2011

The Effect of Corn Distillers Dried Grains With Solubles (DDGS) on Carcass Quality, Color Stability, and Sensory Characteristics of Pork

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Dietary distillers dried grain with soluble (DDGS) inclusion decreased saturated fatty acid and increased unsaturated fatty acid concentrations in fat samples from growing-finishing pigs. Concentration of dietary DDGS does not affect color, chemical composition, or sensory characteristics of pork.

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Summary

A study was conducted to evaluate the effect of feeding 0, 5, 10, or 15% distillers dried grains with solubles (DDGS) on carcass quality, color stability, and sensory characteristics of the longissimus muscle (LM) of finishing pigs. Two hundred forty pigs (61.7 lb) were assigned to 1 of 4 dietary treatments with varying concentrations of DDGS (0, 5, 10, and 15%). Live weight, hot carcass weight, and dressing percentage did not change in response to increased dietary DDGS (P = 0.491, 0.807, 0.316, respectively). After 7 days of retail display, yellowness changed due to DDGS inclusion (P = 0.016). No differences in shear force were observed (P = 0.06). Total polyunsaturated fatty acids increased and total saturated fatty acids decreased (P < 0.01, and 0.04, respectively) as dietary DDGS increased. Treatments did not differ in sensory characteristics (P > 0.10). The results of this investigation suggest that increasing dietary DDGS did not affect carcass quality as evaluated by color, chemical composition, and sensory characteristics of LM of finishing pigs. Increasing concentration of DDGS altered the backfat fatty acid profile of pigs by reducing

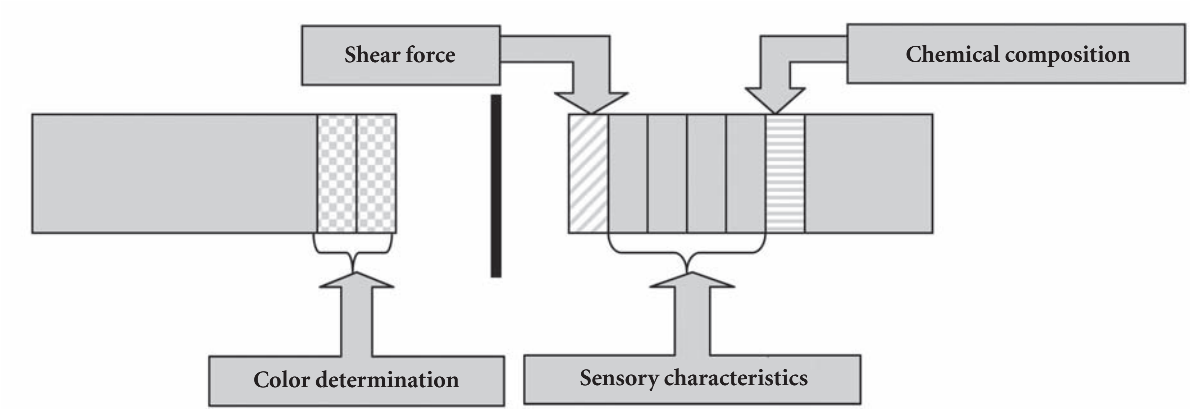

Figure 1. **Longissimus muscle sections of the loins used for shear force, color determination, sensory characteristics, and chemical analysis.**

saturated fatty acids and increasing unsaturated fatty acid concentration which may result in increased carcass softness.

Introduction

In recent years, an increased demand for ethanol from corn has resulted in the construction of several ethanol plants. Consequently, the amount of distillers dried grains with solubles (DDGS) available for animal feeding has also increased. Carcass quality is influenced by dietary ingredients, and evidence indicates that dietary inclusion of DDGS may result in reduced dressing percentage, as well as changes in the fatty acid profile of adipose tissue. Research evidence suggests that when dietary concentrations of DDGS greater than 20% are fed to growing-finishing pigs, the increment in unsaturated fatty acids in fat may result in increased iodine value, which may be an indication of increments in carcass softness. Additionally, changes in the fatty acid profile of carcass may result in changes in sensory characteristics such as color, flavor, and tenderness of pork.

This report is a companion article to a previous article in the *2009 Nebraska Swine Report* in which the feeding value of diets for growing-finishing pigs with increasing DDGS concentration was reported. The objective of this study was to evaluate the effects of feeding varying concentration of DDGS on carcass and sensory characteristics of pork.

Materials and Methods

Carcass Data Collection

Two hundred forty pigs weighing an average of 61.7 lb were assigned to 1 of 4 dietary treatments. Each treatment consisted of a standard diet in which a portion of dietary corn and soybean meal was replaced with 0, 5, 10, and 15% of DDGS. Diets were formulated in a SID lys basis and arranged in a 4-phase dietary growing-finishing regime. Details of the growth study are described in a companion article (*2009 Nebraska Swine Report*). At the end of the feeding phase, all pigs were transported to a commercial pork packing facility located approximately 145 miles from the University of Nebraska Swine Research Unit. Pigs were weighed before entering (live weigh; LW) and before leaving the harvesting floor (hot carcass weight; HCW). Dressing percentage (DP) was calculated using the following formula DP = ((LW / HCW) × 100). Before chilling, carcass 10th rib and LM depth were measured with a Fat-o-meater automated probe (SFK Technology AIS, Denmark), and LM area and lean percent were calculated. Iodine values were estimated using near-infrared spectroscopy at the packing plant. Carcasses were subjected to a standard spray-chilling procedure for 24 hours. Before entering the fabrication floor, two backfat samples were obtained (perpendicular to the 10th rib from the inner and outer layer), submerged in liquid nitrogen and maintained at -112^{o}F until analyzed for fatty acid profile. Two pigs from each pen were randomly selected prior to harvesting; carcasses were identified on the chilling floor, and the bone-in loin (410 pork loin; NAMP, 1997. The Meat Buyer Guide. North American Meat Processors Association. Reston, Va.) from the right side of the carcass was collected. The collected loins were transported to the Meat Science Laboratory at the University of Nebraska for further analysis. Seven days post-mortem the loins were boned and a section of LM (412B pork loin, boneless, center-cut, eight ribs; NAMP, 1997. The Meat Buyer Guide. North American Meat Processors Association. Reston, Va.). Nine 1-inch sections (Figure 1) were obtained and used for color determination, shear force estimation, sensory characteristics evaluation, and chemical composition.

Color Determination

The two sections of the LM used for color determination were packed in Styrofoam trays, wrapped with PVC film, and maintained at 34^{o}F under fluorescent light illumination for 7 days. Color spectrometry measurements L*, a*, and b* (representing lightness, redness, and yellowness, respectively) were obtained through the packing film on five sites on each section at the beginning (day 0) of the 7 day color experiment and daily thereafter using a Hunter Lab® Mini Scan XE plus (Model 45/0-L, Reston, Va.) handheld colorimeter. The

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calibration of the colorimeter was performed daily using black and white tiles. The change in total color (E) was calculated as [$((L^* \text{ at day } 10 - L^* \text{ at day } 0)^2 + (a^* \text{ at day } 10 - a^* \text{ at day } 0)^2 + (b^* \text{ at day } 10 - b^* \text{ at day } 0)^2)^{1/2}$; Minolta, 1998. Precise color communication-color control from perception from instrumentation. Minolta Corp., Ramsey, N.J.]. This formula was developed in order to better describe the changes in color that would occur during periods of retail display.

Warner-Bratzler Shear Force Analysis

The loin sections used for Warner-Bratzel shear force (American Meat Science Association. Research guidelines for cookery, sensory evaluation and tenderness measurements of meat. 1995) were vacuum-packed and maintained at -4°F until analysis. Before the analysis chops were allowed to thaw, cooked to an internal temperature of 158°F on a Hamilton Beach® grill (Washington, N.C.), and cooled for four hours at 35.6°F. During the cooking process temperature was monitored using thermocouples. Three cores of 0.5 in^2 from each section were removed parallel to the arrangement of the muscle fiber. Cores were sheared parallel to the muscle fiber using an Intron Universal Testing Machine (Model 55R1123, Canton, Mass.) equipped with a Warner-Bratzler shear attachment. The speed for the test was 250 mm/min.

Table 1. Attribute, magnitude, and description and scale of sensory characteristics.

	Magnitude		
Attribute	0 mm	150 mm	Comments
General appearance	Very non-uniform	Very uniform	Color of interior meat
Toughness	Very tough	Very tender	During the first bite
Chewiness	Very hard to breakdown	Very easy to breakdown	During chewing
Juiciness	Very dry	Very moist	
Pork flavor	Lacking	Intense	
Off-flavor	Lacking	Intense	
Aftertaste pork flavor	Lacking	Intense	
Overall acceptability	Very undesirable	Very desirable	

Fatty Acid Profile

Fatty acids concentration was measured in the backfat inner and outer layer of two pigs per pen. Fatty acids were extracted in hexane and methyl esters were formed. The mass ratios of fatty acids were quantified using a gas chromatograph (Hewlett-Packard, Model 5890, Farmington Hills, Mich.).

Sensory Evaluation

Chops were cooked and sensory evaluation was conducted using 70 consumer panelists, recruited from the Animal Science Department and the Department of Food Science and Technology at the University of Nebraska–Lincoln. The chops were cooked using an electric grill to an internal temperature of 158°F. Once cooked, chops were trimmed of excess fat. Samples

Table 2. Response and significance of dietary DDGS[a] inclusion on final weight and carcass characteristics of growing-finishing pigs.

	DDGS[a], %					*P*-value		
Item	0	5	10	15	SEM[b]	Treatment	Linear	Quadratic
No. of samples	54	54	59	52				
Live weight, lb	281.1	274.3	275.4	268.4	5.40	0.491	0.163	0.903
Hot carcass weight, lb	208.4	207.6	204.9	203.5	4.02	0.807	0.344	0.938
Dressing percentage, %	74.20	74.90	73.80	74.40	0.4	0.316	0.751	0.867
Percent lean, %	51.2	52.2	52.0	52.7	0.3	0.017	0.004	0.588
10th rib BF[c], in	0.92	0.81	0.85	0.79	0.022	0.003	0.002	0.245
LMA[d], in^2	7.06	7.13	6.99	7.05	0.178	0.955	0.843	0.975
Iodine value								
Jowl	73.52	73.58	73.47	74.04	0.477	0.825	0.507	0.596
Belly	65.98	66.72	65.30	65.30	0.809	0.562	0.351	0.647
Loin	68.16	68.31	66.32	68.33	0.624	0.044	0.906	0.063
Primal cuts[e], %								
Belly	16.05	15.00	15.70	14.30	0.90	0.434	0.184	0.930
Butt	8.30	8.50	8.70	9.20	0.40	0.498	0.149	0.679
Ham	23.88	23.50	24.80	23.50	0.90	0.661	0.931	0.567
Loin	22.00	21.50	23.20	21.70	0.70	0.313	0.825	0.463
Ribs	4.80	5.00	4.80	4.80	0.20	0.944	0.874	0.724
Picnic	11.20	11.50	11.20	11.30	0.40	0.937	0.932	0.849

[a]DDGS = Corn distillers dried grains with solubles.
[b]SEM = Standard error of the mean.
[c]BF = Backfat.
[d]LMA = Longissimus muscle area.
[e]Percentage of hot carcass weight.

Table 3. Response and significance of dietary DDGS[a] inclusion on color, shear force and chemical composition of the longissumus muscle of growing-finishing pigs.

	DDGS[a], %					*P*-value		
Item	0	5	10	15	SEM[b]	Treatment	Linear	Quadratic
No. of samples	13	11	12	11				
Composition, %								
Crude protein	23.12	23.47	23.48	23.53	0.21	0.17	0.06	0.27
Moisture	68.83	70.14	69.92	70.01	0.50	0.08	0.07	0.13
Ash	1.12	1.16	1.16	1.16	0.02	0.52	0.25	0.37
Fat	6.45	4.92	5.09	5.03	0.45	0.10	0.05	0.12
Shear force, lb	7.98	9.87	9.85	9.19	0.26	0.06	0.13	0.02
Color (day 0)								
a* (redness)	18.65	18.23	18.34	18.02	0.355	0.645	0.263	0.886
b* (yellowness)	15.77	14.91	14.84	14.71	0.297	0.061	0.018	0.212
L* (lightness)	50.01	49.45	49.45	49.32	0.614	0.861	0.455	0.727
Color (day 7)								
a* (redness)	14.34	14.76	13.95	13.37	0.588	0.552	0.163	0.388
b* (yellowness)	15.55	15.34	14.99	14.82	0.189	0.016	0.004	0.895
L* (lightness)	51.50	50.09	47.65	50.44	1.759	0.588	0.475	0.229
E[c]	4.97	3.78	7.26	5.10	1.454	0.367	0.553	0.737

[a]DDGS = Corn distillers dried grains with solubles.
[b]SEM = Standard error of the mean.
[c]E = Change in color.

of 1 in^2 were obtained and maintained warm until served to the panelists. A descriptive scale was used to determine the effect of DDGS inclusion on pork quality and flavor. Panelists used an unstructured line-scale to evaluate the attributes provided in Table 1.

Statistical Analysis

Carcass characteristics, chemical composition, fatty acid profile, and sensory characteristics were analyzed as a complete randomized design using the MIXED procedure (SAS Inst., Inc., Cary, N.C.). Each pig was considered an experimental unit and pen was considered a random effect. Color data were analyzed as repeated measures in time using the MIXED procedure; the pig was considered the experimental unit and the tray was considered a random effect.

Results and Discussion

Carcass traits are shown in Table 2. A positive linear response to DDGS concentration was detected for percent lean ($P = 0.004$), which indicates that percentage lean increased as dietary DDGS increased. Contrastingly, 10th rib backfat linearly decreased with increased dietary DDGS inclusion ($P = 0.002$). No changes were detected for live weight, hot carcass weight, and longissimus muscle area (LMA; P = 0.491, 0.807, and 0.995, respectively). Dressing percentage did not change in response to dietary DDGS inclusion ($P = 0.316$). These results agree with those of the similar study reported in the *2008 Nebraska Swine Report*; however, other studies have shown reductions in DP as dietary DDGS concentration increased. Iodine value of jowl and belly fat did not change in response to dietary DDGS inclusion ($P > 0.10$). No changes in primal cut percentage in response to DDGS inclusion were detected ($P > 0.10$).

The results of the chemical analysis and color of LM are provided in Table 3. Moisture and ash were not affected by dietary DDGS inclusion (P = 0.08, and 0.52, respectively). Protein concentration showed a trend to linearly increase in response to increasing dietary DDGS inclusion ($P = 0.06$). In contrast, fat concentration showed a trend to decrease in response to increased dietary DDGS inclusion ($P = 0.05$).

Shear force did not differ among treatments ($P = 0.06$). At days 0 and 7 there was no difference among treatments for redness (a*), yellowness (b*), lightness (L*), and color change (E). These results indicate that during the 7-day experimental period, sections of loins from pigs receiving increasing dietary concentration of DDGS showed a pattern in color and change of color (E) similar to those fed the control diet (0% DDGS).

Tables 4 and 5 show the fatty acid profiles of samples of inner and outer layers of backfat. For the inner layer, myristic, palmitic, palmitoleic, and oleic were not affected by dietary DDGS concentration ($P > 0.10$). Treatments affected stearic and linoleic concentrations (P = 0.01 and < 0.01, respectively). A linear reduction in stearic (18:0) was detected with increased dietary DDGS concentration ($P = 0.01$). In contrast a linear increase in linoleic (18:2) was recorded with increased dietary DDGS concentration ($P < 0.01$). Treatment affected the concentration of total saturated fatty acids ($P = 0.04$). A linear reduction in total saturated fatty acids mass

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Table 4. Response and significance of dietary DDGS[a] inclusion on fatty acid profile of the inner layer of backfat of finishing pigs.

	DDGS[a], %					*P*-value		
Item	0	5	10	15	SEM[b]	Treatment	Linear	Quadratic
No. of samples	12	12	12	12				
Inner layer fatty acid, mass %								
Myristic, (14:0)	1.39	1.31	1.33	1.39	0.42	0.29	0.93	0.06
Palmitic, (16:0)	23.87	23.10	22.72	22.94	0.43	0.23	0.10	0.23
Palmitoleic, (16:1)	2.39	2.21	2.24	2.48	0.10	0.25	0.52	0.05
Stearic, (18:0)	12.63	12.53	11.69	11.16	0.35	0.01	0.01	0.45
Oleic, (18:1)	42.79	43.01	42.25	41.43	0.49	0.11	0.03	0.27
Linoleic, (18:2)	9.95	11.74	12.59	13.77	0.49	<.01	<.01	0.51
α-linolenic, (18:3)	0.40	0.43	0.44	0.47	0.012	0.09	0.01	0.82
Others	6.54	6.64	6.74	6.39	0.43	0.24	0.75	0.50
Total saturated fatty acids	37.90	36.94	35.75	35.45	0.67	0.04	<.01	0.60
Total monounsaturated fatty acids	45.18	45.23	44.67	43.91	0.51	0.29	0.04	0.53
Total polyunsaturated fatty acids	10.36	12.17	13.05	14.25	0.51	<.01	<.01	0.53

[a]DDGS = Corn distillers grains with solubles.
[b]SEM = Standard error of the mean.

Table 5. Response and significance of dietary DDGS[a] inclusion on fatty acid profile of the outer layer of backfat of finishing pigs.

	DDGS[a], %					*P*-value		
Item	0	5	10	15	SEM[b]	Treatment	Linear	Quadratic
No. of samples	12	12	12	12				
Outer layer fatty acid, mass %								
Myristic, (14:0)	1.39	1.39	1.33	1.32	0.46	0.56	0.20	0.96
Palmitic, (16:0)	22.64	21.90	21.69	21.64	0.43	0.24	0.07	0.35
Palmitoleic, (16:1)	2.40	2.28	2.42	2.36	0.11	0.76	0.97	0.78
Stearic, (18:0)	11.54	11.38	10.25	10.41	0.42	0.07	0.01	0.69
Oleic, (18:1)	43.10	42.63	42.22	41.88	0.50	0.33	0.07	0.89
Linoleic, (18:2)	11.14	12.71	13.97	14.97	0.58	<.01	<.01	0.64
α-linolenic, (18:3)	0.45	0.48	0.49	0.52	0.02	0.17	0.03	0.99
Others	7.32	7.20	7.73	6.87	0.49	0.66	0.69	0.43
Total saturated fatty acids	35.56	34.67	33.20	33.76	0.77	0.09	0.01	0.46
Total monounsaturated fatty acids	45.51	44.97	44.65	44.24	0.55	0.37	0.09	0.85
Total polyunsaturated fatty acids	11.60	13.19	14.40	15.50	0.60	<.01	<.01	0.65

[a]DDGS = Corn distillers grains with solubles.
[b]SEM = Standard error of the mean.

Table 6. Response and effect of dietary DDGS[a] inclusion on sensory characteristics of longissumus muscle of growing-finishing pigs.

	DDGS[a], %					*P*-value		
Item	0	5	10	15	SEM[b]	Treatment	Linear	Quadratic
No. of samples	12	12	12	12				
Attribute[c], mm								
General appearance	85.01	82.99	96.76	88.48	4.04	0.08	0.18	0.43
Toughness	79.02	68.04	64.87	79.42	4.31	0.05	0.98	<.01
Chewiness	74.44	64.22	61.20	69.23	4.22	0.13	0.32	0.03
Juiciness	70.31	75.86	69.30	74.67	4.12	0.60	0.72	0.98
Pork flavor	87.55	86.20	82.35	81.17	3.60	0.54	0.15	0.98
Off-flavor	47.09	52.63	52.05	57.52	4.35	0.41	0.11	0.99
Aftertaste pork flavor	84.66	79.06	75.50	79.13	3.55	0.33	0.20	0.19
Overall acceptability	87.50	82.86	77.74	82.87	4.37	0.47	0.32	0.26

[a]DDGS = Corn distillers dried grains with solubles.
[b]SEM = Standard error of the mean.
[c]Attribute description provided in Table 1.

percentage resulted from the inclusion of increasing dietary DDGS concentration ($P < 0.01$). Despite the lack of treatment effect ($P = 0.29$), total monounsaturated fatty acids mass percentage linearly decreased in response to increased dietary DDGS ($P = 0.04$). Total polyunsaturated fatty acid mass % increased linearly in response to increased concentrations of dietary DDGS ($P < 0.01$)

The outer layer backfat mass percentage of myristic, palmitic, palmitoleic, oleic, and total monounsaturated fatty exhibited no response to treatment ($P > 0.05$). However, mass percentage of stearic linearly decreased with increasing DDGS inclusion in the diets ($P = 0.01$). Mass percentage of linoleic in the outer layer of backfat exhibited treatment response ($P < 0.01$) and linearly increased with increased dietary DDGS ($P < 0.01$). Despite the lack of treatment effect ($P = 0.09$), total saturated fatty acid mass percentage, linearly decreased with increased inclusion of dietary DDGS concentration ($P = 0.01$). In contrast total polyunsaturated fatty acids exhibited a positive linear response to inclusion of increasing dietary DDGS inclusion ($P < 0.01$).

Evidence reported in the literature indicates that the inclusion of unsaturated fatty acids in the diets of growing-finishing pigs results in a reduction in the content of saturated fatty acids in adipose tissue. The results of the present study support those findings. The inclusion of DDGS in the diets of growing-finishing pigs increases the concentration of dietary unsaturated fatty acids and in consequence increases concentrations of unsaturated in the adipose tissue. Interestingly, iodine value results determined at the packing plant do not support the fatty acid results.

The effects of DDGS inclusion on sensory characteristics of longissimus muscle of finishing pigs are provided in Table 6. The inclusion of increasing dietary concentration of DDGS had minimal effects on sensory characteristics evaluated in the present study. Dietary treatment allowed ($P < 0.05$) toughness, but this effect was not consistent with increasing dietary DDGS concentration.

Conclusions

These results suggest that the inclusion of increasing levels of DDGS in diets of finishing pigs from the UNL nutrition line did not affect carcass characteristics.

Increasing dietary concentration of DDGS did not change ash or moisture concentration; however, fat concentration was reduced and protein concentration showed a tendency to increase.

Dressing percentage, color, and sensory characteristics of the LM did not exhibit changes in response to the inclusion of dietary DDGS up to 15%.

The results of this investigation suggest dietary inclusion of DDGS may result in an increase in total unsaturated fatty acid and a decrease in total saturated fatty acid concentrations.

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