

Title: Evaluation of the Pork Quality of Sows Fed Diets with different levels of Distillers Dried Grains –
NPB # 09-014 **revised**

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Industry Summary:

Distillers dried grains with solubles (DDGS) are potentially economical feed ingredients in the swine industry, especially in the Midwest. It is well known that DDGS quality varies between processing facilities, but within a plant the average protein and fat contribution are consistent and would be a good ingredient consideration in a non-ruminant diet, especially in the sow. Therefore, the overarching goal of this work was to determine if DDGS at 0, 15 or 30% inclusion during gestation and/or lactation altered sow performance and/or final products, namely bratwurst and breakfast links. The original three treatments (0, 15 or 30%) during gestation were further arranged during the lactation phase to include all possible combinations, i.e., 0, 15 or 30% for a total of 9 total treatments (3 diets during gestation x 3 diets during lactation).

In general, there appeared to be little effect on sow performance and/or piglet numbers regardless of diet fed. That is, no differences were observed in piglet litter size, litter weight gain or litter weight gain per day. There were no differences noted in sow feed intake during gestation and/or lactation between any of the different treatment combinations offered. It should be noted, that some feed intakes decreased in sows going

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from no DDGS to DDGS diets during the lactation phase, which is not surprising since the animals transition to a completely different diet type vs. what they were consuming during gestation. In terms of carcass quality, there were no differences in the relative amount of fat accumulated or deposited during the entire study. It was anticipated that the relative amount of unsaturated fatty acids would be higher in the sows fed DDGS. However, differences in iodine levels was small (~ 72's for DDGS sows vs. 69 in controls). Perhaps that aided in not seeing many differences in bratwurst and/or breakfast links. Across both bratwurst and breakfast links there was relatively little difference in preference of the actual product, i.e., eating experience wise. There were no differences noted in the breakfast links by the untrained panelist. However, the initial purchase or likelihood of purchase favored the control bratwurst, i.e., 58% agreement vs. the DDGS groups which was around 40% in the 15% added DDGS sows and in the 30% range for the 30% DDGS fed sows. This would indicate that initial “purchase” of bratwurst could be affected in bratwurst coming from DDGS fed sows in the way consumers see the product.

Keywords: cull sows, bratwurst, sausage, breakfast links, swine, survey

Scientific Abstract:

Cull sows (N=90, parity = 3+) were blocked by initial BW, breeding date and were assigned to 1 of 9 dietary treatments to assess the impact of feeding dried distillers grains with solubles (DDGS) during gestation and lactation on sow performance and carcass quality. A factorial arrangement created 9 dietary treatments: (1) 0% gestation diet, 0% lactation diet; (2) 0% gestation diet, 15% DDGS lactation diet; (3) 0% gestation diet, 30% DDGS lactation diet; (4) 15% DDGS gestation diet, 0% lactation diet; (5) 15% DDGS gestation diet, 15% DDGS lactation diet; (6) 15% DDGS gestation diet, 30% DDGS lactation diet; (7) 30% DDGS gestation diet, 0% lactation diet; (8) 30% DDGS gestation diet, 15% DDGS lactation diet; (9) 30% DDGS gestation diet, 30% DDGS lactation diet. Individual sow BW and backfat thickness were recorded initially (d 56 mid-gestation), d 0 of lactation, at weaning, and d 8 post-weaning. Individual sow's litter performance was recorded (number born, number born alive, number weaned, litter weaning weight and days of lactation) and litter size adjusted to

9 piglets by d 2 of lactation. Post-weaning, sows were transferred back to gestation crates for an 8 d drying period prior to slaughter. Sows were harvested 8 d following weaning at a commercial processing plant and samples of lean and fat were collected for fatty acid profiles. Bratwurst and breakfast links were prepared and assessed for quality, color, cooking characteristics and taste panel evaluation.

V. Introduction:

Diet plays a major role in determining body fat composition given that pigs can transfer dietary fat directly to fat depots. Direct transfer from diet to fat depots is well known and characterized in growing market pigs. Market pigs are actively “growing” and the fat depots closely resemble the diet. *The relationship between dietary fat intake and fat deposition is less well defined in the sow and may be quite different given the dramatic changes that occur during the life-cycle of the productive female.* The importance of carcass fat relates to ultimate fresh pork and process meat quality. Saturated fatty acids (C12:0 - C18:0) have a positive influence on “fat firmness” and cohesiveness, while monounsaturated fats (C16:1 and C18:1) and polyunsaturated fats (C18:2 and C18:3) have a negative effect. More specifically, pork fat that contains high levels of unsaturated fats is “soft” and is easily oxidized. In addition, soft fat is difficult to slice during further processed meat manufacturing. A direct measure of fat firmness is by determining the fatty acid profile and calculating a iodine value (IV) (Madsen et al., 1992) and is determined as follows: $IV = (\% C16:1 * .950) + (\% C18:1 * .860) + (\% C18:2 * 1.732) + (\% C18:3 * 2.616) + (\% C20:1 * .785) + (\% C22:1 * .723)$ (AOAC, 1998). Depending on the processor, an IV value over (70-75, the actual number varies and is set by individual processing plants according to their standards) indicates soft fat and in some countries (Switzerland) these animals are discounted. Indeed, adverse pork quality can be a consequence of feeding diets with supplemental fat that is high in PUFA (Gatlin et al., 2002).

Feeding diets high in corn oil from high oil corn hybrids to finishing pigs does increase the level of PUFA in tissues (Guo et al. 2007). The greater level of PUFA (especially 18:2n6) in the fat tissue of pigs from feeding high oil corn increased the TBARS values by 14% of cooked ground ham and reduced shelf-life of this product. Research has been conducted evaluating the impact of feeding high oil corn to market pigs. Feeding high oil corn

to market pigs resulted in increased concentrations of linoleic acid and decreased concentrations of saturated fatty acids in the fat tissues (Rentfrow et al., 2002; Guo et al., 2006.). This lead to fat tissues which were visually softer in the pigs fed high oil corn (Carroll et. al., 1999; Rentfrow et al., 2002). Ground pork from pigs fed diets containing high oil corn are more susceptible to oxidation (Guo et al., 2006). The impact of feeding diets with increased concentrations of polyunsaturated fatty acids may require the inclusion of increased concentration of vitamin E to maintain oxidative stability (Buckley et al., 1995; Guo et al., 2006).

Only one research study been conducted recently to evaluate the impact of dietary fatty acid profile of gestation diets on the fatty acid composition of sows (Bee, 2000). Sows fed a high linoleic acid diet from 7 to 97 d of displayed high levels of linoleic content in backfat (Bee, 2000). No trials have been conducted evaluating the impact of increasing the fat content (corn oil) of gestation diets on the fatty acid profile of the sows. Sows are fed just above maintenance during gestation, lose body fat during lactation and regain body fat when fed at higher levels post-weaning.

Sampling of groups of sows from various sources and sampling of sausage products from various suppliers has found substantial variation in the fatty acid content. Sources of sows with high IV values and high linoleic acid concentrations where contacted and found to be feeding higher concentrations of unsaturated fats during gestation and lactation. Source of the cull sows had a substantially greater impact on the fatty acid concentrations than carcass weight or backfat thickness. In a sampling of 14 brands of Bratwurst, Gordon et al. 2005, found linoleic concentrations ranged from 9.7 to 19.6 %, IV ranged from 53 to 71 and concentrations of 18:0 ranged from 9.9 to 19.9%. The results indicate that the fatty acid profiles of the fat tissue of cull sows is affected by the fatty acid profile of the diets fed and possibly to a greater extent with higher fat diets.

As stated previously, the investigators believe the level of linoleic acid is too high and is the major contributor to high IV values. From a diagnostic point of view, this is valuable because linoleic acid is not synthesized by the body and therefore, must be derived from dietary sources. Sows fed diets high in linoleic acid content deposit greater amounts of linoleic acid in the fat depots and therefore as mentioned earlier, the level of linoleic acid should be very high in the proposed DDGS feeding levels (15 & 30%).

Millions of tons of DDGS are going to become available to be used in swine industry. Little research has been conducted evaluating both the growth and carcass quality of sows fed DDGS. Published findings indicate that added DDGS increases carcass IV values of market pigs. The feeding of 20% DDGS also increase the IV values of the belly fat of the pigs relative to pigs fed diets supplemented with soybean oil (70.6 versus 66.8, $P < 0.05$, Whitney et al., 2006). Preliminary work in our laboratory suggests that 20% added DDGS will increase the IV value of pork carcass fat about 6 to 7 IV units in market pigs and possibly a greater amount in cull sows.

VI. Objectives:

- 1) Investigate the effects of Distiller's Dried Grains with solubles (DDGS) on cull sow carcass composition and quality.
- 2) Examine the effects of DDGS-fed pork on fresh- and cooked-sausage quality.
- 3) Determine the utility of a brief corn-soybean meal-based diet feeding regime post-weaning to effect carcass composition and quality of sows fed DDGS.

VII. Materials & Methods:

In this study, ninety sows (10/treatment) of similar BW and body composition (parity 3+) were used. A factorial arrangement of dietary treatments was used to create 9 dietary treatments. In the 9 treatments, three levels of DDGS (0, 15 or 30%) in the gestation diets were factorially arranged by (0, 15 or 30%) in the lactation diets as shown in Table 1.

Table 1. Arrangement of sows used in this experiment

Gestation	Lactation	Drying Period (8 d)
Control	control 15% DDGS 30% DDGS	return to gestation diet return to gestation diet return to gestation diet
15% DDGS	control 15% DDGS 30% DDGS	return to gestation diet return to gestation diet return to gestation diet
30% DDGS	control 15% DDGS 30% DDGS	return to gestation diet return to gestation diet return to gestation diet

The gestation diets were: (1) control, standard corn-soybean meal; (2) 15% DDGS diet and (3) 30% DDGS diet (Table 2). The lactation diets contained 0, 15 or 30% inclusion of DDGS (Table 3). The treatments were as followed: (1) control gestation diet, control lactation diet; (2) control gestation diet, 15% DDGS lactation diet; (3) control gestation diet, 30% DDGS lactation diet; (4) 15% DDGS gestation diet, control lactation diet; (5) 15% DDGS gestation diet, 15% DDGS lactation diet; (6) 15% DDGS gestation diet, 30% DDGS lactation diet; (7) 30% DDGS gestation diet, control lactation diet; (8) 30% DDGS gestation diet, 15% DDGS lactation diet; (9) 30% DDGS gestation diet, 30% DDGS lactation diet. There were three blocks of sows based on breeding date with 30 sows per block. The experiment was conducted in a commercial swine facility in central Indiana.

All gestation and lactation diets meet or exceed NRC (1998) nutrient requirements. To compensate for differences in energy density of the three gestation diets (without altering dietary fat contents), gestation diets were fed at slightly different intakes (2.10, 2.07 and 2.05 kg/d for 0, 15 and 30% DDGS, respectively) to ensure that similar energy intakes occurred across all gestation treatments. Lactation and post-weaning feed intakes were fed as near *ad libitum* as possible with multiple daily feedings.

Sow Performance

Individual sow feed intakes, BW and backfat thickness were recorded initially (d 56 mid-gestation), d 0 of lactation, at weaning, and d 8 post-weaning. Backfat thickness was measured at the 10th rib using a real-time ultrasound (Aloka 500, 12.5-cm and 3.5-MHz probe, Corometrics Medical Systems, Wallingford, CT 06492). Individual sow's litter performance was also recorded (number born, number born alive, number weaned, litter weaning weight and days of lactation) and all sows had litter size adjusted to a minimum of 9 piglets by d 2 of lactation. Average sow lactation length was 21 d. Post-weaning, sows were transferred back to gestation crates for an 8 d drying period prior to slaughter.

Carcass Processing

Sows (n=30) of each block were harvested 8 d following weaning at a commercial processing plant. Hot carcass weight of each sow was recorded. The dressing percentage, (DP) was determined using the formula $DP = (\text{Hot carcass weight} / \text{live weight}) * 100$. From each sow, approximately 7 lb of muscle (supraspinatus and infraspinatus) and 3 lbs of carcass fat (jowl and backfat) was collected and transported back to Purdue University Meat Laboratory. A 50-gram sub-sample of carcass fat (equal mixture) and a 200-gram sub-sample of muscle were collected from each carcass prior vacuum storage at -20°C.

Individual 7 lb muscle and 3 lb fat samples from each sow were combined by treatment to form a final muscle to fat ratio of 70:30. The muscle and fat sample were course ground through a 6 mm plate and divided into three 12 lb and two 5 lb vacuum packages per treatment were stored at -20°C for further processing.

Bratwurst Preparation

Bratwursts were prepared in the Purdue University Meat Laboratory. One 12 lb sample of ground pork per treatment was prepared into bratwurst each week for three weeks. Ground pork was again ground through a 4 mm plate and transferred to a mixer and mixed with water (10% by wt), lemon juice (0.3% by wt) and spice (Excalibur Seasoning, Pekin, IL 61554). The mixture was stuffed into 32 mm natural casings. Three links, each approximately 15.24 cm long, were packaged in 21.4 cm x 15.1 cm x 1.7 cm foam trays, overwrapped with an oxygen permeable PVC film (MAPAC M film, 23, 250 cc/m²/24h, 72 gauge, Resinite Packaging Films Border, Inc., North Andover, MA 01845). Bratwurst were compared fresh and cooked through an untrained taste panel, scored and examined for fatty acid content. A subset of bratwurst packages were placed into stimulated retail display cases.

Display Conditions

Bratwursts were displayed for 0, 5, 10 and 15 d at 2°C under continuous fluorescent lighting (Bulb model F32T8/ADV830/Alto, Philips, Bloomfield, NJ 07003) to simulate retail display at 37F. Temperature was monitored daily. Bratwurst (1 package/treatment) were taken out at each time point and analyzed for color.

Breakfast Link Preparation

Breakfast sausage links were prepared in the Purdue University Meat Laboratory. One 5 lb sample of ground pork per treatment was prepared into breakfast links each week for two weeks. Ground pork was again ground through a 3.18 mm plate and transferred to a mixer and mixed with Legg's Old Plantation Pork Sausage Seasoning (A.C. Legg Packing Co., Inc., Calera, AL 35040). The mixture was stuffed into 10 mm collagen casings. Two links, each approximately 3 inch long, were packaged in 21.4 cm x 15.1 cm x 1.7 cm foam trays, overwrapped with an oxygen permeable PVC film (MAPAC M film, 23, 250 cc/m²/24h, 72 gauge, Resinite Packaging Films Border, Inc., North Andover, MA 01845). Breakfast links were compared fresh and cooked through an untrained taste panel, scored and examined for fatty acid content.

Bratwurst & Breakfast Link Evaluation (Taste Panel Evaluation)

For quality scoring, untrained panel members (n=48 for bratwurst, n=24 for breakfast links) were determined by their purchasing and cooking habits regarding sausage products as shown in Table 4. The criteria to participate in the untrained panel included purchasers of the product that must also prepare and consume the product. Each untrained panel member evaluated fresh and cooked appearance of 4 treatments of bratwurst over the 3-week preparation periods and 6 treatments of breakfast links over the 2-week preparation periods. Each package was randomized and labeled by a number such that no panel member would know the identity of the samples. Survey panelists analyzed a package of fresh product from each treatment to determine the quality of the fresh product. The panel member then would prepare one sample per treatment to evaluate the cooking experience and appearance of the sausage product. Each panelist would consume a small portion but enough to form an opinion on the taste of the sausage product. They completed the prepared instrument as shown in Tables 4-7.

For scoring, panel members had to mark on a continuous line (the line was 88 mm in length, so members marked a hash on the relative scale) the level of acceptance; thereby allowing the panel member to

indicate any range of acceptance. A line marked close to the start signifies a low quality score, as opposed to a hash further to the right being of high quality. Panel members were unaware of how final outcomes would be assessed. After all scoring, the distance in mm was determined from point zero (poorest level) to the actual mark made by the panel member. The panel members were also asked to score how likely they would be to purchase the sausage product on a scale of 1 through 5, with 1 being of definitely would purchase and 5 being definitely would not purchase. Panel members were unaware of how final outcomes would be assessed.

Color Evaluation

Bratwurst color was examined by a hunter test which estimated the amount of relative whiteness in the samples on d 1 pre-freeze, 0, 5, 10 and 15 d post-freeze. Two bratwursts from each treatment were analyzed. Surface measurements were taken at the 1/6, 1/2 and 5/6 distance of the bratwurst. A single Internal reading was taken at the center of each link. Instrumental color was measured using a Hunter Lab Miniscan™ XE Plus Spectrophotometer (Model 45/0 LAV, 2.54-cmdiameter aperture, 10° standard observer, Illuminate A; Hunter Associated Laboratories Inc.; 23 Reston, VA). Color was reported as L* (lightness), a* (redness), b* (yellowness) values. Breakfast links were analyzed the same as the procedure above.

Cooking Loss

Bratwursts (n=3/trt) were weighed and measured prior to cooking and after a cooling period following cooking. Products were prepared on a gas grill and cooked to a final temperature of 71°C. Percentage cooking loss was calculated as $100 * (\text{initial bratwurst weight} - \text{cooked bratwurst weight}) / \text{initial bratwurst weight}$. Breakfast links (n=4/trt) were prepared on an electric stove in a skillet. The products were cooked and analyzed the same as the procedure above.

Fatty Acid Analysis (Extraction of Fatty Acids from Fat)

Approximately 400 mg samples of fat from equal parts of jowl and backfat were placed in 10 mm test tubes. Two mL of pure hexane was added to each test tube. Next, 0.1 mL of 2 N Methanolic KOH was added to each tube to produce fatty acid methylated esters (FAME). The FAME were analyzed for fatty acid composition as described by White et al. (2008). In brief, FAME were examined using gas chromatography

(GC using a Varian 3900 gas-110 liquid chromatograph equipped with an 8400 autosampler and wall coated open tubular fused silica 30 m × 0.32 mm capillary-channel polymer (CP) wax 52 chemically bonded column (Varion Inc., Palo Alto, CA 94301) using helium as a carrier gas (28 mL/min) and a flame-ionization detector. An initial oven temperature of 175°C was increased by 3°C/min until 240°C was reached. A volume of 5 µL of sample was injected into the chamber and mixed with helium at a 1:100 dilution rate and a PUFA-3 standard (Sigma-Aldrich, St. Louis, MO 63178) was used. Fatty acids were identified by comparing unknown peaked to known fatty acid standards.

Extraction of Fatty Acids from Lean

Lipids were extracted from 250 mg samples of freeze dried lean tissue using 7 mL HPLC grade methanol and 14 mL chloroform after tissue homogenization. The extraction procedure was catalyzed with 2 mL of 0.5 N sodium methoxide in methanol after being dissolved in 1 mL dry toluene. The FAME from the LM were analyzed using the same GC and autosampler as pervious described. Fatty acids were compared as described above.

Extraction of Fatty Acids from Bratwurst and Breakfast Links

Lipids were extracted from 250 mg samples of bratwurst and breakfast using 7 mL HPLC grade methanol and 14 mL chloroform after tissue homogenization. The extraction procedure was catalyzed with 2 mL of 0.5 N sodium methoxide in methanol after being dissolved in 1 mL dry toluene. The FAME from the LM were analyzed using the same gas chromatography and autosampler as pervious described. Fatty acids were compared as described above.

Relative fat firmness was evaluated by calculating the iodine value using the fatty acid profile of each sampling according to the following equation: $C_{16:1} (0.95) + C_{18:1} (0.86) + C_{18:2} (1.732) + C_{18:3} (2.616) + C_{20:1} (0.785) + C_{22:1} (0.723)$ (AOAC, 1998). The n6:n3 ratio for this experiment was calculated as $((18:2n_6 + 20:3n_6 + 20:4n_6) / (18:3n_3 + 20:5n_3 + 22:5n_3))$ (Gordon, 2005).

Statistical Analysis

The data were analyzed as a randomized complete block design with a factorial arrangement of treatments (3 x 3) with three levels of DDGS during gestation (0, 15 and 30%) and three levels of DDGS during lactation (0, 15 and 30%). The main effects of gestation diet and lactation diet and their interactions were evaluated using the GLM procedure of SAS (SAS® Inst. Inc., Cary, NC 27513). Least squares means for each measurement of interest were obtained.

Fresh and cooked bratwurst quality measurements (1-5) were assessed by Chi square. All continuous data were analyzed using the GLM procedure of SAS (SAS® Inst. Inc., Cary, NC 27513) for a factorial experiment where animals were arranged in a completely randomized design. Treatment effects were considered significant at $P < 0.05$ and statistical trends were noted at $P < 0.10$. To further delineate differences among treatments, means separation was performed using the Duncan's multiple range test at both $P < 0.05$ and 0.10 levels.

Table 2. Gestation diets containing dried distiller's grains with solubles (DDGS).

Product/Ingredient, %	Control	15% DDGS	30% DDGS
Corn	76.590	64.461	52.360
SBM, 48% CP	17.660	15.165	11.728
Fat – Animal (Lard)	1.100	0.950	0.763
Sow 6 Premix ^a	0.000	0.300	0.300
Sow Base 90 wo/A Premix ^b	4.500	0.000	0.000
Microsource Pak ^c	0.050	0.050	0.050
Nu Sound #1002 Premix ^d	0.050	0.050	0.050
United Mold Inhibitor	0.050	0.050	0.050
Dyna K – Pot. Chl.	0.000	0.552	0.552
Limestone	0.000	1.281	1.436
Salt	0.000	0.450	0.450
Choline Chloride, 60%	0.000	0.127	0.127
Mono-Calcium Phosphate, 21% P	0.000	1.590	1.184
Phytase ^f	0.000	0.013	0.013
DDGS	0.000	15.000	30.000
<u>Nutrient Summary</u>			
ME, Kcal/kg	3307.66	3307.50	3307.55
Crude Fat, %	4.64	5.63	6.63
Crude Fiber, %	2.08	2.65	3.19
Crude Protein, %	14.75	16.75	18.75
Lysine, Total, %	0.72	0.76	0.80
Lysine, Dig, %	0.62	0.62	0.62
Calcium, %	0.88	0.88	0.88
Phosphorus, %	0.74	0.73	0.72
P, Available, %	0.57	0.57	0.57
Phytase, added, FTU/kg	250.60	250.60	250.60
Dig Lys:ME Ratio	1.87	1.87	1.87
M+C, Dig, %	0.47	0.52	0.58
Thr, Dig, %	0.47	0.51	0.55
Trp, Dig, %	0.14	0.15	0.16
Lle, Dig, %	0.53	0.57	0.62
Val, Dig, %	0.61	0.67	0.73

Table 3. Lactation Diets containing Dried Distiller's Grains with Solubles (DDGS).

Product/Ingredient, %	Control	15% DDGS	30% DDGS
Corn	56.834	44.714	32.626
SBM, 48% CP	37.017	34.521	32.022
Fat – Animal (Lard)	1.000	0.850	0.650
Sow 6 Premix ^a	0.000	0.300	0.300
Sow Base 90 wo/A Premix ^b	4.500	0.000	0.000
Microsource Pak ^c	0.050	0.050	0.050
Nu Sound #1002 Premix ^d	0.050	0.050	0.050
Epsom Pak Premix ^e	0.500	0.500	0.500
United Mold Inhibitor	0.050	0.050	0.050
Dyna K – Pot. Chl.	0.000	0.552	0.552
Limestone – Bulk	0.000	1.286	1.442
Salt – Bulk	0.000	0.450	0.450
Choline Chloride 60%	0.000	0.127	0.127
Mono-Calcium Phosphate, 21% P	0.000	1.540	1.170
Phytase ^f	0.000	0.013	0.013
DDGS	0.000	15.000	30.000
<u>Nutrient Summary</u>			
ME, Kcal/kg	3277.03	3277.19	3276.66
Crude Fat, %	7.46	8.45	9.45
Crude Fiber, %	2.33	2.89	3.43
Crude Protein, %	22.12	24.12	26.12
Lysine, Total, %	1.26	1.30	1.34
Lysine, Dig, %	1.11	1.11	1.11
Calcium, %	0.94	0.94	0.94
Phosphorus, %	0.81	0.8	0.79
P, Available, %	0.59	0.59	0.59
Phytase, added, FTU/kg	250.60	250.60	250.60
Dig Lys:ME Ratio	3.23	3.23	3.23
M+C, Dig, %	0.63	0.70	0.75
Thr, Dig, %	0.72	0.77	0.80
Trp, Dig, %	0.24	0.26	0.26
Lle, Dig, %	0.84	0.89	0.93
Val, Dig, %	0.92	0.99	1.04

Table 4. Panelist Initial Survey

Hello, this is Mickey A. Latour from Purdue University, phone 765-494-8011. The purpose of this survey is to identify potential clients for a Breakfast Link study. This is a voluntary survey and you must be at least 18 years of age to participate. At the end of this survey (should be completed in 5 minutes), you are interested in participating, please fill out below and send back to Mickey Latour. The information sent back to M. Latour will be stored in a confidential folder in his office.

Mark (X) the answers which best apply.

1. Record gender:

Female	<input type="checkbox"/>
Male	<input type="checkbox"/>

2. Age

20 or younger	<input type="checkbox"/>
21-29	<input type="checkbox"/>
30-39	<input type="checkbox"/>
40-49	<input type="checkbox"/>
50-59	<input type="checkbox"/>
60+	<input type="checkbox"/>
REFUSED	<input type="checkbox"/>

3. Which of the following best describes your role in your household for purchasing groceries?

I am the primary purchaser	<input type="checkbox"/>
I share purchasing equally with someone else	<input type="checkbox"/>
I do not assist in purchasing of groceries.	<input type="checkbox"/>

4. How many times within the past 6 months have you purchased breakfast links?

Once over the past 6 months	<input type="checkbox"/>
Once every other month	<input type="checkbox"/>
Twice over the past 3 months	<input type="checkbox"/>
Once every month	<input type="checkbox"/>
More than once every month	<input type="checkbox"/>
Once over the past year	<input type="checkbox"/>

5. Who in your family eats the breakfast links that you buy? (*CHECK ALL THAT APPLY*)

You, yourself	<input type="checkbox"/>
Another adult	<input type="checkbox"/>
A child less than 17	<input type="checkbox"/>

6. Which statement would best describe your breakfast links purchase? (You may choose more than one answer and if so, please rank them, 1=top preference and so forth).

- a) Price
- b) Purchase on known cooking characteristics (good experience for example).
- c) Purchase breakfast links based on known taste characteristics.
- d) Purchase breakfast links primarily on initial appearance in the package.

e) Purchase on brand loyalty

f) Other describe _____

7. What is your preferred way to cook breakfast links?

a. Skillet

b. Microwave

c. Oven/broil

d. Other _____ state it here

If you would like to participate in a breakfast links cooking study at Purdue, please fill this out and mail it to: Mickey Latour, Purdue University, 901W State Street, West Lafayette, IN 47907 or email the information at mlatour@purdue.edu

Table 5. Bratwurst Survey Instrument.

Fresh (RAW) Bratwurst Scoring Sheet

Mark Package ID _____

Assigned ID Number to you _____

Step 1: Open the package and remove one of the bratwurst and answer the questions below. The others can be used at your discretion.

Step 2: Please indicate how much you agree or disagree with each statement. Please just make a hash mark along the continuous line as your answer. For example, I have included a question below indicating my response as it relates to the weather.

Step 3: Mark your response on raw bratwurst.

Step 4: Look at the bratwurst and answer the following questions.

1. What, if anything, do you specifically **LIKE** about the appearance of the bratwurst? (WRITE IN ANSWER)
2. What, if anything, do you specifically **DISLIKE** about the appearance of the bratwurst? (WRITE IN ANSWER)
3. How likely would you be to **BUY** this bratwurst if it were available for a reasonable price at a store where you normally shop? (CHECK ONE ANSWER ONLY)
Definitely would purchase _____
Probably would purchase _____
Might or might not purchase _____
Probably would not purchase _____
Definitely would not purchase _____

Cooked Bratwurst Scoring Sheet

Step 5:

1. You will be given disposable plates (one set is for you to bring bratwurst to the cooking station [be sure to discard these plates after cooking begins] and the second set is for you to bring the cooked bratwurst back into your home for evaluation, so they are organized).
2. Cook the bratwurst to your accepted level of finish. Included in your package are some food safety tips for handling pork.
3. When the bratwurst is done, remove it and answer the following **before consuming**.
4. How did you cook the bratwurst? A) gas grill b) Charcoal Grill c) broil d) pan e)other _____ (circle or mark the correct answer)

Please answer the following questions about the cooked bratwurst. Use the same relative hash mark scale as in the previous page.

Lowest ranking

Highest Ranking

FINAL STEP: When you are finished with all four samples, please put all the evaluations in the envelope and mail Monday.

Table 7. Breakfast Link Survey Instrument.

Fresh Breakfast links Scoring Sheet

Mark Package ID _____

Assigned ID Number to you _____

Step 1: Please open the package and remove both breakfast links then answer the questions below.

Step 2: Please indicate how much you agree or disagree that each statement below. The zero implies there was no evidence of an issue. If you score a question as zero, circle it and if not, mark a hash line on the relative scale from lowest to highest.

Step 3: Mark your response on raw breakfast links.

Step 4: Please look at the breakfast links and answer the following questions. (WRITE IN ANSWER)

1. What, if anything, do you specifically **LIKE** about the appearance of the breakfast links?
2. What, if anything, do you specifically **DISLIKE** about the appearance of the breakfast links?
3. How likely would you be to **BUY** these breakfast links if they were available for a reasonable price at a store where you normally shop? (CHECK ONE ANSWER ONLY)
 - Definitely would purchase _____
 - Probably would purchase _____
 - Might or might not purchase _____
 - Probably would not purchase _____
 - Definitely would not purchase _____

Cooked Breakfast link Scoring Sheet

Step 5: In this section, you are to complete the following.

5. Cook the breakfast link to your accepted level of finish. Included on your package are some food safety tips for handling pork.
6. When the breakfast link is done, remove it and place it on the disposable plate provided (one plate for each treatment).
7. **Before consuming**, please answer the following questions about the cooked breakfast link. The zero implies there was no evidence of an issue. If you score a question as zero, circle it and if not, mark a hash line on the relative scale from lowest to highest.

Lowest raking

Highest Ranking

VIII. Results: Report your research results by objective.

Objectives:

- 1) Investigate the effects of Distiller's Dried Grains with solubles (DDGS) on cull sow carcass composition and quality.

In this study, there were no differences in Day 0 or 58 sow BW (Table 8). However, there was a trend for weaning weights to be lighter in the 30% DDGS sows compared to the other two treatments (Table 8). Additionally, there was no difference in sow backfat thickness or change in relative backfat during the experiment (Table 9). At harvest, there was no difference in 8 d post weaning weight, but there was a trend towards a decrease in hot carcass weight of sows given 30% DDGS compared to the other two treatments (Table 10).

The composition of backfat did differ by treatment. Overall, the level of unsaturation increased in both DDGS treatments above control sows (Table 11). More specifically, the levels of 18:2n6, iodine value, and ratio of n6:n3 fatty acids were higher in DDGS sows compared to controls (Table 11). Conversely, the level of C16:0 and relative ratio of saturated:unsaturated fatty acids were lower in DDGS sows compared to controls (Table 11).

- 2) Examine the effects of DDGS-fed pork on fresh- and cooked-sausage quality.

Overall, there were small differences in both fresh and cook bratwurst quality characteristics (tables 12 and 13). When examining the gestation by lactation interaction, there was a significant ($P 0.03$) in off odor, suggesting the odor was higher in controls compared to the DDGS derived bratwurst (Table 12). Also, a trend appeared in fatty bratwurst appearance in the 30 by 30% DDGS derived bratwurst, Question 6 of Table 12. In cooked bratwurst, there were no differences noted in final quality as scored by untrained panelist (Table 13). In terms of juiciness, bratwurst from the DDGS treated sows tended to be higher compared to controls (Table 14). In terms of purchasing bratwurst on appearance, these data would strongly suggest the bratwurst derived from control animal (0 DDGS during gestation and to some degree DDGS during lactation) were preferred by panelist as shown in Table 15. That is, the level of purchase as indicated "probably would purchase" was

much higher in control sows receiving no DDGS during lactation and sows consuming 15% DDGS during lactation compared to the sows consuming 30% DDGS during lactation (Table 15). Likewise, when panelist were asked about their preference on a bun, the bratwurst derived from control sows were highest (58% preference) compared to 40% range in bratwurst originating from sows given 15% DDGS during lactation and finally in the 30% range from sows given 30% DDGS during the lactation period (Table 16). Panelist also suggested (strongly agree, ~ 26%) they would be willing to pay more for bratwurst from control sows compared DDGS fed sows during lactation (Table 17). It should be noted the bratwurst coming from sows given 30% DDGS during lactation and 30% DDGS during gestation had agreement at 24% (Table 17). In this study, there were no differences noted by panelist in fresh and/or cooked breakfast links acceptability (tables 18-20). The internal color appearance of bratwurst overtime (at freezing and out to 15 days) differed in L*, a* and b* mostly by gestation diet (Table 21). At Day 5, the L* value favored control followed by both DDGS groups and conversely, the b* value increased in increasing levels of DDGS treatments compared to control (Table 21). The composition of bratwurst and breakfast links are shown in Table 22. As demonstrated in the fat, the iodine value increases with added levels of DDGS and ratio of saturated:unsaturated fatty acids goes down (Table 22).

- 3) Determine the utility of a brief corn-soybean meal-based diet feeding regime post-weaning to effect carcass composition and quality of sows fed DDGS.

The majority of these effects were discussed in Objective 1 on the relatively little changes in sow performance. The utility of DDGS will be discussed in the next section.

Table 8. The effects of feeding dried distillers grains with solubles (DDGS) during gestation and lactation on sow body weight and weight change.

Gestation Diet ¹	Lactation Diet ²	Sow BW, lb				Sow BW Chg, lb		
		Day 0 ³	Day 58 ⁴	Pre-farrow	Weaning	Early Gestation ⁵	Late Gestation ⁶	Lactation ⁷
0	0	493.8±18.04	496.0±14.93	576.1±16.20	514.0±13.24 ^{a,b}	-3.7±18.30	80.1±8.90 ^a	-62.1±12.29
	15	529.2±19.76	516.8±14.93	568.8±16.20	538.0±13.24 ^a	-37.2±20.05	52.0±8.90 ^{a,b,c}	-30.8±12.29
	30	490.8±19.76	475.1±15.73	524.3±16.20	493.9±13.24 ^{a,b}	-48.5±22.42	42.4±9.39 ^c	-30.4±12.29
15	0	493.1±15.62	492.3±14.93	547.8±16.20	518.7±13.24 ^{a,b}	-14.8±15.85	±55.5±8.90 ^{a,c}	-29.1±12.29
	15	540.3±25.51	501.0±14.93	552.1±16.20	532.7±13.24 ^{a,b}	-46.3±25.88	51.1±8.90 ^{a,b,c}	-19.4±12.29
	30	471.6±15.62	468.2±14.93	541.4±16.20	488.2±13.24 ^b	-6.8±15.85	73.2±8.90 ^{a,b}	-53.2±12.29
30	0	504.4±16.70	493.1±15.73	557.8±17.07	531.4±14.81 ^{a,b}	-10.6±16.95	64.7±9.38 ^{a,b,c}	-31.9±13.74
	15	507.0±14.73	508.6±14.93	573.2±16.20	530.1±13.24 ^{a,b}	6.6±14.94	64.6±8.90 ^{a,b,c}	-43.1±12.29
	30	470.6±14.73	485.8±14.93	559.4±16.20	513.0±13.24 ^{a,b}	18.6±14.94	73.6±8.90 ^{a,b}	-46.4±12.29
Main Effect of Diet Probability, P<		0.297	0.678	0.587	0.090	0.293	0.071	0.228

^{a,b,c} Numbers in the same column with different superscripts differ by P < 0.05 based on means separation using the Duncan's multiple range test.

¹ Percent of dried distillers grains with soluble (DDGS) in the gestation diet.

² Percent of dried distillers grains with soluble (DDGS) in the lactation diet.

³ Day 0 of gestation.

⁴ Day 58 of gestation.

⁵ The difference in sow weight from day 0 to day 58 of gestation.

⁶ The difference in sow weight from day 58 of gestation to day of farrowing.

⁷ The difference in sow weight from day 0 of lactation to weaning.

Table 9. The effects of feeding dried distillers grains with solubles (DDGS) during gestation and lactation on sow 10th rib backfat thickness and backfat change.

Gestation Diet ¹	Lactation Diet ²	Sow Backfat, in				Sow Backfat Chg., in		
		Day 58 ³	Pre-farrow	Weaning	Day 8 post-wean	Gestation ⁴	Lactation ⁵	Post-wean ⁶
0	0	0.3±0.02	0.3±0.01	0.3±0.02	0.4±0.02	0.04±0.020	-0.00±0.022	0.09±0.031
	15	0.3±0.02	0.3±0.01	0.3±0.02	0.4±0.02	0.03±0.020	0.01±0.022	0.09±0.031
	30	0.3±0.02	0.3±0.01	0.3±0.02	0.4±0.02	0.05±0.020	0.02±0.022	0.03±0.031
15	0	0.3±0.02	0.3±0.01	0.3±0.02	0.4±0.02	-0.01±0.020	-0.01±0.022	0.09±0.031
	15	0.3±0.02	0.3±0.01	0.3±0.02	0.3±0.02	0.00±0.020	0.03±0.022	0.01±0.031
	30	0.3±0.02	0.3±0.01	0.3±0.02	0.4±0.02	0.01±0.020	0.05±0.022	0.04±0.031
30	0	0.3±0.02	0.3±0.01	0.3±0.02	0.4±0.02	-0.02±0.021	0.00±0.023	0.08±0.033
	15	0.3±0.02	0.3±0.01	0.3±0.02	0.4±0.02	0.01±0.020	0.01±0.022	0.05±0.031
	30	0.3±0.02	0.3±0.01	0.3±0.02	0.4±0.02	0.01±0.020	-0.02±0.022	0.11±0.031
Main Effect of Diet Probability, P<		0.517	0.753	0.655	0.511	0.382	0.694	0.435

¹ Percent of dried distillers grains with soluble (DDGS) in the gestation diet.

² Percent of dried distillers grains with soluble (DDGS) in the lactation diet.

³ Day 58 of gestation.

⁴ The difference in sow backfat from day 58 of gestation to day of farrowing

⁵ The difference in sow backfat from day 0 of lactation to weaning

⁶ The difference in sow backfat from weaning to day 8 post-wean.

Table 10. The effects of feeding dried distillers grains with solubles (DDGS) during gestation and lactation on cull sow slaughter weight and carcass yield.

Gestation Diet ¹	Lactation Diet ²	Sow Wt., lb		Sow Weight Chg., lb ⁴	Carcass Yield, %
		Day 8 post-wean ³	Hot Carcass Weight		
0	0	476.4±12.77	305.7±9.13 ^{a,b,c}	-37.6±5.53	64.1±0.64 ^{a,b}
	15	493.1±12.77	323.3±9.13 ^a	-44.9±5.53	65.5±0.64 ^a
	30	455.0±12.77	288.3±9.13 ^{b,c}	-38.9±5.53	63.4±0.64 ^b
15	0	464.4±12.77	301.0±9.13 ^{a,b,c}	-54.3±5.53	64.8±0.64 ^{a,b}
	15	493.6±12.77	313.3±9.13 ^{a,b}	-39.1±5.53	63.6±0.64 ^{a,b}
	30	448.1±12.77	280.8±9.13 ^c	-40.1±5.53	62.6±0.64 ^b
30	0	480.1±13.46	307.7±10.21 ^{a,b,c}	-47.9±6.18	63.5±0.72 ^{a,b}
	15	492.6±12.77	315.6±9.13 ^{a,b}	-37.5±5.53	64.1±0.64 ^{a,b}
	30	474.9±12.77	298.6±9.13 ^{a,b,c}	-38.1±5.53	62.9±0.64 ^b
Main Effect of Diet Probability, P<		0.213	0.088	0.125	0.074

^{a-c} Numbers in the same column with different superscripts differ by P < 0.05 based on means separation using the Duncan's multiple range test.

¹ Percent of dried distillers grains with soluble (DDGS) in the gestation diet.

² Percent of dried distillers grains with soluble (DDGS) in the lactation diet.

³ Day 8 post-wean is the day all sows were transported to the sow slaughter facility. Sows were weighed prior to loading for transport.

⁴ The difference in sow weight change from weaning to day 8 post-wean.

Table 11. The main effects of feeding dried distillers grains with soluble (DDGS) during gestation on cull sow backfat fatty acid profiles.

¹ Iodine Values calculated as follows: IV= (%16:1 * 0.950) + (%18:1 * 0.860) + (%18:2 * 1.732) + (%18:3 * 2.616) + (%C20:1 * 0.723); AOAC, 1990. ² Saturated to unsaturated fatty acid ratio calculated as follows: (14:0 + 16:0 + 18:0 + 24:0) / (16:1n7 + 16:2n4 + 16:3n4 + 18:1n9 + 18:1n7 + 18:2n6 + 18:3n4 + 18:3n3 + 18:2n9,11 + 18:2n10,12 + 20:1n9 + 20:4n6 + 20:5n3 + 22:1 + 22:4n6 + 22:5n3). ³ Ratio of n-6 to n-3 calculated as follows: (18:2n6 + 20:4n6 + 22:4n6) / (18:4n3 + 18:3n3 + 20:5n3 + 22:5n3); Gordon et al., 2005.

Gestation DDGS, %	0	15	30	Probability, P<		
				DDGS	Linear	Quadratic
<u>Fatty acid, %</u>						
C14:0	1.17±0.02	1.08±0.02	1.05±0.02	0.0003	0.0001	0.287
C16:0	20.11±0.29	18.58±0.29	18.52±0.30	0.0002	0.0003	0.044
C16:1n7	1.88±0.05	1.71±0.05	1.76±0.05	0.067	0.105	0.096
C16:2n4	0.26±0.01	0.29±0.01	0.28±0.01	0.113	0.155	0.127
C16:3n4	0.20±0.01	0.21±0.01	0.20±0.01	0.699	0.761	0.429
C18:0	10.91±0.34	9.95±0.34	9.61±0.35	0.025	0.009	0.463
C18:1n9	37.51±0.43	35.68±0.43	36.19±0.43	0.010	0.033	0.028
C18:1n7	2.91±0.08	2.79±0.08	2.84±0.08	0.554	0.500	0.399
C18:2n6	17.45±0.40	20.27±0.40	20.16±0.41	<.0001	<.0001	0.004
C18:3n4	0.04±0.004	0.04±0.004	0.04±0.005	0.957	0.776	0.939
C18:3n3	0.580±0.02	0.67±0.02	0.61±0.02	0.014	0.345	0.006
C18:4n3	0.31±0.01	0.30±0.01	0.29±0.01	0.791	0.495	0.985
C18:2n 9,11	0.14±0.01	0.15±0.01	0.14±0.01	0.770	0.812	0.497
C18:2n 10,12	0.01±0.004	0.02±0.004	0.01±0.004	0.514	0.530	0.331
C20:1n9	1.24±0.04	1.19±0.04	1.23±0.04	0.648	0.914	0.357
C20:4n6	1.03±0.03	1.16±0.03	1.19±0.03	0.0002	<.0001	0.162
C20:5n3	0.26±0.01	0.30±0.01	0.31±0.02	0.083	0.036	0.451
C22:0	0.02±0.003	0.01±0.003	0.02±0.003	0.170	0.538	0.075
C22:1	0.01±0.01	0.03±0.01	0.03±0.01	0.050	0.026	0.320
C22:4n6	0.17±0.01	0.19±0.01	0.17±0.01	0.069	0.950	0.021
C22:5n3	0.10±0.01	0.11±0.01	0.11±0.01	0.231	0.198	0.263
C24:0	0.02±0.005	0.03±0.005	0.03±0.005	0.165	0.206	0.159
Iodine Value ¹	69.37±0.65	72.61±0.65	72.83±0.66	0.0003	0.0003	0.060
Sat:Unsat ²	0.51±0.01	0.46±0.01	0.45±0.01	0.001	0.001	0.187
n6:n3 ³	27.78±0.70	28.54±0.70	30.36±0.71	0.034	0.011	0.535

Table 12. The effects of feeding dried distillers grains with soluble (DDGS) during gestation and lactation on fresh bratwurst scoring by untrained consumer panelist¹.

Gestation Diet ²	Lactation Diet ³	Q1 ⁴	Q2 ⁵	Q3 ⁶	Q4 ⁷	Q5 ⁸	Q6 ⁹
0	0	2.88±0.062	2.70±0.125	0.66±0.126	0.59±0.117	0.51±0.105	1.07±0.146
	15	2.90±0.060	2.29±0.122	0.67±0.123	0.77±0.114	0.74±0.102	1.10±0.140
	30	2.91±0.061	2.52±0.124	0.61±0.123	0.69±0.115	0.52±0.104	1.35±0.142
15	0	2.90±0.061	2.54±0.124	0.81±0.123	0.77±0.115	0.41±0.104	1.28±0.140
	15	2.87±0.062	2.67±0.125	0.81±0.125	0.75±0.117	0.48±0.105	1.14±0.144
	30	2.94±0.060	2.39±0.122	0.77±0.122	0.72±0.114	0.65±0.102	1.05±0.140
30	0	2.95±0.061	2.46±0.124	0.88±0.126	0.75±0.115	0.72±0.104	1.38±0.144
	15	2.95±0.062	2.63±0.125	0.80±0.125	0.70±0.117	0.52±0.106	1.31±0.144
	30	2.84±0.062	2.61±0.127	0.64±0.125	0.71±0.117	0.38±0.105	1.47±0.142
<u>Probability, P<</u>							
Gestation DDGS		0.991	0.784	0.291	0.814	0.629	0.078
Lactation DDGS		0.960	0.790	0.523	0.928	0.772	0.659
Gestation X Lactation		0.588	0.068	0.947	0.834	0.034	0.499

¹ Bratwurst were scored on a continuous scale. A measurement of 0 in is considered very low (or disagree with the statement) and 3.44in being very high (or agree with the statement).

² Percent of dried distillers grains with soluble (DDGS) in the gestation diet.

³ Percent of dried distillers grains with soluble (DDGS) in the lactation diet.

⁴ Bratwurst were easy to remove.

⁵ Bratwurst were free from defects.

⁶ Bratwurst were unusually greasy.

⁷ Bratwurst were slimy.

⁸ Bratwurst presented an off odor.

⁹ Bratwurst were fatty in appearance.

Table 13. The effects of feeding dried distillers grains with soluble (DDGS) during gestation and lactation on cooked bratwurst scoring by untrained consumer panelist¹.

Gestation Diet ²	Lactation Diet ³	Q1 ⁴	Q2 ⁵	Q3 ⁶	Q4 ⁷	Q5 ⁸
0	0	2.46±0.106	1.20±0.140	2.40±0.107	0.71±0.142	0.79±0.129
	15	2.39±0.104	1.09±0.136	2.30±0.105	1.08±0.142	0.95±0.126
	30	2.32±0.104	1.15±0.138	2.30±0.106	1.10±0.141	1.02±0.129
15	0	2.35±0.104	1.31±0.138	2.07±0.106	0.88±0.141	0.84±0.128
	15	2.21±0.107	1.02±0.140	2.20±0.109	1.17±0.142	0.76±0.129
	30	2.28±0.104	1.36±0.136	2.37±0.105	1.30±0.141	0.94±0.126
30	0	2.18±0.107	1.38±0.140	2.20±0.109	1.24±0.142	0.91±0.131
	15	2.17±0.106	1.33±0.140	2.23±0.109	1.07±0.142	0.81±0.129
	30	2.25±0.104	1.09±0.138	2.28±0.106	1.09±0.141	0.92±0.128
<u>Probability, P<</u>						
Gestation DDGS		0.071	0.553	0.317	0.243	0.800
Lactation DDGS		0.698	0.440	0.464	0.157	0.445
Gestation X Lactation		0.861	0.371	0.457	0.169	0.831

¹ Bratwurst were scored on a continuous scale. A measurement of 0in is considered very low (or disagree with the statement) and 3.44in being very high (or agree with the statement).

² Percent of dried distillers grains with soluble (DDGS) in the gestation diet.

³ Percent of dried distillers grains with soluble (DDGS) in the lactation diet.

⁴ Brats had a high quality appearance.

⁵ Brats were excessively oily.

⁶ Rate the overall cooking experience of this brat.

⁷ Do you feel the brat shrank too much?

⁸ Do you feel the brat swelled too much?

Table 14. The effects of feeding dried distillers grains with soluble (DDGS) during gestation and lactation on bratwurst taste scoring by untrained consumer panelist¹.

Gestation Diet ²	Lactation Diet ³	Q1 ⁴	Q2 ⁵	Q3 ⁶	Q4 ⁷	Q5 ⁸	Q6 ⁹	Q7 ¹⁰
	0	2.46±0.116	2.46±0.113	2.28±0.126	0.74±0.131	0.95±0.126	1.49±0.147	2.34±0.127
0	15	2.11±0.113	2.19±0.110	2.07±0.123	0.82±0.128	0.93±0.123	1.29±0.144	1.87±0.125
	30	2.30±0.115	2.39±0.111	2.17±0.125	0.65±0.130	0.76±0.124	1.34±0.145	2.22±0.125
15	0	2.32±0.115	2.31±0.111	2.17±0.125	0.70±0.130	0.71±0.124	1.20±0.145	2.02±0.125
	15	2.26±0.118	2.36±0.113	2.16±0.126	0.70±0.131	0.89±0.126	1.35±0.147	2.01±0.127
	30	2.33±0.113	2.30±0.110	2.10±0.123	0.71±0.128	0.67±0.123	1.38±0.144	2.24±0.124
30	0	2.27±0.118	2.17±0.114	2.06±0.129	0.65±0.133	0.96±0.188	1.39±0.149	1.29±0.129
	15	2.20±0.116	2.26±0.113	1.93±0.126	0.61±0.131	0.88±0.126	1.41±0.147	2.29±0.129
	30	2.24±0.115	2.21±0.111	2.22±0.125	0.69±0.130	0.85±0.124	1.35±0.145	1.97±0.125
<u>Probability, P<</u>								
Gestation DDGS		0.739	0.339	0.619	0.703	0.336	0.789	0.061
Lactation DDGS		0.234	0.881	0.434	0.970	0.387	0.998	0.439
Gestation X Lactation		0.702	0.458	0.611	0.892	0.863	0.769	0.055

¹ Bratwurst were scored on a continuous scale. A measurement of 0in is considered very low (or disagree with the statement) and 3.44in being very high (or agree with the statement).

² Percent of dried distillers grains with soluble (DDGS) in the gestation diet.

³ Percent of dried distillers grains with soluble (DDGS) in the lactation diet.

⁴ Overall liking.

⁵ Overall flavor liking.

⁶ Overall texture liking.

⁷ Off flavor.

⁸ Too lean.

⁹ Fattiness Taste.

¹⁰ Juiciness.

Table 15. Fresh Bratwurst Appearance: How likely would you be to buy this bratwurst if it were available for a reasonable price at a store where you normally shop?

Gestation Diet ¹	Lactation Diet ²	Definitely would purchase	Probably would purchase	Might or might not purchase	Probably would not purchase	Definitely would not purchase
0	0	26.83	53.66	12.20	7.32	0.00
	15	26.19	45.24	23.81	4.76	0.00
	30	21.95	46.34	24.39	7.32	0.00
15	0	21.95	51.22	21.95	4.88	0.00
	15	15.00	50.00	30.00	5.00	0.00
	30	17.07	48.78	29.27	4.88	0.00
30	0	17.50	35.00	27.50	17.50	2.50
	15	15.38	38.46	20.51	25.64	0.00
	30	17.50	25.00	45.00	10.00	2.50

Row Mean Scores Difference Probability P<0.016.

¹ Percent of dried distillers grains with soluble (DDGS) in the gestation diet.

² Percent of dried distillers grains with soluble (DDGS) in the lactation diet.

Table 16. Cooked Bratwurst Taste Evaluation: Would make great tasting bratwurst on buns.

Gestation Diet ¹	Lactation Diet ²	Agree strongly	Agree somewhat	Neither agree nor disagree	Disagree somewhat	Disagree strongly
0	0	58.54	26.83	9.76	0.00	4.88
	15	42.86	33.33	9.52	9.52	4.76
	30	42.50	45.00	2.50	10.00	0.00
15	0	41.46	51.22	2.44	4.88	0.00
	15	40.00	42.50	7.50	10.00	0.00
	30	48.78	29.27	12.20	7.32	2.44
30	0	35.14	35.14	10.81	16.22	2.70
	15	37.50	35.00	10.00	10.00	7.50
	30	46.34	34.15	9.76	9.76	0.00

Row Mean Scores Difference Probability P<0.314.

¹ Percent of dried distillers grains with soluble (DDGS) in the gestation diet.

² Percent of dried distillers grains with soluble (DDGS) in the lactation diet.

Table 17. Cooked Bratwurst Taste Evaluation: Would be worth paying more for.

Gestation Diet ¹	Lactation Diet ²	Agree strongly	Agree somewhat	Neither agree nor disagree	Disagree somewhat	Disagree strongly
0	0	26.83	21.95	29.27	21.95	0.00
	15	26.19	11.90	28.57	19.05	14.29
	30	17.07	29.27	31.71	17.07	4.88
15	0	19.51	26.83	36.59	7.32	9.76
	15	17.50	12.50	37.50	25.00	7.50
	30	19.51	14.63	34.15	19.51	12.20
30	0	18.42	18.42	21.05	31.58	10.53
	15	12.50	25.00	30.00	20.00	12.50
	30	24.39	24.39	21.95	19.51	9.76

Row Mean Scores Difference Probability $P < 0.523$.

¹ Percent of dried distillers grains with soluble (DDGS) in the gestation diet.

² Percent of dried distillers grains with soluble (DDGS) in the lactation diet.

Table 18. The effects of feeding dried distillers grains with soluble (DDGS) during gestation and lactation on fresh breakfast link scoring by untrained consumer panelist¹.

Gestation Diet ²	Lactation Diet ³	Q1 ⁴	Q2 ⁵	Q3 ⁶	Q4 ⁷	Q5 ⁸	Q6 ⁹
0	0	1.15±0.237	1.11±0.220	0.98±0.224	0.56±0.163	0.51±0.150	0.82±0.156
	15	1.38±0.257	1.18±0.238	1.15±0.243	0.62±0.176	0.44±0.162	0.93±0.170
	30	1.16±0.237	1.06±0.220	0.98±0.224	0.49±0.163	0.44±0.150	0.83±0.156
15	0	1.34±0.265	1.18±0.246	0.94±0.251	0.89±0.188	0.68±0.167	0.90±0.175
	15	1.28±0.237	1.27±0.220	1.11±0.230	0.33±0.167	0.36±0.154	0.73±0.165
	30	1.15±0.237	1.08±0.220	1.02±0.224	0.31±0.163	0.36±0.150	0.72±0.156
30	0	1.40±0.257	1.07±0.238	0.93±0.251	0.70±0.182	0.68±0.167	0.88±0.175
	15	1.41±0.257	0.97±0.238	1.14±0.251	0.51±0.182	0.72±0.167	0.95±0.175
	30	1.21±0.237	1.07±0.220	1.01±0.224	0.40±0.163	0.33±0.150	0.73±0.156
<u>Probability, P<</u>							
Gestation DDGS		0.856	0.747	0.997	0.937	0.610	0.793
Lactation DDGS		0.637	0.926	0.645	0.069	0.143	0.649
Gestation X Lactation		0.982	0.974	0.999	0.456	0.558	0.896

¹ Breakfast links were scored on a continuous scale. A measurement of 0in is considered very low (or disagree with the statement) and 3.44in being very high (or agree with the statement).

² Percent of dried distillers grains with soluble (DDGS) in the gestation diet.

³ Percent of dried distillers grains with soluble (DDGS) in the lactation diet.

⁴ Breakfast links were easy to remove.

⁵ Breakfast link were free from defects.

⁶ Breakfast links were unusually greasy.

⁷ Breakfast links were slimy.

⁸ Breakfast links presented an off odor.

⁹ Breakfast links were fatty in appearance.

Table 19 . The effects of feeding dried distillers grains with soluble (DDGS) during gestation and lactation on cooked breakfast link scoring by untrained consumer panelist¹.

Gestation Diet ²	Lactation Diet ³	Q1 ⁴	Q2 ⁵	Q3 ⁶	Q4 ⁷	Q5 ⁸
0	0	1.32±0.181	0.90±0.180	1.32±0.177	0.76±0.143	0.64±0.173
	15	1.42±0.196	1.38±0.195	1.41±0.193	0.44±0.159	0.48±0.194
	30	1.22±0.185	1.00±0.184	1.31±0.182	0.44±0.150	0.63±0.183
15	0	1.48±0.196	1.37±0.195	1.56±0.193	0.66±0.155	0.75±0.188
	15	1.31±0.196	0.93±0.189	1.33±0.182	0.55±0.146	0.51±0.178
	30	1.43±0.190	0.92±0.189	1.40±0.187	0.31±0.150	0.59±0.183
30	0	1.41±0.202	1.17±0.195	1.22±0.193	0.49±0.159	0.52±0.200
	15	1.27±0.202	0.95±0.195	1.34±0.193	0.55±0.155	0.81±0.194
	30	1.32±0.181	1.02±0.180	1.21±0.177	0.51±0.143	0.65±0.173
<u>Probability, P<</u>						
Gestation DDGS		0.822	0.949	0.533	0.948	0.877
Lactation DDGS		0.845	0.523	0.866	0.221	0.957
Gestation X Lactation		0.938	0.153	0.896	0.625	0.631

¹ Breakfast links were scored on a continuous scale. A measurement of 0in is considered very low (or disagree with the statement) and 3.44in being very high (or agree with the statement).

² Percent of dried distillers grains with soluble (DDGS) in the gestation diet.

³ Percent of dried distillers grains with soluble (DDGS) in the lactation diet.

⁴ Cooked breakfast link has a high quality appearance.

⁵ Cooked breakfast link is not excessively oily.

⁶ How would you rate the overall cooking experience of this breakfast link.

⁷ Do you feel the breakfast link shrank too much?

⁸ Do you feel the breakfast link swelled too much?

Table 20. The effects of feeding dried distillers grains with soluble (DDGS) during gestation and lactation on breakfast link taste scoring by untrained consumer panelist¹.

Gestation Diet ²	Lactation Diet ³	Q1 ⁴	Q2 ⁵	Q3 ⁶	Q4 ⁷	Q5 ⁸	Q6 ⁹	Q7 ¹⁰
	0	1.52±0.159	1.49±0.171	1.44±0.166	0.60±0.142	0.60±0.115	0.84±0.154	1.24±0.155
0	15	1.69±0.173	1.59±0.185	1.45±0.180	0.69±0.154	0.62±0.125	1.05±0.167	1.35±0.168
	30	1.30±0.159	1.39±0.171	1.27±0.166	0.50±0.142	0.67±0.115	0.92±0.158	1.19±0.155
15	0	1.54±0.173	1.56±0.185	1.43±0.180	0.50±0.154	0.64±0.125	0.66±0.167	0.98±0.173
	15	1.47±0.159	1.50±0.171	1.56±0.166	0.54±0.146	0.51±0.121	1.20±0.163	0.25±0.155
	30	1.58±0.159	1.53±0.171	1.46±0.166	0.58±0.146	0.52±0.128	0.81±0.158	0.23±0.155
30	0	1.38±0.173	1.35±0.185	1.35±0.180	0.84±0.154	0.55±0.128	0.96±0.172	0.06±0.168
	15	1.56±0.178	1.51±0.191	1.42±0.185	0.64±0.164	0.35±0.133	0.60±0.178	0.23±0.173
	30	1.48±0.159	1.48±0.171	1.33±0.166	0.57±0.150	0.41±0.121	1.02±0.163	0.01±0.159
<u>Probability, P<</u>								
Gestation DDGS		0.924	0.849	0.709	0.515	0.213	0.837	0.471
Lactation DDGS		0.648	0.864	0.638	0.716	0.656	0.639	0.387
Gestation X Lactation		0.581	0.930	0.985	0.715	0.897	0.080	0.883

¹ Breakfast links were scored on a continuous scale. A measurement of 0in is considered very low (or disagree with the statement) and 3.44in being very high (or agree with the statement).

² Percent of dried distillers grains with soluble (DDGS) in the gestation diet.

³ Percent of dried distillers grains with soluble (DDGS) in the lactation diet.

⁴ Overall liking.

⁵ Overall flavor liking.

⁶ Overall texture liking.

⁷ Off flavor.

⁸ Too lean.

⁹ Fattiness Taste.

¹⁰ Juiciness.

Table 21. The effects of feeding dried distillers grains with solubles (DDGS) during gestation and lactation on internal bratwurst color made from cull sows.

Gestation Diet ¹ Lactation Diet ²	0			15			30			SE	Probability, P<		
	0	15	30	0	15	30	0	15	30		Gestation	Lactation	G X L
<u>Day 0 Pre-freeze</u>													
L* ¹	52.88	52.77	54.56	51.13	52.25	51.77	53.96	53.05	53.11	0.61	0.012	0.566	0.209
a* ²	9.90	9.36	10.69	11.05	11.95	13.07	11.80	10.21	10.64	0.59	0.007	0.193	0.168
b* ³	15.40	15.02	15.48	15.97	16.65	16.60	16.04	15.67	16.28	0.39	0.021	0.518	0.662
<u>Day 1</u>													
L* ¹	50.90	52.54	53.03	53.00	50.88	51.75	50.24	52.44	51.11	0.87	0.466	0.655	0.155
a* ²	8.03	8.70	7.36	7.24	7.94	8.78	8.82	8.47	8.92	0.48	0.157	0.641	0.156
b* ³	14.13	14.49	13.85	13.58	13.32	14.48	15.18	14.33	14.09	0.36	0.094	0.710	0.087
<u>Day 5</u>													
L* ¹	54.24	53.35	50.29	52.78	52.05	46.37	50.65	51.97	52.57	0.99	0.063	0.011	0.021
a* ²	7.00	6.83	9.20	7.08	8.70	11.17	6.16	7.74	7.61	0.52	0.006	0.001	0.072
b* ³	13.60	13.66	16.24	13.26	14.31	15.58	13.50	13.81	13.94	0.41	0.042	0.0003	0.033
<u>Day 10</u>													
L* ¹	50.38	51.10	49.76	45.86	48.07	46.08	52.01	47.68	47.99	2.23	0.165	0.718	0.665
a* ²	12.93	11.09	12.93	11.87	10.95	11.69	10.40	11.88	12.03	1.11	0.576	0.620	0.650
b* ³	18.14	16.60	16.45	14.77	15.62	15.16	16.50	16.47	17.38	0.95	0.079	0.954	0.608
<u>Day 15</u>													
L* ¹	51.04	47.55	47.13	48.19	53.49	47.01	51.75	47.61	50.40	1.12	0.356	0.112	0.008
a* ²	9.64	10.45	11.94	10.79	6.00	9.05	5.08	8.02	9.80	0.56	0.0003	0.003	0.001
b* ³	14.01	15.06	16.16	16.04	12.86	14.26	11.71	12.66	13.48	0.61	0.002	0.131	0.024

¹ Percent of dried distillers grains with soluble (DDGS) in the gestation diet.

² Percent of dried distillers grains with soluble (DDGS) in the lactation diet.

³ L* relates to the intensity of the lightness from the internal bratwurst surface. Ranges from black = 0 to white = 100.

⁴ a* relates to the redness of the internal bratwurst surface. Positive a* indicates a hue of red-purple; negative a*, indicates a hue of bluish-green.

⁵ b* relates to the yellowness of the internal bratwurst surface. Positive b* indicates yellow and negative b* indicates blue.

Table 22. The effects of feeding dried distillers grains with soluble (DDGS) on bratwurst pooled sausage mix fatty acid profiles.

Gestation DDGS, %	0			15			30		
Lactation DDGS, %	0	15	30	0	15	30	0	15	30
<u>Fatty acid, %</u>									
C14:0	0.92	0.85	0.88	0.90	0.89	0.86	0.75	0.80	0.87
C16:0	18.89	18.08	17.30	18.09	17.80	17.43	17.74	17.45	18.04
C16:1n7	1.75	1.81	1.62	1.39	1.81	1.54	1.69	1.60	1.47
C16:2n4	0.07	0.07	0.07	0.07	0.07	0.08	0.07	0.07	0.08
C16:3n4	0.23	0.23	0.23	0.22	0.24	0.25	0.23	0.27	0.29
C18:0	11.78	11.65	11.84	13.03	10.59	11.64	11.62	10.79	11.39
C18:1n9	38.34	40.63	37.69	36.82	39.93	37.37	38.39	38.91	36.29
C18:1n7	2.83	3.44	3.07	2.69	3.43	3.08	3.21	2.94	2.81
C18:2n6	16.88	14.85	16.59	18.25	16.37	18.35	17.69	19.24	20.36
C18:3n4	0.04	0.04	0.04	0.05	0.04	0.05	0.04	0.04	0.04
C18:3n3	0.09	0.11	0.10	0.10	0.11	0.10	0.10	0.11	0.10
C18:4n3	0.34	0.38	0.42	0.45	0.38	0.39	0.37	0.32	0.34
C18:2n 9,11	0.14	0.13	0.13	0.12	0.14	0.13	0.12	0.13	0.13
C18:2n 10,12	0.01	0.01	0.00	0.01	0.01	0.01	0.01	0.01	0.01
C20:1n9	1.43	1.79	1.62	1.57	1.75	1.62	1.68	1.41	1.33
C20:4n6	0.48	0.47	0.55	0.47	0.44	0.54	0.49	0.43	0.48
C20:5n3	0.16	0.15	0.21	0.17	0.17	0.14	0.18	0.16	0.17
C22:0	0.04	0.03	0.02	0.02	0.04	0.00	0.01	0.03	0.03
C22:1	0.03	0.02	0.02	0.03	0.03	0.03	0.02	0.02	0.02
C22:4n6	0.22	0.32	0.31	0.27	0.31	0.34	0.32	0.26	0.31
C22:5n3	0.17	0.13	0.18	0.15	0.17	0.15	0.15	0.12	0.15
C24:0	0.04	0.02	0.04	0.07	0.02	0.02	0.01	0.01	0.02
Iodine Value ¹	67.77	67.11	66.96	68.50	69.11	69.69	69.71	72.31	71.72
Sat:Unsat ²	0.50	0.48	0.48	0.52	0.45	0.47	0.47	0.44	0.47
n6:n3 ³	23.15	20.42	19.43	22.10	20.88	24.54	23.22	28.43	28.09

¹ Iodine Values calculated as follows: IV= (%16:1 * 0.950) + (%18:1 * 0.860) + (%18:2 * 1.732) + (%18:3 * 2.616) + (%C20:1 * 0.723); AOAC, 1990.

² Saturated to unsaturated fatty acid ratio calculated as follows: (14:0 + 16:0 + 18:0 + 24:0) / (16:1n7 + 16:2n4 + 16:3n4 + 18:1n9 + 18:1n7 + 18:2n6 + 18:3n4 + 18:3n3 + 18:2n9,11 + 18:2n10,12 + 20:1n9 + 20:4n6 + 20:5n3 + 22:1 + 22:4n6 + 22:5n3).

³ Ratio of n-6 to n-3 calculated as follows: (18:2n6 + 20:4n6 + 22:4n6) / (18:4n3 + 18:3n3 + 20:5n3 + 22:5n3); Gordon et al., 2005.

IX. Discussion: Explain your research results and include a summary of the results that is of immediate or future benefit to pork producers.

Distillers dried grains with solubles (DDGS) are potentially excellent feed ingredients in the swine industry, especially in the Midwest. It is well known that DDGS varies strongly between processing facilities, but within a plant the average protein and fat contribution are quite high and would be a good ingredient consideration in a non-ruminant diet. In this experiment, a complete factorial arrangements of treatments were examined, i.e., 0, 15 or 30% added DDGS both within gestation and lactation. Furthermore, the sows were harvested at a commercial plant equipped for sows and corresponding products were developed, namely bratwurst and breakfast links.

In general, there appeared to be little effect on sow performance and/or piglet numbers as it relates to general management for the actual producer. That is, no differences were observed in piglet litter size, litter weight gain or litter weight gain per day. Also, there were no differences noted in sow feeding intake during gestation and/or lactation as a function of the different treatment combinations offered. In terms of carcass quality trait changes, there were no differences in the relative amount of lipid accumulation or deposition as measured in back fat thickness. It was anticipated, the relative amount of unsaturated fatty acids did increase in the sows fed DDGS as shown in results section; however, the magnitude of difference in actual IV is relative low (~ 72's for DDGS sows vs. 69 in controls) when considering the level of DDGS contributed in 15 or 30% of the diet; that is, in market pigs the relative difference in unsaturation of fat tissue would have likely been much higher between control vs. DDGS fed. The relatively small change observed in this experiment may be accounted for by what is going on in the sow relative to a market pig; that is, the sow has a embryos growing on ingested lipids as well as piglets nursing during the lactation phase, so it is unknown if the relative proportion of high unsaturates, i.e., linoleic acid (18:2n6, the primary fatty acid of DDGS) were preferentially given to the offspring. Furthermore, across both bratwurst and breakfast links there was relatively little difference in preference

of the actual product, i.e., eating experience wise. In fact, there were no differences noted in the breakfast links by the untrained panelist. However, it is worth noting that initial purchase or likelihood of purchase favored the control bratwurst, i.e., 58% agreement vs. the DDGS groups.

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