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Effects of Distillers Grains With Solubles (DDGS) and Paylean® Supplementation on Carcass Quality, Color Stability, and Sensory Characteristics of Pork

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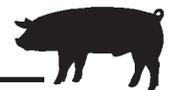
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Effects of Distillers Grains With Solubles (DDGS) and Paylean[®] Supplementation on Carcass Quality, Color Stability, and Sensory Characteristics of Pork

Withdrawing dietary DDGS four weeks prior to harvesting partially alleviated the reduced saturated and increased unsaturated fatty acid concentrations in fat observed due to DDGS feeding during growing and early finishing periods. Dietary inclusion or withdrawal of DDGS and RAC does not affect chemical composition and minimally affected sensory characteristics of pork.

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Summary

Forty pigs (66.6 lb) were used in a 14-week 4-phase regime study conducted to evaluate the effect of feeding varying concentrations of DDGS to growing-finishing pigs formulated on a standardized ileal digestibility (SID) lysine (lys) basis, DDGS withdrawal at the last feeding phase, and ractopamine (RAC) supplementation 4 weeks prior to harvesting on carcass quality, and color stability and sensory characteristics of longissimus muscle (LM) of finishing pigs. Treatments consisted in 0, 15, or 40% dietary DDGS inclusion supplemented with or without RAC (4.5 ppm) 4 weeks prior harvesting. Final body weight, hot carcass weight, and dressing percentage were not affected by dietary DDGS inclusion, withdrawal or RAC supplementation ($P > 0.10$). Color characteristics were not affected by dietary DDGS inclusion or withdrawal ($P > 0.10$); however, dietary RAC supplementation reduced a^* and b^* at days 0 and 7 ($P > 0.10$). Total polyunsaturated fatty (TPUFA) acids

increased and total saturated fatty acids (TSFA) were decreased in response to increased dietary DDGS inclusion ($P < 0.01$); however, DDGS withdrawal partially alleviated these changes in fatty acid composition by increasing TSFA and reducing TPUFA ($P < 0.01$). The inclusion of RAC decreased TSFA and increased total monounsaturated fatty acids concentration ($P = 0.03$ and 0.04 , respectively). Sensory characteristics were not affected by dietary RAC, DDGS inclusion or DDGS withdrawal ($P > 0.10$). The results of this investigation suggest that dietary RAC, DDGS inclusion or DDGS withdrawal did not affect carcass quality as evaluated by color, chemical composition, and sensory characteristics of LM of growing-finishing pigs. Increasing the concentration of dietary DDGS altered the fatty acid profile of backfat of pigs by decreasing saturated and increasing unsaturated fatty acids. However, withdrawing DDGS, 4 weeks prior to harvesting partially alleviated the increase in PUFA, and consequently the “soft pork” problems associated with the use of DDGS.

Introduction

Evidence available in the literature indicates that dietary DDGS inclusion greater than 30% can be used in diets for growing-finishing without negatively affecting growth performance; however, the effect of dietary inclusion

of DDGS may result in altered carcass characteristics and pork quality. Among the most important effects of dietary inclusion of DDGS on swine diets is the altered fatty acid profile of adipose tissue. Evidence indicates that inclusion of ractopamine (RAC) may affect carcass characteristics and pork quality especially by increasing protein and reduced fat deposition. Research has been conducted to reduce the changes in carcass characteristics originated by the dietary DDGS inclusion. Among other strategies, DDGS withdrawal during the late-finishing phase has been used to alleviate the negative effect of dietary DDGS inclusion on carcass characteristics. Ractopamine addition also may help to alleviate problems associated with the unsaturated fat content of DDGS by reducing fatty acid deposition. 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 varying DDGS concentration, DDGS withdrawal, and RAC inclusion was reported. The present report examines the effect of dietary DDGS concentrations of 15 and 40% and the interaction with the inclusion of RAC, DDGS withdrawal, or both during the last 4 weeks of the finishing period on carcass characteristics, color stability, and sensory characteristics of pork.

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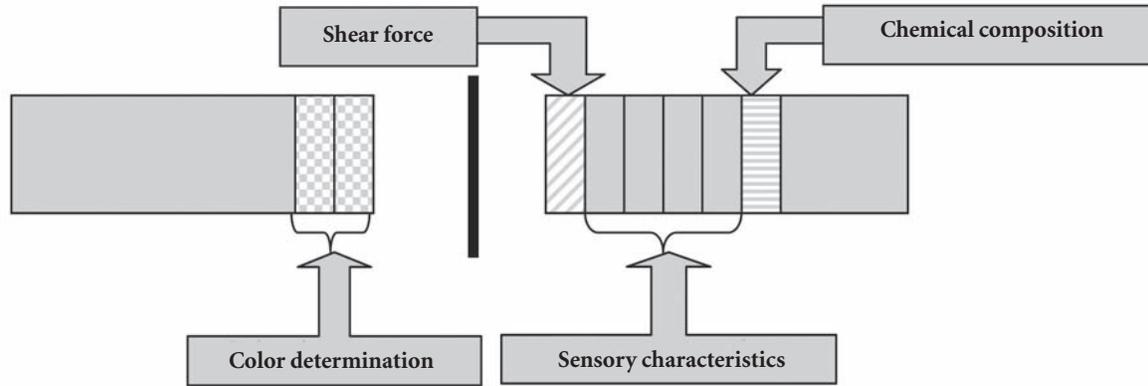
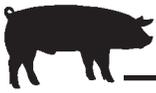


Figure 1. Longissimus muscle sections of the loins used for shear force, color determination, sensory characteristics, and chemical analysis.

Materials and Methods

Carcass Data Collection

Forty barrows (weighing an average of 66.6 lb at the beginning and 273.2 lb at the end of the feeding period) were assigned to 4 dietary regimens designed to provide DDGS inclusion of 0, 15 or 40% throughout the experiment or 40% dietary DDGS inclusion during the first 3 feeding phases and 0% dietary DDGS inclusion during the last feeding phase. Eight treatments were produced by randomly assigning pigs to 1 of 4 dietary treatments or their RAC-supplemented counterparts. 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 170 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 $DP = ((LW / HCW) \times 100)$.

Carcasses were subjected to a standard spray-chilling procedure for 24 hours. Before entering the fabrication floor, backfat samples were obtained (perpendicular to the 10th rib), submerged in liquid nitrogen and maintained at -112°F until analyzed for fatty acid profile. Carcasses were identified on the chilling floor, marked in the vertebrae, 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 individually vacuum packed and 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 longissimus muscle (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°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 calibration of the colorimeter was performed using black and white tiles. The change in total color (E) was calculated as $[(L^* \text{ at d } 10 - L^* \text{ at d } 0)^2$

$+ (a^* \text{ at d } 10 - a^* \text{ at d } 0)^2 + (b^* \text{ at d } 10 - b^* \text{ at d } 0)^2]^{1/2}$; 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-Bratzler 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 in² from each section were removed parallel to the arrangement of the muscle fiber. Cores were sheared parallel to the muscle fiber using an Instron Universal Testing Machine (Model 55R1123, Canton, Mass.) equipped with a Warner-Bratzler shear attachment. The speed for the test was 250 mm/min.

Fatty Acid Profile

Fatty acid concentration was measured in the backfat of all pigs. Fatty acids were extracted in hexane and methyl esters were formed. The

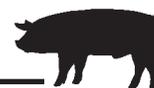


Table 1. Attribute, magnitude and description and scale of sensory characteristics.

Attribute	Magnitude		Comments
	0 mm	150 mm	
General appearance	Very nonuniform	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	

mass ratio of fatty acids were quantified using a gas chromatograph (Hewlett-Packard, Model 5890, Farmington Hills, Mich.).

Sensory Evaluation

Loin sections used for sensory evaluation were vacuum packed and maintained at -4°F until further analysis. Chops were thawed, cooked, and sensory evaluation was conducted using 38 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, and excess fat was trimmed. Samples of 1 in² were obtained and maintained warm until served to the panelists. Panelists used a descriptive 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. Contrasts were designed to evaluate linear and quadratic responses to dietary DDGS inclusion and withdrawal as well as RAC inclusion. For the color stability study, pig was considered the experimental unit and tray was considered a random effect.

Results and Discussion

Carcass traits are shown in Table 2. Treatment did not affect hot carcass weight ($P = 0.54$), similarly, no effects of RAC or DDGS withdrawal were detected ($P = 0.56$ and 0.29 , respectively). In contrast to results reported in the literature, DP was not affected by RAC inclusion ($P = 0.56$). In the present study, DP did not show a linear reduction in response to increasing

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Table 2. Response and effect of dietary distillers grains with soluble (DDGS) inclusion and ractopamine (RAC) on carcass characteristics and chemical composition of longissimus muscle of growing-finishing pigs.

Treatment	1	5	2	6	3	7	4	8	P-value					
	SEM ^c	Trt ^d	L ^e	Q ^f	RAC	W ^g								
DDGS, % for G1, G2, and F1 ^a	0	0	15	15	40	40	40	40	12.08	0.50	0.31	0.70	0.46	0.33
DDGS, % for F2 ^b	0	0	15	15	40	40	0	0						
RAC, ppm	0	4.5	0	4.5	0	4.5	0	4.5						
Item	5	5	5	5	5	5	5	5	SEM ^c	Trt ^d	L ^e	Q ^f	RAC	W ^g
No. of pigs	5	5	5	5	5	5	5	5						
Final BW, lb	272.52	272.9	289.7	306.4	271.2	271.8	279.5	287.3	12.08	0.50	0.31	0.70	0.46	0.33
Chemical composition, %														
Crude protein	21.61	22.49	21.97	22.35	21.38	21.63	21.37	21.98	0.50	0.57	0.56	0.71	0.12	0.71
Moisture	67.09	67.52	67.00	68.10	66.40	65.86	67.05	67.32	1.10	0.87	0.87	0.67	0.66	0.31
Ash	1.16	1.11	1.17	1.20	1.14	1.10	1.10	1.14	0.46	0.72	0.40	0.33	0.77	0.99
Fat	9.37	8.57	9.44	8.23	10.87	10.00	11.68	9.65	1.93	0.67	0.63	0.42	0.28	0.88
Carcass characteristics														
Hot carcass wt, lb	202.2	200.8	216.5	225.8	197.9	201.2	207.3	212.2	10.73	0.54	0.48	0.89	0.56	0.29
Dressing, %	74.15	73.51	74.66	73.74	72.88	73.94	74.08	73.81	0.53	0.48	0.12	0.21	0.61	0.32
10 th rib BF, cm	3.60	3.60	4.20	3.75	3.40	3.80	3.60	3.60	0.52	0.96	0.87	0.53	0.97	1.00

^aG1 = Grower 1; G2 = Grower 2; F1 = Finisher 1.

^bF2 = Finisher 2.

^cSEM = Standard error of the mean.

^dTRT = Treatment.

^eL = Linear.

^fQ = Quadratic.

^gW = Withdrawal ; W × RAC interaction, $P > 0.05$.

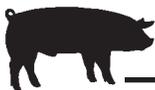


Table 3. Response and effect of dietary distillers grains with solubles (DDGS) inclusion and ractopamine (RAC) on color, and shear force longissimus muscle of growing-finishing pigs.

Treatment	1	5	2	6	3	7	4	8	P-value					
Item									SEM ^c	Trt ^d	L ^e	Q ^f	RAC	W ^g
DDGS, % for G1, G2, and F1 ^a	0	0	15	15	40	40	40	40						
DDGS, % for F2 ^b	0	0	15	15	40	40	0	0						
RAC, ppm	0	4.5	0	4.5	0	4.5	0	4.5						
No. of pigs	5	5	5	5	5	5	5	5						
Shear force, lb	9.70	10.18	9.26	9.26	9.61	11.02	7.49	9.56	1.19	0.54	0.52	0.39	0.20	0.10
Color (day 0)														
a* (redness)	10.08	9.85	9.96	8.17	10.28	8.52	9.58	8.79	0.67	0.16	0.29	0.29	0.01	0.71
b* (yellowness)	15.40	14.46	15.44	13.89	15.05	12.82	14.27	13.64	0.63	0.04	0.62	0.49	0.01	0.97
L* (lightness)	52.12	48.10	51.8	49.54	50.15	47.57	50.05	51.35	1.25	0.13	0.38	0.78	0.04	0.15
Color (day 7)														
a* (redness)	12.23	13.26	11.39	13.19	12.77	12.33	13.02	13.12	0.61	0.27	0.46	0.25	0.12	0.35
b* (yellowness)	15.20	14.92	14.69	14.37	14.90	13.18	14.42	14.90	0.64	0.34	0.75	0.79	0.02	0.29
L* (lightness)	54.77	50.56	54.72	50.96	53.40	49.90	53.39	53.24	1.39	0.05	0.17	0.30	0.01	0.19
E ^h	3.54	4.73	3.46	5.64	4.28	4.96	4.84	5.00	0.64	0.16	0.16	0.28	0.01	0.61

^aG1 = Grower1; G2 = Grower 2; F1 = Finisher 1.

^bF2 = Finisher 2.

^cSEM = Standard error of the mean.

^dTRT = Treatment.

^eL = Linear.

^fQ = Quadratic.

^gW = Withdrawal; W × RAC interaction, $P > 0.10$.

^hChange of color.

Table 4. Response and effect of dietary distillers dried grains with solubles (DDGS) inclusion and ractopamine (RAC) on fatty acid profile of backfat of growing-finishing pigs.

Treatment	1	5	2	6	3	7	4	8	P-value					
Item									SEM ^c	Trt ^d	L ^e	Q ^f	RAC	W ^g
DDGS, % for G1, G2, and F1 ^a	0	0	15	15	40	40	40	40						
DDGS, % for F2 ^b	0	0	15	15	40	40	0	0						
RAC, ppm	0	4.5	0	4.5	0	4.5	0	4.5						
No. of pigs	5	5	5	5	5	5	5	5						
Fatty acid, mass %														
Myristic, (14:0)	1.31	1.24	1.23	1.20	1.18	1.07	1.21	1.23	0.05	0.15	0.14	0.81	0.20	0.05
Palmitic, (16:0)	24.60	23.05	22.34	22.22	21.54	19.64	22.74	22.52	0.68	<.01	<.01	0.55	0.02	<.01
Palmitoleic, (16:1)	2.12	1.91	1.82	1.85	1.63	1.62	1.78	1.93	0.11	0.01	0.02	0.34	0.88	0.01
Stearic, (18:0)	13.97	13.21	12.36	12.03	11.39	9.92	13.14	12.15	0.81	0.01	0.01	0.72	0.07	<.01
Oleic, (18:1)	40.93	42.67	39.77	42.54	38.21	38.87	39.97	39.53	0.98	<.01	0.83	0.13	0.05	0.13
Linoleic, (18:2)	9.28	10.64	14.54	13.46	18.79	21.04	14.52	14.34	0.83	<.01	<.01	0.08	0.24	<.01
α-linolenic, (18:3)	0.36	0.45	0.50	0.47	0.52	0.61	0.46	0.50	0.03	<.01	<.01	0.19	0.02	<.01
Others	7.39	6.79	7.40	6.18	6.70	7.19	6.14	7.75	0.76	0.50	0.52	0.76	0.87	0.99
TSFA ^h	39.89	37.54	35.94	35.46	34.12	30.65	37.10	35.91	1.43	<.01	<.01	0.92	0.03	<.01
TMUFA ⁱ	43.05	44.59	41.59	44.40	39.84	40.49	41.76	41.47	0.96	<.01	0.60	0.10	0.04	0.07
TPUFA ^j	9.65	11.09	15.04	13.94	19.32	21.65	14.99	14.84	0.86	<.01	<.01	0.08	0.22	<.01

^aG1 = Grower1; G2 = Grower 2; F1 = Finisher 1.

^bF2 = Finisher 2.

^cSEM = Standard error of the mean.

^dTRT = Treatment.

^eL = Linear.

^fQ = Quadratic.

^gW = Withdrawal; W × RAC interaction, $P > 0.10$.

^hTotal saturated fatty acids.

ⁱTotal mono-unsaturated fatty acids.

^jTotal poly-unsaturated fatty acids.

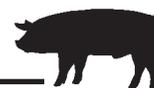


Table 5. Response and effect of dietary distillers dried grains with solubles (DDGS) inclusion and ractopamine (RAC) on sensory characteristics of longissimus muscle of growing-finishing pigs.

Treatment	1	5	2	6	3	7	4	8	P-value					
Item									SEM ^c	Trt ^d	L ^e	Q ^f	RAC	W ^g
DDGS, % for G1, G2, and F1 ^a	0	0	15	15	40	40	40	40						
DDGS, % for F2 ^b	0	0	15	15	40	40	0	0						
RAC, ppm	0	4.5	0	4.5	0	4.5	0	4.5						
No. of pigs	5	5	5	5	5	5	5	5						
Attribute ^h , mm														
General appearance	91.75	92.69	100.07	83.96	95.69	91.27	90.51	75.80	6.09	0.05	0.71	0.25	0.03	0.07
Chewiness	71.71	69.66	76.29	76.27	78.02	69.47	81.82	63.87	6.25	0.37	0.45	0.44	0.08	0.87
Toughness	78.56	74.78	81.5	78.32	74.81	70.57	88.95	68.71	6.04	0.21	0.56	0.56	0.04	0.30
Juiciness	63.01	66.41	66.13	66.91	68.62	61.81	65.55	72.72	6.43	0.92	0.50	0.89	0.79	0.51
Pork flavor	81.95	75.60	81.22	78.49	88.97	81.33	83.77	83.10	5.52	0.81	0.27	0.29	0.23	0.76
Off-flavor	59.84	57.95	59.49	54.90	55.09	46.95	47.14	54.45	6.00	0.58	0.51	0.34	0.64	0.96
After taste pork flavor	79.99	72.76	80.70	78.11	86.88	75.55	85.32	81.29	5.65	0.65	0.30	0.21	0.09	0.69
Overall acceptability	77.29	75.27	80.43	75.82	83.46	75.74	86.85	74.89	5.85	0.71	0.41	0.49	0.09	0.80

^aG1 = Grower1; G2 = Grower 2; F1 = Finisher 1.

^bF2 = Finisher 2.

^cSEM = Standard error of the mean.

^dTRT = Treatment.

^eL = Linear.

^fQ = Quadratic.

^gW = Withdrawal; W × RAC interaction, $P > 0.10$.

^hAttribute description provided in Table 1.

dietary DDGS inclusion ($P = 0.12$). No changes were detected in chemical composition of LM in response to dietary DDGS, RAC inclusion, or DDGS withdrawal ($P > 0.10$); however, numeric increase in LM protein concentration in response to RAC inclusion were observed ($P = 0.12$).

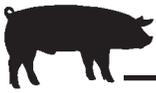
Shear force was not affected by dietary DDGS, RAC inclusion, or DDGS withdrawal ($P > 0.10$). Dietary DDGS did not change color characteristics of the LM on day 0 (Table 3; $P > 0.10$); however, the addition of RAC resulted in decreased a^* (redness; $P = 0.01$), and b^* (yellowness; $P = 0.01$), which agrees with data reported by other authors. In the present study, the inclusion of RAC also decreased L^* (lightness) in LM ($P = 0.04$). On day 7, RAC inclusion produced a reduction in b^* and L^* ($P = 0.02$ and 0.01 , respectively); however, a^* was not affected by RAC ($P = 0.12$).

The backfat fatty acid profile is presented in Table 4. The concentration of myristic acid did not change in

response to increased dietary DDGS inclusion ($P = 0.14$ and 0.81 for linear and quadratic responses, respectively). The withdrawal of DDGS increased the concentration of myristic acid ($P = 0.05$). Palmitic and stearic acids concentration in backfat linearly decreased with increased concentration of dietary DDGS ($P = 0.01$ and < 0.01 , respectively). Palmitic acid increased in response to DDGS withdrawal ($P < 0.01$); however, a reduction was detected for this fatty acid in response to RAC inclusion ($P = 0.02$). The withdrawal of DDGS resulted in increased stearic acid concentration ($P < 0.01$). Palmitoleic, oleic, and linoleic acids concentrations were affected by dietary treatment ($P < 0.05$). Palmitoleic showed a negative linear response to increased dietary DDGS inclusion ($P = 0.02$), and was not affected by the inclusion of RAC ($P = 0.88$). Withdrawing DDGS resulted in increased palmitoleic and reduced linoleic concentration ($P = 0.01$ and < 0.01 , respectively). The inclusion of increasing concentration of dietary DDGS

resulted in a linear increase in the concentration of α -linoleic acid ($P < 0.01$); similarly, the inclusion of RAC increased this fatty acid concentration in backfat ($P = 0.02$). In contrast, a reduction in α -linoleic concentration in response to DDGS withdrawal was detected ($P < 0.01$). Total saturated fatty acids concentration showed a negative linear response to increasing concentration of dietary DDGS ($P < 0.01$); similarly, the inclusion of RAC negatively affected TSFA concentration ($P = 0.03$). Increment in TSFA in response to DDGS withdrawal was detected ($P < 0.01$). Total monounsaturated fatty acid was unchanged by increasing concentration of dietary DDGS ($P = 0.60$), and increased in response to RAC inclusion ($P = 0.04$). Total polyunsaturated fatty acids concentration linearly increased in response to greater concentration of dietary DDGS ($P < 0.01$); in contrast, a reduction in TPUFA was detected in response to DDGS withdrawal ($P < 0.01$).

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Dietary DDGS did not alter the sensory characteristics of the LM (Table 5; $P > 0.10$). This is in agreement with results reported in similar studies. The inclusion of RAC resulted in increased toughness ($P = 0.04$) and a trend for increased chewiness ($P = 0.08$), which is in agreement with other studies in which the use of RAC resulted in reduced tenderness and increased chewiness. The inclusion of RAC also resulted in reduced scores for general appearance ($P = 0.03$) which is an indication of reduced uniformity in meat color. Despite the lack of treatment effect ($P = 0.65$), LM showed a tendency to have a reduced aftertaste pork flavor, and overall acceptability in response to RAC inclusion ($P = 0.09$). No effect of DDGS withdrawal was detected for any of the sensory characteristics evaluated in the present study ($P > 0.10$); however, the general appearance of the LM showed a tendency to be less uniform with DDGS withdrawal ($P = 0.07$).

Summary

The results of this investigation suggest that increasing dietary concentration of DDGS, ractopamine inclusion, or DDGS withdrawal did not affect carcass characteristics of growing-finishing pigs from the UNL Nutrition Line.

Sensory characteristics, color, and chemical composition of longissimus muscle did not change in response to increasing concentration of DDGS up to 40%, or DDGS withdrawal. The inclusion of RAC resulted in altered color characteristics of the longissimus muscle at days 0 and 7 of retail display.

The inclusion of RAC 4 weeks before harvesting did not alleviate the changes in fatty acid profile that resulted from the inclusion of DDGS in the diet of growing-finishing pigs.

The results of the present study suggest dietary inclusion of DDGS may result in an increase in TUSFA and a decrease in TSFA in backfat of growing-finishing pigs; however,

withdrawing DDGS during the last 4 weeks of the finishing period may partially reverse the changes in fatty acid profile that result from the inclusion of dietary DDGS up to 40%. The “soft pork” problems associated with changes in fatty acid profile due to dietary DDGS inclusion, may be partially resolved by withdrawing DDGS from the diet of finishing pigs 4 weeks prior harvesting.

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