated on total amino acid basis. Wang *et al*. (2007b) concluded that DDGS could be included in broiler diets at levels of 15% when formulated on a digestible amino acid basis. It has been noted that digestibility of several amino acids in DDGS is relatively poor, especially Lys and Thr (Batal and Dale, 2006; Fiene *et al*., 2006; Parsons *et al*., 2006; Fastinger *et al*., 2006; Waldroup *et al*., 2007). Failure to compensate for this reduced amino acid digestibility in formulating diets may inhibit the usage of high levels of DDGS in broiler diets.

In evaluating the formulas used in the current study (Table 2) it is likely that some amino acids other than those specified in the formulation of the diets may have become marginal or limiting in diets with 30% DDGS. While it is difficult to make direct comparison to NRC (1994) recommendations due to differences in dietary energy levels and time of feeding, it is possible that tryptophan, isoleucine and arginine may be marginal or deficient in diets with 30% DDGS. The marginal level of isoleucine may be exacerbated by the increasing levels of leucine in the diet (Waldroup *et al*., 2002), while the marginal level of tryptophan may be exacerbated by increasing levels of the large neutral amino acids Ile, Leu, Val, Phe and Tyr (Si *et al*., 2004). As greater amounts of DDGS become available and supplies of corn diminish, the poultry industry may be forced to use higher levels of DDGS. Further research is needed to evaluate the use of other synthetic amino acids or higher crude protein levels in diets with high levels of DDGS.

Few studies in the literature appear to address the problems arising from abrupt changes in feed composition. Much of the research related to alterations in feed intake and resultant changes in dietary energy have been conducted with egg-type strains (Gleaves *et al*., 1968; Cherry *et al*., 1983, 1984) or with older meat-type strains (Mraz *et al*., 1956, 1957: Wolf *et al*., 1969; Carew *et al*., 1963). The modern broiler has been genetically selected for rapid gains and increased body weight, factors that are positively associated with appetite and feed intake (Kondra and Hodgson, 1961; Siegel and Wisman, 1966; Marks, 1979, 1980; Sibbald and Slinger, 1963; Siegel *et al*., 1984). Skinner *et al*. (1993) reported that abrupt and multiple changes in dietary nutrient density (low energy versus high energy) did not adversely affect live weight or caloric utilization of broiler chickens grown to 49 d of age. In this cited study, birds were fed diets with high or low nutrient density on a constant basis or changed between high and low nutrient densities on a weekly basis.

Results of the present study confirm previous research from our laboratory that diets containing 15% DDGS, when formulated on a digestible amino acid basis, can be fed to broilers continuously with no loss in live performance or carcass composition. It also demonstrates that abrupt changes in diets containing 15% DDGS do not appear to inhibit performance. At the present time, it appears that inclusion of 30% DDGS will reduce overall performance and adversely affect breast meat yield. This may be due in part to a deficiency of some amino acids that are not typically accounted for in formulation and in part to reduced pellet quality associated with this level of DDGS. Further studies are proposed to evaluate these conditions.

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[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. This research was supported in part by the Novus International-Walton Foundation Endowed Professorship

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