The effects of feeding distillers dried grains with solubles on broiler meat quality

A. Corzo,* M. W. Schilling,†[1] R. E. Loar II,* V. Jackson,† S. Kin,† and V. Radhakrishnan†

*Department of Poultry Science, Box 9665, Mississippi State University, Mississippi State, MS 39762; and †Department of Food Science, Nutrition, and Health Promotion, Box 9805, Mississippi State University, Mississippi State, MS 39762

ABSTRACT A randomized complete block design with 3 replications (n = 144) was utilized to evaluate the effects of feeding distillers dried grains with solubles (DDGS; 0% control and 8%) on broiler breast and thigh meat quality. Electrical stunning was performed, and broiler carcasses were scalded, picked, and eviscerated using commercial prototype equipment. At 4 h postmortem, carcasses were removed from the chill tank and breast and thigh removal was performed. Color, pH, cooking loss, and shear force values were measured on breasts that were removed from the right side of the carcass. Breasts removed from the left side of the carcass were utilized for sensory testing. Thigh meat was evaluated for TBA reactive substances and fatty acid composition. On average, no differences ($P > 0.05$) existed among the DDGS and control treatment with regards to color (CIE L*, a*, b*), ultimate pH, cooking loss, and shear values. In addition, no differences ($P > 0.05$) existed among treatments regarding the acceptability of texture, but the control treatment was slightly preferred ($P < 0.05$) over the DDGS treatment with respect to flavor and overall acceptability. However, 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) did not differentiate between the 2 treatments. In addition, in a sensory difference test, consumers could not differentiate ($P > 0.05$) between the control and DDGS treatment. Fatty acid composition varied slightly ($P < 0.05$) between treatments. The DDGS treatment had a greater ($P < 0.05$) percentage of linoleic and total polyunsaturated fatty acids, indicating that it may be slightly more susceptible to oxidation. Overall, data suggest that both feeding treatments yielded high-quality breast and thigh meat with minimal product differences.

Key words: distillers dried grains with solubles, breast meat quality, fatty acid composition, lipid oxidation

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INTRODUCTION

Distillers dried grains with solubles (**DDGS**) is a coproduct that is generated from the production of corn-based ethanol (Rosentrater, 2006). A vast increase in ethanol production over the last 5 to 10 yr has led to an increased supply of DDGS that is available for livestock feed (Noll et al., 2007). Researchers have previously evaluated the effects of feeding DDGS on broiler carcass composition and growth performance, but minimal research has been reported on the effects of feeding DDGS on broiler meat quality. Wang et al. (2007a,b) reported that broilers can be fed 15% DDGS on a constant basis without affecting carcass composition or growth. Similarly, Lumpkins et al. (2004) concluded that broilers can be fed 6% DDGS in the starter period and 12 to 15% DDGS in the grower and finishing stages, respectively, without affecting growth.

Even though no published research could be located regarding the effects of feeding DDGS on broiler meat quality, research has been conducted to determine the feasibility of using DDGS in the finishing diet of pigs at concentrations of 10 to 30% in regards to carcass performance and meat quality (Whitney et al., 2006; Widmer et al., 2008). Whitney et al. (2006) concluded that the inclusion of 10% DDGS could be utilized in swine grower-finisher diets without affecting growth performance, carcass characteristics, or meat quality. These researchers also reported that inclusion of 20 to 30% DDGS in the diet resulted in decreased growth performance but had minimal effects on pork quality. Widmer et al. (2008) reported that feeding 10% DDGS to pigs did not affect meat quality and that feeding 20% DDGS had minimal effects on meat quality with the exception of decreased belly firmness, an indicator

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[1]Corresponding author: schilling@foodscience.msstate.edu

of decreased bacon quality, and percentage of polyunsaturated fatty acids in the meat.

Broiler breast meat quality is often evaluated in terms of color, pH, water-holding capacity, tenderness, and sensory acceptability because consumers prefer meat that is juicy, tender, and not too pale (McKee and Sams, 1997; van Laack et al., 2000; Schilling et al., 2003; Fletcher and Smith, 2006). In addition, diet directly affects the fatty acid composition of broiler thigh meat because fatty acids from the feed are deposited in the muscle (Wood and Enser, 1997). Therefore, the saturation level of the triglycerides in the feed affects the saturation level of the fatty acids in the thigh meat and thus its oxidation potential and shelf-life (Adams et al., 1994; Cortinas et al., 2004; Suksombat et al., 2007). Considering observations by Widmer et al. (2008), which state that under certain dietary conditions there may be an effect on swine meat characteristics, it is reasonable to think that similar effects may occur in poultry meat. Because feed composition directly affects the amino acid and fatty acid composition in muscle tissue, research was performed to evaluate the following objectives: 1) the effects of feeding broilers DDGS on the color, pH, water-holding capacity, tenderness, and sensory acceptability of broiler breast meat and 2) the effects of feeding broilers DDGS on the fatty acid composition of thigh meat and its sensitivity to oxidation.

MATERIALS AND METHODS

Treatments

Three treatments that differed in inclusion of DDGS in the diet were used in this experiment. A corn-soybean meal-based diet served as the control (no use of DDGS), whereas the second and third diet differed to the control in that they contained 8% of dietary inclusion and were obtained from 2 different sources. Because no statistical differences existed ($P > 0.05$) between DDGS sources, the data from these 2 commercial sources were pooled together and compared with the control treatment. Diets with or without DDGS were formulated to be isocaloric and similar in all limiting amino acids and other nutrients (Table 1) and were formulated to meet or exceed NRC (1994) nutrient recommendations. Diets were offered in 2 feeding phases, starter and grower, in crumbles from 0 to 21 d and pellets from 21 to 42 d of age.

Sample Preparation

At 42 d of age, 4 broilers from each of 3 treatments within 12 replications (total of 144 Ross × Ross 708 birds per treatment) were randomly selected for slaughtering and whole breast and thigh removal at

Table 1. Experimental diet composition[1]

	Starter phase (0 to 21 d)		Grower phase (21 to 42 d)	
Item	Control	+DDGS	Control	+DDGS
Ingredients				
Corn	60.843	54.338	68.325	61.823
Soybean meal	33.048	30.701	26.021	23.674
DDGS	—	8.0	—	8.0
Poultry oil	2.629	3.517	2.258	3.145
Dicalcium phosphate	1.776	1.659	1.665	1.548
Calcium carbonate	0.676	0.762	0.716	0.802
NaCl	0.439	0.404	0.443	0.408
Vitamin-mineral premix[2]	0.25	0.25	0.25	0.25
DL-Met	0.221	0.207	0.165	0.151
L-Lys	0.068	0.111	0.106	0.149
Coccidiostat[3]	0.05	0.05	0.05	0.05
Calculated composition				
CP (%)	21.5	21.9	18.6	19.0
AME (kcal/kg)	3,100	3,100	3,150	3,150
Fiber (%)	2.1	2.6	2.1	2.6
Fat (%)	5.0	6.4	4.9	6.2
Ca (%)	0.90	0.90	0.84	0.84
Available P (%)	0.45	0.45	0.42	0.42
Lys (%)	1.16	1.17	1.00	1.01
TSAA (%)	0.86	0.87	0.74	0.75
Thr (%)	0.78	0.80	0.67	0.69
Digestible Lys (%)	1.10	1.10	0.95	0.95
Digestible TSAA (%)	0.83	0.83	0.71	0.71
Digestible Thr (%)	0.72	0.72	0.62	0.62

[1]+DDGS is representative of the ingredient and nutritional composition of the 8% distillers dried grains with solubles (DDGS) diet.

[2]The vitamin-mineral premix contained (per kg of diet): retinyl acetate, 2,654 μg; cholecalciferol, 110 μg; DL-α-tocopherol acetate, 9.9 mg; menadione, 0.9 mg; B_{12}, 0.01 mg; folic acid, 0.6 μg; choline, 379 mg; D-pantothenic acid, 8.8 mg; riboflavin, 5.0 mg; niacin, 33 mg; thiamin, 1.0 mg; D-biotin, 0.1 mg; pyridoxine, 0.9 mg; ethoxyquin, 28 mg; manganese, 55 mg; zinc, 50 mg; iron, 28 mg; copper, 4 mg; iodine, 0.5 mg; selenium, 0.3 mg.

[3]Dietary inclusion of 60 g of salinomycin sodium per 907.2 kg of feed.

4 h postmortem. Broilers were hung by their feet in steel shackles and were electrically stunned by manually placing their heads in a saturated saline bath (11.5 V, <0.5 mA alternating current to direct current for 3 s). The shackle line speed was constant and set so that approximately 22 broilers were stunned per minute. Unilateral neck cutting was manually performed immediately after stunning, and bleeding lasted for 140 s. Upon completion of exsanguination, the broilers were scalded at 53.3°C for 191 s, picked for 35 s using a rotary drum picker (Baader-Johnson, Kansas City, KS), and then mechanically eviscerated. After slaughter, broiler carcasses were stored in ice water in metal (173 cm in length, 85 cm in width, and 68.5 cm in depth) and rubber containers (142 cm in length, 81 cm in width, and 50.8 cm in depth) to mimic the chilling process in a poultry plant. At 4 h postmortem, breast (boneless) and thigh (bone-in) muscles were removed from the carcass. Within these samples, 1 carcass from each treatment per replication (total of 36 samples) was selected for 15 min postmortem pH measurements ($\mathbf{pH_{15}}$) to evaluate initial pH decline after slaughtering. Thigh meat samples were placed into labeled Ziploc bags (Ziploc brand bags, S. C. Johnson & Son Inc., Racine, WI) and frozen (−23°C) until fatty acid and lipid peroxidation (TBA reactive substances, **TBARS**) tests could be performed. Each whole breast was placed into a labeled Ziploc bag and cooled (2°C) overnight. At 24 h postmortem, the whole breast was separated into right and left halves. Breast samples were measured for color and pH (right side of carcass), then individually vacuum-packaged (Turbovac 320-ST-S, Inject Star of the Americas Inc., Brookfield, CT) in 15.2 × 20.3 cm, 3 mil vacuum pouches (item 75001815, Rebel Butcher Supply Co. Inc., Flowood, MS) and frozen (−23°C) until cook loss and shear force determinations could be performed. The breasts from the left side of the carcass were bagged (3 breasts per bag), vacuum-packaged (40.64 × 50.8 cm, 4 mil vacuum pouch; item 75001987, Rebel Butcher Supply Co.) and frozen (−23°C) until consumer sensory acceptability tests could be performed.

pH Measurement

A pH meter (Accumet 61a, Fisher Scientific, Hampton, NH) was used to measure the pH of 1 broiler from each treatment per replication (total of 36 samples) at pH_{15} by inserting a pH probe (FlexipHet SS Penetration Tip, Cole Palmer, Vernon Hills, IL) 2.5 cm below the pectoralis muscle at approximately 2.5 cm from the top of the breast and 2.5 cm from the breast bone. At 24 h postmortem, ultimate pH measurements for each sample (n = 144) were taken using the same pH meter in the same anatomical location as the 15-min pH measurements.

Color Measurement

Instrumental color measurements were taken for each breast (right side) within each treatment using a chromameter (C8202489, Chromameter Model CR-200, Minolta Camera Co. Ltd., Osaka, Japan) that was calibrated using a standard white calibration plate (20933026). Three measurements were taken at 3 identical locations for each breast on the medial portion of the pectoralis muscle. Color for each sample was expressed in terms of CIE values for lightness (L*), redness (a*), and yellowness (b*).

Cooking Loss

Frozen breast samples were thawed at 2°C overnight. The thawed breasts were weighed and baked in an oven (JBP25DOJ2WH, General Electric, Louisville, KY) to a final internal temperature of 77°C. Internal chicken breast temperatures were determined using thermocouples and a data logger (UWTR, Omega Engineering, Stamford, CT). Cooked breasts were cooled to ambient temperature (20°C), patted dry with 1 paper towel (1-ply), and reweighed. Cooking loss was reported as a percentage and calculated as (initial weight − final weight)/(initial weight) × 100.

Warner-Bratzler Shear Force Determination

Tenderness was assessed using an objective texture procedure described by Meek et al. (2000). Breasts that were used for cooking loss determinations were used for shear force determinations. Four to 6 adjacent 1 cm (width) × 1 cm (thickness) × 2 cm (length) strips were cut from the cooked breast, parallel to the direction of the muscle fibers. Each strip was sheared once, and the mean was calculated for each breast. Samples were sheared perpendicular to the muscle fibers using a Warner-Bratzler shear attachment mounted on an Instron Universal Testing Center (3300, Instron, Norwood, MA) using a 50-kg load transducer and a crosshead speed of 200 mm/min.

Lipid Oxidation (TBA)

Thiobarbituric acid concentrations, expressed as milligrams of malonaldehyde per kilogram of sample were determined using the direct chemical-extraction method described by Spanier and Traylor (1991). One broiler thigh meat sample was randomly selected from each of 3 treatments for each of the 12 replications (n = 36) to determine lipid peroxidation changes as a function of storage (4°C) time at 1, 3, and 5 d after thawing. Thighs were thawed for 24 h at 4°C before storage.

Fatty Acid Profile

Fatty acid profiles were conducted on broiler thigh meat samples from each of the treatments within 12 replications (n = 36). Lipids were extracted in ether as described by the AOAC (2000a, 996.06). The extracted lipids were converted to methyl esters as described by AOAC (2000b, 969.33) and analyzed for individual fatty acids (C14:0 and C20.4) using a gas chromatograph (3400, Varian Inc., Walnut Creek, CA) fitted with a flame ionization detector. Gas chromatography parameters were as follows: the column temperature was 50°C for 3 min and then increased to 220°C at 4°C/min and was held for 15 min. The injector temperature was 200°C, and the detector temperature was 250°C. The flow rates of the carrier gases (hydrogen and oxygen) were 30 and 300 mL/min, respectively. Identification and quantification of individual fatty acids was made by using a standard fatty acid methyl ester mixture (2010, Matreya Biochemicals LLC, Pleasant Gap, PA).

Sensory Analysis

Two consumer-based sensory panels (n = 105) were conducted to evaluate the acceptability of chicken breast meat from broilers fed diets with or without DDGS and consisted of a difference-from-control test and a consumer acceptability test (n = 50 to 55 panelists per panel). Each panel consisted of students, staff, and faculty at Mississippi State University. Chicken breasts were thawed at 2°C for 24 h before sensory testing and were placed on broiler pans for even distribution of heat during cooking. Meat thermometers (78631, Farberware, Westbury, NY) were inserted in the thickest portion of each breast sample and baked to an internal temperature of 77°C. Baked breasts were cooled at room temperature for 15 min, cut into 2.5 × 2.5 cm cubes, and kept warm (60 to 70°C) in 8-quart chafer dishes (53042, Polarware Co., Kiel, WI), until panelists evaluated the samples. Random 3-digit numbers were assigned to identify the samples. Sample order was randomized to account for sampling order bias. Consumers evaluated breast samples for the difference-from-control test first, and, once finished, samples for consumer acceptance were presented to the panelists. Water and unsalted crackers were provided, and panelists were asked to expectorate and rinse their mouths between each sample.

For the difference-from-control tests, each panelist was presented with a chicken breast sample labeled as control (no DDGS in the diet of the broilers) and coded breast samples, in which one of the coded chicken breast samples was the same as the control sample and the other samples were from broilers fed diets containing 8% DDGS. Panelists were asked to evaluate the control sample first and then determine how different (in terms of flavor) the other coded samples were from the control sample by rating this difference on a scale from 0 to 4, where 0 = no difference; 1 = slight difference; 2 = moderate difference; 3 = large difference; and 4 = very large difference. For the consumer panels, each panelist was asked to evaluate coded chicken breast samples from broilers that were fed diets without DDGS (control diet) and 8% DDGS for texture, flavor, and overall acceptability using a 9-point hedonic scale, where 1 = dislike extremely; 5 = neither like nor dislike; and 9 = like extremely (Meilgaard et al., 1999).

Statistical Analysis

A randomized complete block design (replications as blocks) with 12 replications (n = 48 broilers per treatment) was used to test the effects of diet (with and without DDGS) on pH decline, ultimate pH, color, cooking loss, and shear force of broiler breast meat and the peroxidation (TBARS) and fatty acid profile of broiler thigh meat (version 9.1, SAS Institute, Cary, NC). In addition, a factorial structure was utilized in the TBARS analysis because samples were analyzed over time for each diet. When significant differences ($P < 0.05$) existed among treatments, the Fisher's least significant difference test was used to separate treatment means. A randomized complete block design (replications and panelists as blocks) with 2 replications was utilized to test the treatment effects ($P < 0.05$) of diet on the ability of panelists to perceive a difference from the control, the overall acceptability, and the acceptability of texture and flavor.

RESULTS AND DISCUSSION

pH and Color

At pH_{15}, the mean pH of breast meat did not differ ($P > 0.05$) between broilers that were fed DDGS (6.4) and the control diet (6.3) (Table 2). In addition, neither treatment had a significant incidence of pH_{15} values below 6.0, with an 8% incidence in both control and DDGS-fed broilers. It has been found that pH_{15} is a potential indicator that meat may exhibit poor quality characteristics because rapid postmortem pH decline can lead to protein denaturation that may result in pale color and low water-holding capacity (Briskey and Wismer-Pedersen, 1961). Results from this study are similar to those of Debut et al. (2003) and Battula et al. (2008), who reported that, on average, pH_{15} was between 6.3 and 6.6 for broiler breast meat that was considered normal meat. At 24 h postmortem, pH did not differ in broiler breast meat ($P > 0.05$) among dietary treatments (Table 2). It has been found that pH is an indicator of meat quality, and a low pH (<5.7) at 24 h postmortem is indicative of poor meat quality (Fernandez et al., 1994; Alvarado et al., 2007). In the present study, no breasts had a pH below 5.7 and only 1 breast out of 144 had a 24-h pH below 5.8. This indicates that there were no quality problems with the breast meat from each treatment group.

Table 2. pH (15 min and 24 hr), cooked color, cooking loss, and shear force values of chicken breast meat from broilers feds diets with or without distillers dried grains with solubles (DDGS)[1]

Treatment	pH (15 min)	pH (24 h)	CIE L* (lightness)	CIE a* (redness)	CIE b* (yellowness)	Cooking loss (%)	Shear force[2] (N)
Control (no DDGS)	6.3	6.1	54.9	1.5	4.9	19.3	13.5
8% DDGS	6.4	6.0	54.5	1.6	5.4	20.1	14.5
P-value	0.62	0.16	0.47	0.79	0.11	0.19	0.19
SEM	0.10	0.02	2.1	0.1	0.3	0.5	0.7

[1]n = 48 (per treatment).

[2]Shear force (N) = maximum peak force (N) required to shear through the sample.

There were no differences ($P > 0.05$) in CIE L*, a*, or b* (lightness, redness, and yellowness) between the DDGS and control treatments (Table 2). Previous studies have used L* as a measure to estimate the incidence of paleness or the pale, soft, and exudative condition, or both, in broiler breast meat (Barbut, 1998; van Laack et al., 2000; Woelfel et al., 2002). van Laack et al. (2000) reported that breasts appearing to be normal had L* values of 55 and those appearing to be pale had CIE L* values of 60 and stated that high L* values and low ultimate pH (<5.7) were indicative of broiler breast meat that was pale in color with low water-holding capacity. The L* and mean ultimate pH values for both treatments during the current study were similar to values that have been reported by previous researchers (55, 5.9 to 6.1) as characteristic of normal broiler breast meat at 24 h postmortem (Barbut, 1998; Sams, 1999; van Laack et al., 2000; Woelfel et al., 2002).

Cooking Loss and Shear Force

There were no differences ($P > 0.05$) in cooking loss percentage between broiler breast meat from the DDGS and control dietary treatment (Table 2). In addition, cooking loss percentages were more variable within each treatment than among treatments. Similarly, no differences ($P > 0.05$) existed among the DDGS and control treatment with respect to shear force (Table 2). All samples were very tender (<30 N), indicating that they would be highly acceptable to consumers (Lyon and Lyon, 1990; Schilling et al., 2003).

Lipid Oxidation (TBA)

There was no difference ($P > 0.05$) in TBARS between broiler thigh meat due to diet at each storage time (1, 3, and 5 d; Figure 1). However, there was a trend for TBARS to have a greater increase over time for the DDGS-fed treatment when compared with the control treatment. This is evidenced by a greater increase in TBARS from d 3 to 5 for the DDGS treatment in comparison to the control (Figure 1). This trend was also demonstrated by the DDGS d 5 treatment having greater TBARS ($P < 0.05$) values than d 1 and 3 for both treatments, whereas the d 5 control treatment was not different ($P > 0.05$) from any other treatment. The TBARS values were also similar to thigh meat that was stored for 0 and 1 d (2°C) but had lower values than those that were reported by these researchers for samples that were stored for 2 to 5 d (Ang and Lyon, 1990). Results from the current study may have been different from the study referenced above because the lipid percentage in the thigh was greater in the referenced study. Results from TBARS testing reveal that thigh meat from broilers that were fed 8% DDGS may be slightly more susceptible to oxidation than thigh meat from broilers fed the control diet.

Fatty Acid Composition

Three out of the 16 fatty acids that were detected differed ($P < 0.05$) in proportion among the 2 treatments (Table 3). Heptadecenoic acid was detected at low percentages in both treatments but had a greater percentage ($P < 0.05$) in the control treatment when compared with the DDGS treatment. In addition, oleic acid was the most prevalent fatty acid for both treatments and had a slightly greater concentration ($P < 0.10$) in the control treatment. Linoleic acid was elevated ($P < 0.05$) in the DDGS treatment in comparison to the control. Linoleic acid is a polyunsaturated fatty acid that is susceptible to lipid oxidation that can lead to the formation of aldehydes, including hexanal.

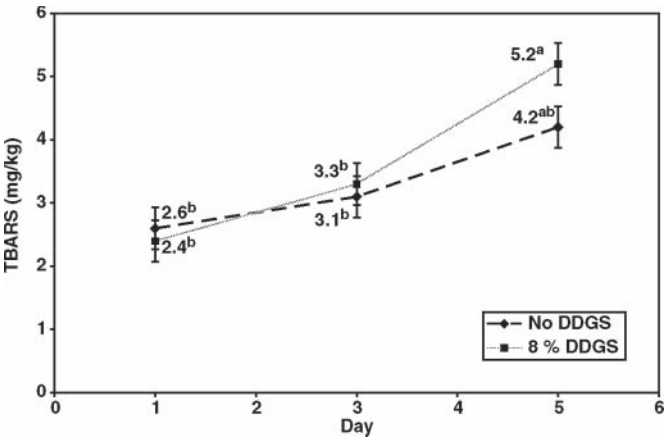

Figure 1. Thiobarbituric acid reactive substances (TBARS) values (mg/kg) of chicken thighs from broilers fed diets with or without 8% distillers dried grains with solubles (DDGS). Means with different letters are significantly different ($P < 0.05$). Standard error bars are included for treatment means.

Table 3. Fatty acid profile of chicken thigh meat from broilers fed diets with or without 8% distillers dried grains with solubles[1] (DDGS)

Fatty acid	Control (no DDGS)	8% DDGS	*P*-value	SEM
Myristic (C14:0)	0.55	0.54	0.42	0.01
Palmitic (C16:0)	23.65	23.35	0.11	0.25
Heptadecanoic (C17:0)	0.09	0.10	0.14	0.01
Stearic (C18:0)	6.89	6.53	0.15	0.19
Arachidic (C20:0)	0.10	0.09	0.76	0.01
Myristoleic (C14:1)	0.14	0.14	0.65	0.01
Palmitoleic (C16:1)	6.48	6.22	0.36	0.21
Heptadecenoic (C17:1)	0.16	0.09	0.005	0.02
Oleic (C18:1 *cis*)	38.80	37.82	0.08	0.36
Linoleic (C18:2 *cis*)	19.39	21.83	0.002	0.57
Linolenic (C18:3n-6)	0.16	0.17	0.29	0.02
Linolenic (C18:3n-9)	0.91	0.89	0.40	0.01
Eicosenoic (C20:1)	0.28	0.24	0.07	0.01
Eicosadienoic (C20:2)	0.13	0.16	0.04	0.01
Eicosatrienoic (C20:3n-8)	0.39	0.38	0.68	0.02
Arachidonic (C20:4)	1.89	1.93	0.97	0.11
Saturated (%)	31.28	30.42	0.03	0.31
Monounsaturated (%)	45.86	44.47	0.03	0.41
Polyunsaturated (%)	22.86	24.95	<0.001	0.32

Values are expressed as a percentage of the total fatty acid concentration.

Hexanal is highly correlated with TBARS (Shahidi and Pegg, 1994), and the increased prevalence of this fatty acid in thigh meat from the DDGS treatment may be why thigh meat from this treatment had slightly elevated TBARS values when compared with thigh meat from the control treatment. Eicosadienoic acid was also elevated ($P < 0.05$) in the 8% DDGS dietary treatment but was only present at 0.16 and 0.13% of the total fatty acids percentage for the DDGS and control treatments, respectively. In addition, the control treatment had greater ($P < 0.05$) percentages of saturated and monounsaturated fatty acids when compared with the DDGS treatment, but the DDGS treatment had a greater ($P < 0.05$) percentage of polyunsaturated fatty acids. These differences are probably due to the elevated percentage of linoleic acid in the DDGS treatment when compared with the control treatment. However, an increase in polyunsaturated fatty acid composition is an indicator of increased susceptibility to oxidation (Faustman, 1994). It is evident from literature that fatty acid composition of the feed is the most important determinant of the fatty acid composition in the resulting broiler breast and thigh meat (Cortinas et al., 2004). Therefore, even though DDGS caused slight differences ($P < 0.05$) in linoleic acid and polyunsaturated fatty acid content, altering the composition of the feed may be able to minimize differences that could occur due to the inclusion of DDGS.

Sensory Analysis

No difference existed ($P > 0.05$) between the DDGS and the control dietary treatment with respect to the difference-from-control test (Table 4). The blind control and DDGS treatment both received mean scores of 1.3, representing a slight difference. Because the blind control and DDGS treatment samples received the same mean score, it is unlikely that consumers would be able to differentiate between baked broiler breasts from broilers that are fed DDGS.

With respect to consumer acceptability, there were minimal differences between treatments. No difference existed ($P > 0.05$) between treatments with respect to acceptability in regards to texture. These results are further substantiated by the shear force results that were previously reported in this study. In addition, the average texture acceptability scores were very high (like moderately) for both treatments. On average, consumers did have a slight preference ($P < 0.05$) for breast meat derived from broilers fed the control diet when

Table 4. Difference from control test and mean hedonic score for texture, flavor, and overall acceptance of chicken breast meat from broilers fed diets with or without distillers dried grains with solubles (DDGS)

Treatment	Difference from control[1]	Acceptability of texture[2]	Acceptability of flavor[2]	Overall acceptability[2]
Control (no DDGS)	1.3	7.1	7.0[a]	7.0[a]
8% DDGS	1.3	7.0	6.6[b]	6.7[b]
P-value	0.90	0.24	0.008	0.03
SEM	0.10	0.13	0.12	0.13

[a,b]Means with different letters are significantly different ($P < 0.05$).

[1]Difference from control test: 0 = no difference; 1 = slight difference; 2 = moderate difference; 3 = large difference; 4 = very large difference. Panelists were asked how different the control sample was in terms of flavor to the other samples.

[2]Hedonic scale was based on a 9-point scale: 1 = dislike extremely; 5 = neither like nor dislike; 9 = like extremely.

compared with the breast meat from broilers that were fed the DDGS diet with respect to flavor and overall acceptability. However, the numerical differences were minimal and were in the like moderately range (6.6 to 7.0) on the hedonic scale. These values are very close to those reported in other studies (Schilling et al., 2003; Battula et al., 2008). In addition, the majority of panelists liked both treatments, and the consumers that rated the samples the greatest (like moderately to like very much, 7.0 to 8.0) did not differ in their acceptability ratings of the samples. Because both treatments were liked by consumers and no differences existed between consumers who had high acceptability scores for treatments, feeding broilers DDGS at a concentration of 8% should have minimal effects on the sensory quality of baked chicken breast.

In conclusion, it is apparent from this research that inclusion of 8% DDGS in the diets of broilers has minimal effects on the quality of broiler breast and thigh meat from the resulting birds. Feeding diets containing up to 8% DDGS resulted in slight differences in consumer acceptability of breast meat but resulted in no differences in instrumental quality measurements. Further research should be conducted to determine if there are any flavor differences that can be identified between the control and DDGS-based treatments and if fatty acid composition can be made more similar between treatments by altering diet.

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