The nutritional value of high-protein corn distillers dried grains for broiler chickens and its effect on nutrient excretion

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ABSTRACT Two experiments were conducted with a co-product of corn endosperm fermentation. The first experiment determined nutrient digestibility of high-protein corn distillers dried grains (HP-DDG; 54% CP) after feeding semi-purified diets from 15 to 22 d of age. The AME_n of HP-DDG was 2,526 kcal/kg, whereas standardized ileal Lys, Met, and Thr digestibilities were 73.0, 84.9, and 73.0%, respectively. In a second experiment, an industry control diet (I) regimen was compared with that of either an approximate 25 or 50% replacement for the level of 48% CP soybean meal (SBM) inclusion in the diet utilizing the amino acid digestibility and AME_n determined from the first experiment. From 0 to 14, 14 to 28, and 28 to 42 d of age, the HP-DDG in the 50% SBM replacement diet was added at 25, 23.5, and 21% of the diet, respectively. To meet digestible amino acid needs, the diet containing 50% SBM replacement with HP-DDG contained 3.2, 3.6, and 4.4% units more CP than the I diet regimen from 1 to 14, 14 to 28, and 28 to 42 d of age, respectively. Dietary replacement of up to 50% of SBM inclusion with HP-DDG had no effect on bird performance at 14 or 42 d of age or breast fillet yield at 42 d of age; however, it decreased BW gain and increased feed:gain ratio from 14 to 28 d of age. Birds consuming a diet with 50% replacement of SBM with HP-DDG consumed 17.1% more N compared with those consuming I diets. This additional N and fiber consumed resulted in birds being fed the 50% replacement for SBM diet excreting 21.9 and 31.8% more manure DM and N, respectively. Due in large part to the amino acid profile and digestibility of HP-DDG, use of this feedstuff as a large proportion of the diet is feasible but results in more manure and manure N from broilers.

Key words: broiler, corn, high-protein distillers dried grain, manure, nitrogen

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INTRODUCTION

In 2007, 33% of the US corn crop was used for food and industrial uses, 21% of which was used for ethanol production (http://www.corn.org). To optimize the fermentation process, new corn processing and fractionation technologies are being studied and implemented before the traditional dry-grind ethanol fermentation. (Singh et al., 2005; Martinez-Amezcua et al., 2007). The resulting co-products of fermentation, therefore, have led to a variety of new distillers products entering the marketplace with relative uncertainty as to their nutritional value for poultry. If the bran, pericarp fiber, and germ are removed from corn, fermentation of the endosperm, the result is a co-product that is much greater in CP versus conventional distillers dried grains plus solubles (**DDGS**). One expected benefit of this co-product could likely be nutrient consistency, which has been a primary criticism of DDGS by the poultry industry (Batal and Dale, 2006; Waldroup et al., 2007). The objectives of the current research were 2-fold: i) determine the AME_n and standardized ileal amino acid digestibility for high-protein distillers dried grain (**HP-DDG**; a co-product of corn endosperm fermentation) and ii) quantify the effect of HP-DDG as a partial replacement of SBM in broiler diets on bird performance and DM, N, and P excretion to 42 d of age.

MATERIALS AND METHODS

All research reported herein was approved by the Purdue University Animal Care and Use Committee. The HP-DDG used in this experiment was obtained as a by-product of corn fractionation and endosperm fermentation for ethanol production (specifics on fractionation and fermentation are proprietary). The HP-DDG was supplied by Mor Technology LLC (Metropolis, IL), and nutritional characteristics are presented in Table 1.

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Table 1. Analyzed and determined nutrient content for high-protein corn distillers dried grains (HP-DDG) used in experiments 1 and 2

Nutrient	HP-DDG
DM, %	94.09
CP, %	53.39
Total amino acids, %	52.26
Ether extract, %	3.48
Ca, %	0.16
P, %	0.32
Na, %	0.02
Crude fiber, %	7.30
Acid detergent fiber, %	27.3
Neutral detergent fiber, %	34.0
AME,[1] kcal/kg	2,471 ± 186
AME_n,[1] kcal/kg	2,526 ± 187

[1]Means represent AME and AME_n from 6 replicate pens of 8 birds per pen. (±SD).

Table 2. Dietary composition of the semipurified diet to determine the AME_n and amino acid digestibility of high-protein corn distillers dried grains (HP-DDG; as-fed basis), experiment 1

Ingredient, %	Diet
HP-DDG[1]	38.08
Dextrose	56.78
Vitamin-mineral premix[2]	0.35
Dicalcium phosphate	1.84
Limestone	1.26
Sodium chloride	0.19
Chromic oxide premix[3]	1.50

[1]HP-DDG was the only CP and amino acid source in this diet. The experimental diet was formulated to contain 20% CP (21.3% analyzed), 0.93% Ca, and 0.45% P.

[2]Provided per kilogram of diet: iron, 71.6 mg; copper, 11.0 mg; manganese, 178.7 mg; zinc, 178.7 mg; iodine, 3.0 mg; selenium, 0.4 mg; vitamin A (retinyl acetate), 18,904.3 IU; vitamin D_3 (cholecalciferol), 9,480.0 IU; vitamin E (DL-α-tocopheryl acetate), 63.0 IU; vitamin K activity, 6.4 mg; thiamine, 3.2 mg; riboflavin, 9.4 mg; pantothenic acid, 34.7 mg; niacin, 126.0 mg; pyridoxine, 4.7 mg; folic acid, 1.6 mg; biotin, 0.5 mg; vitamin B_{12}, 35.4 μg; choline, 956.9 mg.

[2]Prepared by mixing 1 g of chromic oxide with 4 g of cornstarch.

Experiment 1

From 0 to 15 d of age, 48 Ross × Ross (308; Aviagen Inc., Huntsville, AL) male chicks were fed, ad libitum, a corn-soybean meal (**SBM**)-based diet that met or exceeded all nutrient requirements (NRC, 1994) in stainless steel battery cages equipped with nipple waterers (Alternative Design Manufacturing and Supply Inc., Siloam Springs, AR). On d 15, birds were individually weighed and sorted into groups. Birds were then assigned to cages such that each cage was reflective of the total population BW and differences among cages were minimized. The experimental diet was a semi-purified diet containing 0.3% chromic oxide as a digestive marker and is described in Table 2. The HP-DDG source was the only source of CP and amino acids and formulated to 20% CP. The diet was fed to 6 replicate cages with 8 birds per cage.

A partial and representative excreta collection was conducted from 20 to 22 d of age from each pen for determination of AME_n. Excreta were frozen and stored at −20°C. At 22 d of age, birds were killed with CO_2 for collection of ileal digesta. The digesta in the ileum (as defined by the digesta found between Meckel's diverticulum and 2 cm proximal to the ileo-cecal junction) was flushed with distilled water, placed on ice, and subsequently frozen (−20°C). Excreta and ileal digesta were lyophilized and ground through a 0.5-mm screen.

Gross energy determinations of feed and excreta samples were performed in a Parr adiabatic bomb calorimeter (Parr Instruments Co., Moline, IL) with benzoic acid as a standard. Nitrogen content of feed, HP-DDG, and excreta samples were determined using a LECO model FP 2000 N combustion analyzer (LECO Corp., St. Joseph, MI; AOAC International, 2000; method 990.03). The AME_n of the diets was calculated using the index method (Cr as the digestive marker) by adapting the formula of Hill and Anderson (1958) as described by NRC (1994). Determination of AME and AME_n was done with the assumption that the dextrose used in the experimental diet contributed 3,640 kcal/kg (Hill and Anderson, 1958).

Apparent ileal amino acid digestibility was determined using the index method (Cr as the digestive marker). Standardization for endogenous amino acid flow was done using values from broilers fed a N-free diet published by Adedokun et al. (2007). Dry matter content was determined on ground diets and freeze-dried ileal digesta by drying the samples at 100°C for 24 h. Diet, HP-DDG, and ileal digesta samples for amino acid analyses (University of Missouri Experiment Station Chemical Laboratories, Columbia) were hydrolyzed in 6 *N* HCl for 24 h at 110°C under N atmosphere. Performic acid oxidation was carried out before acid hydrolysis for analysis of Met and Cys. Samples for tryptophan analysis were hydrolyzed using barium hydroxide (AOAC International, 2000; method 982.30 E [a, b, c]). Amino acids in the hydrolysate were subsequently determined by HPLC after post-column derivatization. Amino acid concentrations were not corrected for incomplete recovery resulting from hydrolysis. Chromium, P, and Ca were determined by the inductively coupled plasma atomic emission spectroscopy method (AOAC International, 2000; method 990.08).

Diet and HP-DDG fat content were determined after drying at 100°C for 12 h and refluxed with diethyl ether for 6 h for gravimetric determination of ether extract. Analyses of HP-DDG for crude fiber, acid detergent fiber, and neutral detergent fiber were determined according to AOAC International (2006; methods 978.1, 973.18[A-D]; Holst, 1973, respectively).

Experiment 2

An industry control diet (**I**) regimen was compared with that of either an approximate 25 or 50% replacement for the level of 48% CP SBM inclusion in the diet with HP-DDG utilizing the amino acid digestibility and AME_n determined from experiment 1. The 25% replacement of the level of SBM with HP-DDG was done by

Table 3. Diet formulation and nutrient composition of diets formulated with replacement of soybean meal (SBM) with high-protein corn distillers dried grains (HP-DDG)[1], experiment 2

	Replacement of HP-DDG for SBM, %					
	Starter (1 to 14 d of age)		Grower (14 to 28 d of age)		Finisher (28 to 42 d of age)	
Item	0	50	0	50	0	50
Ingredient, %						
Corn	56.23	48.71	62.00	56.60	67.84	60.35
HP-DDG	—	25.00	—	23.50	—	21.00
SBM, 48% CP	36.25	17.77	31.24	12.32	25.54	11.05
Soy oil	3.60	4.45	3.40	3.97	3.36	4.22
Sodium chloride	0.48	0.44	0.46	0.42	0.46	0.46
DL-Met	0.24	0.09	0.20	0.07	0.15	0.02
L-Lys, HCl	0.08	0.40	0.04	0.40	0.04	0.29
L-Thr	0.06	0.01	0.01	—	—	—
L-Trp	—	0.06	—	0.05	—	—
Limestone	1.07	1.12	1.13	1.18	1.30	1.34
Dicalcium phosphate	1.64	1.60	1.17	1.14	0.96	0.92
Vitamin-trace mineral premix[2]	0.35	0.35	0.35	0.35	0.35	0.35
Formulated nutrient composition						
ME_n, kcal/kg	3,101	3,101	3,150	3,150	3,200	3,200
CP, %	22.08	26.17	20.03	22.79	17.72	21.56
Lys, %	1.28	1.31	1.11	1.13	0.95	0.99
SID[3] Lys, %	1.15	1.14	0.99	0.99	0.85	0.85
Met, %	0.58	0.61	0.52	0.55	0.44	0.47
TSAA, %	0.94	1.07	0.85	0.96	0.75	0.87
SID Met, %	0.55	0.55	0.49	0.49	0.42	0.42
SID Met + Cys, %	0.86	0.92	0.78	0.82	0.74	0.68
Thr, %	0.91	0.97	0.78	0.83	0.68	0.79
SID Thr, %	0.77	0.76	0.66	0.66	0.61	0.57
Na, %	0.21	0.21	0.20	0.20	0.20	0.20
Ca, %	0.90	0.90	0.80	0.80	0.80	0.80
Nonphytate P, %	0.45	0.45	0.35	0.35	0.30	0.30
Total P, %	0.72	0.65	0.60	0.53	0.54	0.48
Analyzed nutrient composition						
CP, %	23.22	26.43	20.10	23.37	17.31	21.69
Acid detergent fiber, %	2.90	7.71	2.52	7.08	2.82	6.76
Neutral detergent fiber, %	8.77	17.51	6.70	14.31	7.95	14.61
Lys, %	1.50	1.38	1.20	1.25	0.99	1.07
Met, %	0.54	0.64	0.49	0.54	0.40	0.46
TSAA, %	0.89	1.10	0.80	0.94	0.66	0.85
Thr, %	0.95	0.98	0.75	0.84	0.62	0.79
Trp, %	0.28	0.28	0.26	0.26	0.22	0.20
Total P, %	0.73	0.62	0.57	0.50	0.51	0.45

[1]A 25% replacement for SBM concentration with HP-DDG diet was obtained by mixing equal proportions of the 0 and 50% SBM replacement diets during each age phase.

[2]Supplied per kilogram of diet: vitamin A, 13,233 IU; vitamin D_3, 6,636 IU; vitamin E, 44.1 IU; vitamin K, 4.5 mg; thiamine, 2.21 mg; riboflavin, 6.6 mg; pantothenic acid, 24.3 mg; niacin, 88.2 mg; pyridoxine, 3.31 mg; folic acid, 1.10 mg; biotin, 0.33 mg; vitamin B_{12}, 24.8 μg; choline, 669.8 mg; iron from ferrous sulfate, 50.1 mg; copper from copper sulfate, 7.7 mg; manganese from manganese oxide, 125.1 mg; zinc from zinc oxide, 125.1 mg; iodine from ethylene diamine dihydroidide, 2.10 mg; selenium from sodium selenite, 0.30 mg.

[3]SID = standardized ileal digestible amino acid, calculated from standardized ileal digestible amino acids obtained for HP-DDG and values for corn and SBM (Adedokun et al., 2008).

mixing a 50:50 mixture of the I and 50% replacement of SBM with HP-DDG for each of the dietary phases.

One-day-old Ross × Ross (308; Aviagen Inc.) male broiler chicks were weighed and randomly sorted into normalized groups to minimize BW differences among pens and were placed in 3.72-m^2 floor pens. Before the beginning of the trial, wood shavings were weighed and distributed at a depth of 11 cm. A composite wood shavings sample was retained for determination of initial N and P content. Each diet was fed to 8 replicate pens with 39 birds per pen. Each of the 3 diet treatments was fed from hatch to 14 (starter phase), 14 to 28 (grower phase), and 28 to 42 d (finisher phase). The HP-DDG used in experiment 2 was from the same batch as in experiment 1. Dietary formulations, as well as calculated and determined nutrient analyses, are presented in Table 3. Diets were formulated to be isocaloric with similar concentrations of digestible amino acids. No CP minimums were fixed for diet formulation, and the Lys and TSAA concentrations of the diet were considered independent for diet formulation purposes. Dietary amino acid targets were set as 90% of the recommendations of Aviagen Inc. for the Ross × Ross 308. The standardized ileal amino acid digestibility for corn and SBM values used for formulation were from Adedokun et al. (2008).

Pen BW and feed consumption were determined at 14, 28, and 42 d of age. Mortality was checked twice

Table 4. Apparent and standardized ileal amino acid digestibilities (SIAAD) of 22-d-old broiler chicks fed high-protein corn distillers dried grains, experiment 1

	HP-DDG				
Item	Apparent	Standardized	SD[1]	Ingredient	SIAAD
Essential amino acids	(% of total amino acid)			(% of ingredient, as-is basis)	
Arg	79.03[2]	81.31	3.89	2.09	1.70
His	72.81	77.20	4.62	1.26	0.97
Ile	74.43	78.11	4.80	2.11	1.65
Leu	80.00	81.02	4.61	7.59	6.15
Lys	69.86	73.00	4.28	1.40	1.02
Met	83.12	84.93	3.86	1.29	1.10
Phe	79.52	80.94	4.68	2.95	2.39
Thr	68.79	73.02	4.90	1.92	1.40
Trp	75.20	79.58	3.42	0.28	0.22
Val	72.58	75.76	5.09	2.56	1.94
Nonessential amino acids					
Ala	79.24	80.64	4.53	4.14	3.34
Asp	68.14	71.45	4.56	3.32	2.37
Cys	73.69	76.77	5.01	0.98	0.75
Glu	78.53	80.93	4.50	9.08	7.35
Gly	69.50	72.77	4.44	1.74	1.27
Pro	77.51	79.34	4.73	4.22	3.35
Ser	75.55	79.79	5.41	2.39	1.91
Tyr	81.02	82.56	4.12	2.48	2.05
Total amino acids	76.16	77.48	4.55	52.90	40.99

[1]The SD was the same for both the apparent and standardized digestibilities.

[2]Means represent 6 pens per diet, 8 chicks per pen.

daily, and BW of birds that died was used to adjust feed consumption and feed:gain ratio. At 42 d of age, 8 birds per pen were randomly selected and killed with an overdose of CO_2. Broiler BW was recorded and the weight of the pectoralis major and minor determined.

All litter from each pen was removed within 1 d after removal of broilers from the building. All litter from each pen was weighed and thoroughly mixed in a 256-L cement mixer (Crown Corporation Equipment, Winnipeg, Manitoba, Canada) before subsample collection. Subsamples were taken at routine intervals during the emptying of the cement mixer. Litter DM was subsequently determined in triplicate after freeze-drying and subsequently drying in a 100°C oven for 6 h. Litter samples were then ground twice in a Wiley mill through a 1.0-mm screen. Nitrogen and P analyses of feed and litter were determined as described for experiment 1. Similarly, amino acid and fiber analyses of feed samples were conducted as described in experiment 1. Net DM, N, and P excretion was determined by subtracting the initial mass and nutrient content determined from the fresh litter samples.

Statistical analyses consisted of ANOVA using the GLM procedure of SAS (SAS Institute Inc., Cary, NC). Mean separation was by Tukey adjustment (Kramer, 1956), and level of significance was set at $P \leq 0.05$.

RESULTS AND DISCUSSION

Experiment 1

The HP-DDG used in the experiments herein was 9.3 and 0.6% units greater in CP and fat (Table 1), respectively, than the HP-DDGS source reported by Kim et al. (2008). Nevertheless, the resulting AME_n of the HP-DDG of the current study was 431 kcal/kg (15%) less than the TME_n reported by Kim et al. (2008). This reduction in ME was likely due to the lack of solubles content or experimental methodology, or both (broiler chicks fed a semi-purified diet versus precision-fed roosters). After analyzing 17 conventional DDGS samples, Batal and Dale (2006) reported that fat content accounted for 29% of TME_n variability among samples, with an additional 14% being accounted for by crude fiber. Little improvement in predictability of TME_n from DDGS samples, however, could be accounted for by either CP or ash content (Batal and Dale, 2006).

Digestibility of Lys was similar between this HP-DDG source (73%) and that of Kim et al. (2008), whereas Met and Thr were 5.3 and 10.1% units (of total amino acids) lower in the current study (Table 4). The HP-DDG used in the current study provided 32, 34, and 24% more digestible Lys, Met, and Thr than the HP-DDGS source reported by Kim et al. (2008).

Experiment 2

Notably, the analyzed CP and Lys values for the I and HP-DDG diets were considerably greater than formulated values for the starter and grower phases. Diet had no effect on performance from 1 to 14 d of age. However, replacement of 50% of SBM inclusion with HP-DDG decreased BW gain and increased feed:gain ratio from 14 to 28 d of age. Diet had no effect on broiler performance or breast fillet yields at 42 d of age (Table 5). The lack of performance effects is in contrast

Table 5. Performance and breast fillet yield of broilers fed high-protein corn distillers dried grains (HP-DDG) as a replacement for soybean meal, experiment 2[1]

Variable and bird age	0% HP-DDG	25% HP-DDG	50% HP-DDG	SEM	Probability of diet effect
BW, kg/bird					
14 d of age	0.390[2]	0.390	0.380	0.0082	0.61
28 d of age	1.412[a]	1.440[a]	1.346[b]	0.014	0.0003
42 d of age	2.87	2.92	2.82	0.029	0.061
BW gain, kg/bird					
0 to 14 d of age	0.343	0.344	0.344	0.008	0.60
14 to 28 d of age	1.021[a]	1.048[a]	0.963[b]	0.012	0.0002
28 to 42 d of age	1.41	1.45	1.42	0.032	0.65
0 to 42 d of age	2.77	2.84	2.72	0.03	0.07
Feed intake, kg/bird					
0 to 14 d of age	0.464	0.453	0.467	0.010	0.57
14 to 28 d of age	1.657	1.585	1.689	0.042	0.22
28 to 42 d of age	2.83	2.99	2.85	0.088	0.43
0 to 42 d of age	4.95	5.02	5.01	0.11	0.88
Feed:gain, g/g					
0 to 14 d of age	1.353	1.330	1.401	0.039	0.43
14 to 28 d of age	1.622[b]	1.514[c]	1.750[a]	0.037	0.0007
28 to 42 d of age	2.029	2.073	2.019	0.087	0.90
0 to 42 d of age	1.740	1.749	1.787	0.029	0.47
Breast fillet[3]					
kg/bird	0.531	0.510	0.495	0.012	0.12
% of BW	17.19	16.97	16.83	0.23	0.55

[a–c]Means in rows within a measured characteristic with no common superscripts differ significantly ($P \leq 0.05$).

[1]Mortality was not affected by diet ($P = 0.81$) for broilers fed 0, 25, and 50% replacement diets and was 4.8, 3.2, and 4.2%, respectively (SEM ± 1.75).

[2]Means represent 8 pens per diet, 39 birds per pen.

[3]Means represent 8 pens per diet, 8 birds per pen at 42 d of age.

to results reported by Wang et al. (2007). Inclusion of up to 20% of traditional DDGS into broiler diets did not affect BW or feed:gain ratio, whereas feeding up to 25% DDGS increased feed intake by 4% and decreased carcass yield by 2% (Wang et al., 2007). Similarly, Lumpkins et al. (2004) noted no difference in BW or carcass yield when up to 12% DDGS was included in broiler diets to 42 d of age, but 18% DDGS decreased BW gain by 3%.

Birds consuming a diet with 50% replacement of SBM with HP-DDG ate 17.1% more N compared with those consuming I diets to 42 d of age (Table 6). This increase in N consumed is reflective of the diets for birds fed the 50% replacement for SBM, with HP-DDG having 3.2, 3.6, and 4.4% units more CP to balance diets for digestible AA concentration in the starter, grower, and finisher phases, respectively. This additional N and fiber intake resulted in birds being fed the 50% replacement for SBM diet having 21.9 and 31.8% more DM and N excreted into the litter (Table 7). Litter DM percentage was unaffected by dietary regimen (mean = 68.3% DM). Extrapolating differences in nutrient excretion to a 20,000-bird flock would result in the 50% SBM replacement with HP-DDG-fed birds excreting 5,574 kg more DM and 458 kg more N per flock.

Despite being low in total fiber (approximately 9.5% neutral detergent fiber), corn can contribute a proportion of total fiber in the diet (Watson, 1987). The hull and germ fractions contribute 51 and 16%, respectively, of fiber within the corn kernel, of which 70 and 25% are hemicellulose and cellulose, respectively (Watson, 1987). Despite contributing a small amount of total fiber to the diet, reductions in these fractions can have an effect on nutrient excretion. For example, Moeser et

Table 6. Nitrogen intakes of birds fed high-protein corn distillers dried grains (HP-DDG) as a replacement for soybean meal (SBM), experiment 2

HP-DDG replacement for SBM, %	Age, d 0 to 14	14 to 28	28 to 42	0 to 42
	(g/bird per period)			
0	21.5[b,1]	68.3[b]	99.1[b]	258.8[b]
25	21.3[b]	68.7[b]	114.5[a]	262.3[b]
50	24.0[a]	78.2[a]	118.1[a]	303.1[a]
SEM	0.5	1.9	3.4	6.4
Probability of diet effect	0.0007	0.0017	0.0018	0.0001

[a,b]Means within a column with no common superscript differ significantly ($P \leq 0.05$).

[1]Means represent 8 pens per diet, 39 birds per pen.

Table 7. Net apparent DM, N, and P excretion per pen of birds fed a high-protein corn distillers dried grains (HP–DDG) as a replacement for soybean meal (SBM), experiment 2

HP-DDG replacement for SBM, %	DM excretion[1]	N excretion	P excretion
		(kg / pen)	
0	38.78[b,2]	1.915[c]	0.549
25	40.59[b]	2.145[b]	0.518
50	49.65[a]	2.808[a]	0.514
SEM	2.21	0.109	0.031
Probability of diet effect	0.0049	0.0001	0.68

[a–c]Means in columns with no common superscripts differ significantly.

[1]Litter DM percentage was unaffected by dietary regimen and averaged 65.1, 70.7, and 69.1% (SEM ± 0.02) for the 0, 25, and 50% replacement of SBM concentration in the diet with HP-DDG.

[2]Means represent 8 replicate pens per diet, 39 birds per pen.

al. (2002) noted a 13% improvement in DM digestibility when growing pigs were fed diets composed primarily of dehulled-degermed corn versus corn grain. Similarly, chicks fed diets containing dehulled-degermed corn excreted 78.1 g less DM (11%) from 0 to 42 d of age than those fed a corn grain diet (Applegate, 2005). Little recent work has been done with DDGS, in regards to DM digestibility in broilers. In laying hens, however, including diets with 10% DDGS increased the NDF and ADF content of diets by 2.4 and 0.9% units, respectively, but did not affect DM digestibility of 45- to 58-wk-old hens (Roberts et al., 2007). The greater inclusion of the HP-DDG in the current study resulted in considerably greater dietary soluble (8.7, 7.6, and 6.7% units for starter, grower, and finisher diets, respectively) and insoluble fiber content (4.8, 4.6, and 4.0% units for starter, grower, and finisher diets, respectively) than the I diets. Thus, the large difference in dietary fiber with the 50% replacement of SBM with HP-DDG likely accounted for the increase in DM excretion. Due in large part to the amino acid profile and digestibility of HP-DDG, use of HP-DDG feedstuffs of up to 50% replacement for the level of SBM inclusion is feasible, but doing so may contribute to more manure and N excretion from broiler operations.

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