Title: Evaluation of Choice White Grease and Beef Tallow to Improve Pork Quality when Pigs are Fed Distillers Dried Grains **- NPB #07-167**

Investigators: B.T. Richert,

Institution: Purdue University

Co-Investigators: A.P. Schinckel and M. Latour

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Industry Summary

The feeding of dried distillers grains with solubles (DDGS) is becoming a common place in the swine industry to help reduce feed costs. However, there can be reduced growth performance, carcass yields, and softer pork fat that causes processing issues when feeding high levels of DDGS. We investigated what a short (26 day) withdrawal of 20% DDGS prior to slaughter in combination with beef tallow (BT) or choice white grease (CWG) would do to grow-finish pig performance, carcass traits and bacon quality.

At day 77 of the experiment, some pig's diets were switched from 20% DDGS to corn-SBM control or a corn-SBM control +5% BT or +5% CWG to evaluate their impact on final pork quality when fed at the end of the grow-finish period (last 26 days prior to slaughter). Pigs that stayed on the 20% DDGS diet throughout the GF period were nearly 9 lb lighter than the Corn-SBM control pigs at the end of the grow-finish period. Pigs that switched from the 20% DDGS diet to being fed the Control+5% BT diet the last 26 days prior to slaughter had 18% greater ADG than pigs fed the 20% DDGS diet during this phase (1.90 lb/d vs. 2.25 lb/d). Also pigs fed the Control+5% BT and the Control+5% CWG diets had 20% better feed efficiency (G:F) than the pigs fed the 20% DDGS diet during these final 4 weeks premarket (0.30 vs. 0.25). Carcass weights were reduced by 8.5 lb when pigs were fed 20% DDGS throughout the grow-finish period compared to the corn-soy control pigs. The 26 day preslaughter removal of the DDGS and supplementing with either 5% fat sources in the corn-soy diet during this preslaughter period restored carcass weights to that of the corn-soy control pigs. Hot carcass yield was 1.7% less for pigs fed 20% DDGS throughout the grow-finish period (d 0-103) than corn-soy control pigs (77.3 vs. 75.6%). When pigs were fed 5% fat with the 20% DDGS followed by a corn-soy diet with 5% fat prior to slaughter also increased the carcass yield 1.8% over pigs fed 20% DDGS throughout the grow-finish period ($P<0.05$). There were no differences in 10^{th} rib backfat or loin eye area among treatments leading to similar percent leans.

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Feeding corn-SBM control in comparison to 20% DDGS throughout the grow-finish period impacted the fatty acid concentrations of the backfat layers, belly and to a lesser extent the loin. In all cases, concentrations of saturated fatty acids were less and unsaturated fatty acids, especially linoleic (18:2n6), increased for pigs fed 20% DDGS compared to the control corn-SBM control diet throughout grow-finish. Belly and backfat iodine values increased 8-10 units when pigs were fed 20% DDGS. The 26 day withdrawal of DDGS only partially recovered fat iodine values by 1-4 units depending on supplemental fat source inclusion, with the greatest response due to switching to a corn-soy+5% beef tallow diet preslaughter. Feeding 20% DDGs for any amount of time preslaughter tended to reduce bacon slice cracks but increased bacon slice webbing. Bacon slice cooking losses were 19% greater when pigs were fed 20% DDGS+5% fat followed by a corn-SBM +5% fat diet prior to market compared to corn-SBM control fed pigs.

The improved performance of pigs switching from a 20% DDGS diet to a corn-SBM or corn-SBM+5% fat (either BT or CWG) diet at the end of the grow-finish period offers some indication of the limitations that the 20% DDGS can have on pig performance. The removal of 20% DDGS from the pig diet 26 days prior to slaughter can completely recover the slight reductions in carcass weights and yields if the withdrawal diet contains added energy (5% added fat in this study). The withdrawal of DDGS from the diet was successful in reducing all carcass fat and loin depots IV values. A longer withdrawal period may be needed to have a greater impact on carcass IV values, depending on the amount carcass IV needs to reduced or changed to meet your processors target for acceptable pork fat quality. However, the feeding of 20% DDGS had only minor effects on the processing and cooking characteristics of thick cut bacon slices in this study.

Key Words: Swine, Dried distillers grains, Beef tallow, Choice white grease, Bacon quality, Fatty acid profile

Scientific Abstract

Crossbred pigs (N=112; initial BW = 29.0 kg) were blocked by initial BW and sex and assigned to 1 of 7 dietary treatments to assess the impact of removing dried distillers grains w/ solubles (DDGS) and adding fat to the late finish diet on growth and carcass traits. Dietary treatments were: 1) Corn-soybean meal (CS) control d 0-103; 2) 20% DDGS d 0-103; 3, 4, and 5) 20% DDGS d 0-77 and CS or CS+5% Beef tallow (BT) or 5% Choice white grease (CWG) from d 77-103, respectively; 6 and 7) 20% DDGS+5% CWG d 0-77 and CS+5% BT or 5% CWG d 77-103, respectively. All diets were formulated on an equal dig. Lys to calorie ratio and met the minimum digestible amino acid ratios for all diets. Pigs were fed 2 grower diets (G1 d 0-28; G2 d 28-56) and 2 finisher diets (F1 d 56-77; F2 d 77-103). Pigs fed treatment 3 vs pigs fed treatments 4 and 5 tended to have lower F2 ADG (0.898 vs 1.057 and 1.005 kg/d, respectively; $P = 0.081$) and GF (0.26 vs 0.30 and 0.29, respectively; $P = 0.055$). No other differences ($P > 0.05$) were observed for ADG, ADFI, and GF during F2. No differences ($P > 0.05$) were observed for overall ADG and ADFI across treatments. Overall GF was greater (0.356 vs 0.335, $P = 0.031$) for treatments 6 and 7 than treatments 4 and 5. No differences were observed for final BW, carcass percent lean, visual 10^{th} rib loin color, marbling, firmness, loin and ham pH, driploss, and Minolta color L* and color a. Pigs fed treatment 2 compared to treatment 1 had smaller 10^{th} rib LM area ($P = 0.081$), decreased last rib BF ($P = 0.036$) and decreased carcass yield ($P = 0.034$). Pigs fed added fat for the entire grow finish period (treatments 6 and 7) tended to have greater last rib back fat than pigs fed added fat during F2 (treatments 4 and 5) (29.9 mm vs 31.4; $P = 0.065$). Pigs fed treatment 1 were firmer than pigs fed treatment 2 (8.4 vs 5.8 cm avg. lateral flex scores; $P = 0.001$). Treatments 6 & 7 experienced higher cook scores than treatments 4 & 5 ($P = 0.095$). The level of linoleic acid changed the most with treatments 1 & 2 in all adipose tissues ($P = 0.001$) resulting in greater IV, increased omega 6 to omega 3 ratios, and decreasing saturated to unsaturared ratios ($P= 0.037$) in all adipose tissues. Withdrawing 20% DDGS and adding CWG or BT for the last 26 d recovered carcass weights and yields in grow finish pigs prior to slaughter. CWG and BT may also partially recover some of the adverse fat quality effects caused by the increase in linoleic acid in the diet.

Introduction

Due to the rapid increase in corn ethanol production, large quantities of dried distillers grains with soluble (DDGS) have been utilized by the swine industry in nearly all phases of swine rations. The Renewable Fuels Association (2008) reports that an estimated 14 million metric tons will be produced by U.S. ethanol plants by 2012. The vast majority of this feedstuff will be used in ruminant diets; however, the swine industry currently utilizes around 20% of the DDGS produced (RFA, 2008).

The addition of DDGS in grow finish diets has been proven to have a linear decrease in ADG with diets containing 0, 10, 20, and 30% DDGS in a trial conducted by Whitney et al., (2006). Cromwell et al., (1993) and Fu et al., (2004) also reported linear reductions in ADG and ADFI with diets containing greater than 30% DDGS. Lastly, in a study conducted by Linneen et al., (2008) in a commercial setting showed that including DDGS between 10 and 15% inclusion levels had no affect on growth performance. These statements prove that feeding DDGS at a 10 to 20% inclusion level have no affect on growth performance; however significant reductions in fat quality have been reported with the inclusion of DDGS in pig diets. Prescott et al., (1998) and Eggert et al., (2001) reported that the primary fatty acid in corn and soybean oil is, linoleic acid (C18:2n6), which is the main contributor of soft pork fat. It is believed that this soft pork fat is caused by the fatty acid composition of corn DDGS which typically contains approximately 8 to 10% corn oil.

Literature has shown that including fat and oils in pig grow-finish diets have been shown to reduce feed intake and increase feed efficiency (Engel et al., 2001; Gatlin et al., 2002; Eggert et al., 2007) in addition to altering the fatty acid composition of the pork fat (Wiseman and Agunbiade, 1998; Bee et al., 2002 and Guo et al., 2006).

Project Objectives –

Overall: To optimize the use of DDGS and maintain the pork quality of pigs fed DDGS, the joint impact of feeding higher levels of DDGS, the addition of Choice White Grease (CWG) and Beef Tallow (BT), and DDGS withdrawal programs.

1. Evaluate the effect of feeding choice white grease or beef tallow with distiller dried grains with solubles (DDGS) either fed completely through the grow-finish period or withdrawal of the DDGS four weeks prior to market in comparison to pigs fed more conventional corn-soybean meal diets.
2. Evaluate the effect of feeding choice white grease or beef tallow on carcass fatty acid profiles and belly quality when pigs are fed 20% DDGS either for the entire grow-finish period or withdrawal of DDGS during the final four weeks prior to slaughter and the possible interactions between the DDGS treatments and the feeding of added fat. The response of added fat to increase carcass weight growth, to improve belly quality, and to impact fatty acid profiles may interact with the withdrawal of DDGS 4 weeks prior to market.
3. Evaluate the combined use of animal fats and DDGS to meet future carcass composition and pork quality specifications.

Materials and methods:

Animals and Dietary Treatments

All procedures involving animals during this study were approved by the Purdue Animal Care and Use Committee. A total of 112 crossbred pigs were used with an initial body weight (BW) of 63.5 lb. One gilt on block 1 was removed after 8 wks on test due to a belly hernia. Pigs were assigned to 1 of 56 pens (2 pigs/pen 15.7 ft^2/ pig) and blocked by BW and sex. Pigs were assigned 2 pigs per pen either as 2 barrows or 2 gilts. A total of 4 blocks were used with 7 pens of barrows and 7 pens of gilts, giving each block a total of 28 pigs. Each pen was assigned to one of 7 dietary treatments. The dietary treatments involved the utilization of 3 diets for d 0-77. The 3 diets used for this period were: 1) corn-SBM control, 2) corn-SBM with 20% distillers dried grains with soluble (DDGS), and 3) corn-SBM with 20% DDGS and 5% choice white grease (CWG). At d 77 the diets were switched, and 4 diets were used for the last 26 days of the grow finish period. The 4 diets used for this period were 1) corn-SBM control, 2) corn-SBM with 20% DDGS, 3) corn-SBM with 5% CWG, and 4) corn-SBM with 5% beef tallow (BT). The diet switch at day 77, 26 days prior to slaughter allowed for 7 dietary treatments to be evaluated for this study. The dietary treatments were as follows: Trt1) corn-SBM control d (0-77) and d (77-103), Trt2) corn-SBM with 20% DDGS d (0-77) and d (77-103), Trt3) corn-SBM with 20% DDGS d (0-77) and corn-SBM control d (77-103), Trt4) corn-SBM with 20% DDGS d (0-77) and corn-SBM with 5% BT d (77-103), Trt5) corn-SBM with 20% DDGS d (0-77) and corn-SBM with 5% CWG d (77-103), Trt6) corn-SBM with 20% DDGS and 5% CWG d (0-77) and corn-SBM with 5% BT, and Trt7) corn-SBM with 20% DDGS and 5% CWG d (0-77) and corn-SBM with 5% CWG d (77-103). All pens contained a single nipple drinker and single hole feeder. One body weight block was started on test each week for 4 consecutive weeks.

Growth performance was evaluated on a four-phase grow-finish feeding program. The dietary phases were grower 1 (d 0-28), grower 2 (d 28-56), finisher 1 (d 56-77). At d 77 the dietary switch was made and finisher 2 (d 77-103) began. Day 103 was the completion of the grow finish period.

Diet compositions and calculated nutrient levels are presented in Tables 1, 2, 3, and 4 for the grower 1 (4 wks) grower 2 (4 wks), finisher 1 (3 wks), and finisher 2 (26 d) growth phases, respectively. Diets were formulated on a digestible lysine basis and were formulated to have an equal lysine to calorie ratio by altering the amount of L-Lysine in the diets. All diets within each growth phase were formulated to have similar concentrations of total amino acids, Ca, P, and ME and to meet or exceed all nutrient requirements (NRC, 1998).

Growth Performance and Carcass Data Collection

All pigs had adlibitum access to feed and water throughout the study. Individual BW and pen feed consumptions were recorded every 14d during all grower and finisher phases. These data were used to calculate ADG, ADFI, and G:F. After d 103 on test, both pigs from each pen, an equal number of barrows and gilts for each block, were slaughtered at the Purdue University meats lab to collect carcass data.

The day before each group of 28 animals was slaughtered; each animal was tattooed with an individual number for identification during carcass data collection. On the day of slaughter, each block was transported in 2 trips, alternating between barrows or gilts first for the remaining 3 blocks. Pigs were electrically stunned and exsanguinated. At the time of slaughter, live weight, hot carcass weight (HCW), kidney, liver, and leaf fat weights were recorded.

All blocks were removed from their respective diets the afternoon previous to slaughter to stimulate a 24 hr feed withdrawal. Pigs were allowed full access to water up until the point of slaughter. Carcass data were collected approximately 24 h after slaughter for each block. Carcass quality measurements were obtained from 111 carcasses. These include: 10th rib backfat (BF), inner and middle BF at the 10th rib, outer BF at the 10th rib, outer last rib BF, last lumbar BF, 10th rib longissimus area (LMA), subjective loin color, objective loin color under C:20 luminance, marbling, and firmness at the 10th LM, loin pH, ham pH, BF separation from the loin and belly bending, loin drip loss. From these data, HCW yield, percent lean muscle, and percent of carcasses with BF separation were calculated. Color, marbling, and firmness at the 10th rib were evaluated using official NPPC color and marbling standards (2004). To measure the loin and ham pH a Hanna Instruments (584 Park East Drive Woonsocket, RI 02895) 99161 pH food probe was calibrated using pH 4.00 and 7.00 buffer solution. To measure the objective loin color a Minolta CR-300(Konica Minolta 222 W Murdock St Wichita, KS 67203) with an 8mm diameter lens calibrated on a white color plate using C:20 luminance. Loin drip loss was determined following procedures outlined by (Rasmussen and Stouffer, 1996) by taking three 0.75 in. (19 mm) dia. cores from a 1.0 in. (2.54 cm) thick section of the loin taken on the proximal side of the ribbed carcass. Cored sections were weighed and placed in drip loss tubes and allowed to remain in the cooler for 24 hrs. At the end of the 24 hr period, cores were removed and the purge was weighed to calculate the amount of drip loss from the meat cores. The remaining portion of the loin section was trimmed of fat and frozen at -5^{o} F for further analysis. The trimmed fat from the loin section was separated into inner & middle and outer backfat layers and frozen at -5^{o} F. An additional sample from the center of the belly weighing approximately 100g was also removed and frozen the same as the backfat samples. The loin samples would be used to determine percent intramuscular fat via ether extract and fatty acid analysis. The fat samples from the backfat and belly were used for fatty acid analysis. Percent crude fat was determined according to standards set by AOAC, (1990) samples were extracted with petroleum ether using a Goldfisch fat extraction apparatus (Labconco model 35001, Kansas City, Missouri). Fat samples from the inner and outer backfat and belly were used for fatty acid analysis, ~400mg samples of fat from the inner and outer backfat and belly was dissolved in hexane and KOH in MeOH to produce fatty acid methylated esters (FAME). The FAME were analyzed for fatty acid composition according to procedures by White et al. (2008) using gas chromatography (Varion 3900 with CP-8400 autosampler, flame ionization detector; Varian Inc, 3120 Hansen Way Palo Alto, CA 94304) and a column (GC capillary column WCOT fused cilica column, 30m x0.32mm, coating CP Wax 52 CDF 0.25 µm thickness. FAME were identified by comparing the retention times of fatty acid standards. LM FAME were extracted following the procedure outlined by Li and Watkins (2001). Lipid was extracted from ~250 mg samples of loin tissue using HPLC grade methanol and chloroform after tissue homogenization. The extraction procedure was catalyzed with sodium methoxide in methanol after being dissolved in dry toluene. The same gas chromatography and autosampler were used for the LM as the backfat and belly.and the same gas chromatography and autosampler as the backfat and belly.

Bacon Analysis and Processing

Bellies for this study were removed from the right side of the individually identified pork carcasses approximately 24hr post-slaughter. Bellies were placed interior side down in an anterior to posterior direction over a belly bend apparatus designed by Rentfrow et al., (2002) and photographed. The distance the 2 sides of the belly flexed on a vertical and horizontal axis was recorded to calculate the relative bend. Bellies were then labeled and placed in a vacuum sealed bag (Prime Source Vacuum Pouches; Banzl 528 E 19th Ave Kansas City, MO 64116) and frozen at -5^{o} F for later processing. Prior to processing bellies were removed from the freezer and allowed to thaw for 2 d at 38^{o} F. Bellies were then pumped with a brine solution made from Legg's Quick Cure (AC Legg P.O. Box 10283 Birmingham, AL 35202) to 110% of the initial weight. After pumping, bellies were placed in the brine solution previously mentioned and allowed to soak for 4 d at 38^{o} F. Bellies were then placed on combs and loaded in Purdue University's Alkar Smokehouse (Alkar 932 Development Dr. Lodi, Wisconsin 53555). The bellies remained in the smokehouse until an internal temperature of 142^{o} F was reached with a wet bulb humidity of 66% approximately 6 hrs. Bellies were removed from the smoke house and the skin was then removed. Bellies were cut in half and 2 slices 0.16 in (4 mm) thick were removed from the face of each half for further analysis. Four bacon slices per belly were photographed and objectively measured for cracks, webbing, separation, length and weight. Bacon slices were then placed on baking sheets and baked in a conventional oven for 12 minutes at 400^{o} F. Bacon slices were then allowed to cool for 5 minutes and assigned a subjective cook score in accordance with Rentfrow et al. (2002). Length and weight of each bacon slice was taken to calculate cooking loss.

Statistical Analysis

Growth performance, carcass quality traits and bacon analysis were analyzed using the GLM procedure of SAS (SAS Inst. Inc., Cary, NC). Means for BF separation were analyzed using the ProcFREQ procedure and Cochran-Mantel-Haenszel statistical test. The statistical model for growth performance traits included each diet treatment (Tr1, Tr2, Tr3, Tr4, Tr5, Tr6 and Tr7), initial weight block, sex and single degree of freedom interactions of dietary treatments. The statistical model for carcass quality traits utilized the GLM procedure and included each dietary treatment, initial weight block, and sex. All means presented in tables 3.5-3.20 and are reported as least squares means. 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 test at both $P < 0.05$ and 0.10 levels.

Results:

Growth Performance

Least square means for d 0-77 growth parameters are present in Table 5. During the grower 1 period (d 0-28), ADFI tended to be less for pigs fed DDGS + CWG compared to the corn-SBM fed control pigs (1.67 and 1.78 kg/d, $P = 0.051$). This reduced ADFI for the pigs fed DDGS + CWG led to a significantly greater G:F when compared to the DDGS diet ($P = 0.036$) with the control pigs being intermediate. No significant differences were observed among the diets for any of the growth parameters measured during the grower 2 period (d 28-56).

For the finisher 1 period (d 56-77), the DDGS + CWG fed pigs had a greater G:F when compared to the DDGS treatment (0.336, and 0.296; P = 0.027). Pigs fed DDGS + CWG from d 0-77 had 8% greater G:F (P = 0.004) than pigs fed a DDGS diet without CWG. The corn-SBM control was intermediate and not different from the other two diets. Pig ADFI tended (P = 0.067) to also be lower for the pigs fed the DDGS + CWG diet compared to the control and DDGS diets with no difference in ADG or d 77 BW among the treatments. No dietary treatment by sex interactions were observed from d 0-77.

At day 77 of the experiment, some pig diets were switched from 20% DDGS to evaluate their impact on pork quality when fed at the end of the grow-finish period (last 26 days). Least square means for the 7 dietary treatments during the last stage of finishing (d 77-103) and overall (d 0-103) are presented in Table 6. Evaluating the contrasts among treatments resulted in very few significant differences in growth performance d 77-103 or overall (d 0-103). Several trends appeared when comparing TRT3 (20% DDGS to switched to corn-SBM) vs. TRT4 and TRT5 (20% DDGS switched to corn-SBM + 5% fat) in the late grow-finish periods. After the diet changed on d 77, TRT4 and TRT5 with 5% added fat gained 2.25 lb/d compared to TRT3 with no added fat which gained 1.98 lb/d the last 26 days prior to slaughter (P = 0.081). Increased ADG from d 77-103 also resulted in a tendency for TRT4 and TRT5 pigs to have a greater G:F from d 77-103 compared to TRT3 pigs (P = 0.055). Overall G:F (d 0-103) was greater (P = 0.031) for pigs fed DDGS+ fat throughout the trial (TRT6 and TRT7) than pigs fed DDGS followed by corn-SBM and fat (TRT4 and TRT5).

Carcass Quality

Least square means for the carcass parameters are presented in Table 7. Hot carcass yield was 1.7% less for pigs fed 20% DDGS from d 0-103 than corn-soy control pigs (P = 0.034). Last rib backfat was 0.09 in less (P = 0.036) and LMA tended to be less (0.42 in^2, P < 0.081) for TRT2 (DDGS) then TRT1 (corn-soy control). Pigs fed DDGS + fat throughout the study (TRT6 and TRT7) had a trend for greater last rib backfat thickness (P = 0.065) and greater intramuscular fat (P = 0.064) than pigs fed DDGS followed by corn-SBM + fat (TRT4 and TRT5).

Liver weight (P = 0.035), kidney weight (P = 0.011) and liver + kidney weight (P = 0.012) were greater for DDGS fed pigs (TRT2) than control (TRT1) pigs. As a percentage of body weight, kidney weight (P= 0.001), liver weight (P = 0.002), and liver + kidney weight (P = 0.001) were greater for TRT2 (DDGS) than TRT1 (Corn-soy control). Kidney weights (P = 0.001) and liver + kidney (P < 0.010) combined weights as well as when expressed on percent of body weight basis were greater for TRT2 than TRT3. Leaf fat weight as a percentage of BW was greater (P = 0.032) for TRT4 and TRT5 than TRT3. Leaf fat for TRT4 and TRT5 (pigs fed 5% fat last 26 d) was 0.66 lb heavier than TRT3 (pigs fed no added fat last 26 d; P = 0.051). Liver weight expressed as a percent of BW tended to be greater (P = 0.065, contrasts 5) for TRT4 and TRT5 than to TRT6 and TRT7. Liver (P = 0.004) and liver + kidney weights combined (P = 0.005) and liver weight expressed as percent body weight (P = 0.013) and kidney + liver expressed as percent BW (P = 0.019) were significantly greater for TRT4 and TRT6 (pigs fed 5% BT last 26 d) compared to TRT5 and TRT7(pigs fed 5% CWG last 26 d).

Visual loin color, marbling, IM fat, firmness, driploss, loin pH, ham pH, Minolta L*, and Minolta a* were not different for TRT1 and TRT2. Visual loin marbling scores were greater for TRT5 and TRT7 (pigs fed 5% CWG last 26 d) vs. TRT4 and TRT6 (pigs fed 5% BT last 26 d; P = 0.049). Loin backfat separation was different among treatments (P = 0.005). All other treatments had greater incidence of backfat separation than the control (TRT1).

Belly and Bacon Quality

Least square means for belly and bacon parameters are presented in Table 8. Pump yield was greater for DDGS fed pigs (TRT2) than corn-SBM fed pigs (TRT1, P = 0.060). Pigs fed TRT4 and TRT5 tended to have greater pump yields (P = 0.098) than TRT6 and TRT7 pigs. Smoke yield was greater for pigs fed BT (TRT4 and TRT6) than pigs fed CWG (TRT5 and TRT7, P = 0.009) the last 26 d prior to slaughter. Average lateral flex (ALF) was significantly greater for TRT1 than TRT2 (P = 0.001). Average vertical flex (AVF) tended to be greater for TRT2 than TRT1 (P = 0.084). The AVF of the belly tended to be greater for TRT3 than TRT1 (P = 0.084). The ALF were greater for TRT1 than TRT3 (P = 0.006). TRT4 and TRT5 had greater ALF than TRT3 (P = 0.023).

Pigs fed the control diet (TRT1) tended to have more cracks in the bacon slice than DDGS (TRT2) fed pigs (P = 0.067). The final cook weight of the bacon slice for TRT1 control pigs tended to be 2.6 g greater than TRT2 DDGS pigs (P = 0.069). There were no differences in belly and bacon parameters between feeding DDGS continuously (TRT2) vs. a DDGS withdrawal to the control diet prior to slaughter (TRT3). Pigs of TRT1 had significantly more cracks than pigs of TRT3 (4.4 vs. 2.4, respectively; P = 0.019). Upon cooking, TRT 3 had less weight loss than TRT1 (P = 0.017). No significant differences were observed for any of the bacon slice parameters measured comparing TRT3 vs. TRT4 and TRT5. The number of cracks per bacon slice tended to be less for TRT4 and TRT5 than TRT6 and TRT7 (3.0 vs. 4.0; P = 0.089). Raw bacon length tended to be longer for TRT6 and TRT7 than TRT4 and TRT5 (P = 0.062). Cooked bacon scores tended to be higher, indicating a lesser quality, for TRT6 and TRT7 when compared to TRT4 and TRT5 (P = 0.095). Cooking TRT6 and TRT7 resulted in greater length loss and weight loss than TRT4 and TRT5 (P = 0.001). No significant differences were observed comparing supplemental fat sources, TRT4 and TRT6 to TRT5 and TRT7, for any of the bacon slice or whole belly parameters measured.

Fatty Acid Profiles

Least square means for the fatty acid concentrations of the inner and outer layers of backfat are presented in Tables 9 and 10. Feeding corn-SBM control (TRT1) in comparison to 20% DDGS throughout the grow-finish period (TRT2) impacted the fatty acid concentrations of the inner and middle backfat layers. In all cases, with the exception of C22:0, concentrations of saturated fatty acids were less (P < 0.026) for pigs fed TRT2 than pigs fed TRT1. However, C22:0 concentrations were 0.02 percent greater for TRT1 (P = 0.002) than TRT2. Pigs fed TRT2 diets had greater concentrations of C18:2n6, C18:3n3, C20:4n6, C20:5n3, and C22:4n6 (P < 0.004) than pigs fed TRT1 diets. The most significant change occurred in C18:2n6 concentrations which increased from 9.28 to 17.31% (P = 0.001) when grow finish pigs were fed (DDGS) TRT2 in comparison to TRT1. The concentrations of C16:1n7, C18:1n9, C18:1n7, and C18:2n10,12 were less for pigs fed TRT2 than pigs fed TRT1 (P = 0.017). Pigs fed TRT2 had greater IV values than pigs fed TRT1 (65.75 and 54.47, P = 0.001). Control pigs (TRT1) had greater ratios of saturated to unsaturated fatty acids (0.77 vs. 0.62, P = 0.001) and a lesser ratio of omega-6 to omega-3 fatty acids (P = 0.001) than TRT2 pigs.

The concentrations of C18:0 were greater (12.91 to 14.18 percent, P = 0.001) and concentrations of C18:1n7 tended to be greater for pigs of TRT3 than TRT2 (P = 0.075). Pigs of TRT3 had less C18:2n6 (P = 0.001), C18:3n3, C20:4n6, C22:0 and C22:4n6 (P < 0.040), and tended to have less C20:1n9 (P = 0.078) than pigs of TRT2. The changes in fatty acid concentrations in TRT3 resulted in pigs with decreased IV values and omega-6 to omega-3 ratios (P = 0.010), and a tendency to have increased saturated to unsaturated ratios (0.62 to 0.68, P = 0.062) than TRT2 pigs.

Pigs on TRT3 had decreased concentrations of C16:0 and C18:0 (P < 0.004) and a tendency for decreased C14:0 (P = 0.079) in comparison to TRT1 pigs. Pigs fed TRT3 had less C16:1n7, C18:1n9, C18:1n7, C18:2n 10,12 (P < 0.010), and C20:1n9 tended (P = 0.081) to less than pigs of TRT1. The concentrations of the omega-6 and omega-3 fatty acids were greater (P < 0.013) and C22:5n3 tended to be greater for TRT3 pigs in comparison to TRT1 pigs. Pigs fed TRT3 had greater backfat IV values (P = 0.001) and omega-6 to omega-3 ratios (P = 0.010), and decreased saturated to unsaturated ratio (P =0.003) than TRT1 pigs.

Pigs fed TRT4 and TRT5 had greater concentrations of C14:0 (P = 0.056) and C22:0 (P = 0.007) and lesser concentrations of C18:0 (P = 0.027) than TRT3 pigs. Unsaturated fatty acids were greater for pigs fed TRT4 and TRT5 than TRT3 (C18:1n9, C18:1n7, C18:2n 9,11, C20:1n9, P < 0.045). No significant differences were observed for either IV or saturated to unsaturated ratio where TRT3 was compared to TRT4 and TRT5. However, the omega-6 to omega-3 ratios were less (19.19 to 17.34) for pigs of TRT3 than pigs of TRT4 and TRT5, respectively (P = 0.010).

Saturated fatty acids (P < 0.013) had lesser concentrations for pigs of TRT4 and TRT5 than TRT6 and TRT7 pigs. The only exception was C22:0 concentrations which were greater (P = 0.039) for pigs of TRT6 and TRT7 than TRT4 and TRT5 pigs. Conversely, the concentration of all unsaturated C18 fatty acids were greater for TRT6 and TRT7 than TRT4 and TRT5 with the exception of C18:2n 10,12 which was greater for TRT6 and TRT7 (P < 0.039). Pigs of TRT6 and TRT7 had lower concentrations of C20:4n6 (P = 0.022) concentrations than TRT4 and TRT5 pigs. Pigs of TRT6 and TRT7 had greater IV values (64.19 vs. 62.94; P = 0.010) and lower saturated to unsaturated ratios (P = 0.014) than TRT4 and TRT5 pigs. Pigs of TRT4 and TRT6 had greater C14:0 concentrations than pigs of TRT5 and TRT7. All C16 unsaturated fatty acid concentrations were less for TRT5 and TRT7 pigs than TRT4 and TRT6 pigs (P < 0.020). Concentrations of C18:2n6 were 1.24% greater for TRT5 and TRT7 pigs than TRT4 and TRT6 pigs (P = 0.013). The remaining omega-6 fatty acids C20:4n6 and C 22:4n6 were also greater for TRT5 and TRT7 than TRT4 and TRT6 (P < 0.043). The concentrations of C18:2n9,11 were greater for TRT4 and TRT6 pigs than TRT5 and TRT7 pigs (P = 0.001). No differences were observed in the saturated to unsaturated ratio between TRT5 and TRT7 versus TRT4 and TRT6. However, TRT5 and TRT7 pigs had greater IV values (2.04 units, P = 0.012) and greater omega-6 to omega-3 ratios (P = 0.005) than TRT4 and TRT6 pigs.

Dietary changes for the fatty acid concentrations of the outer backfat layer are similar to changes found for inner backfat layers. The concentrations of saturated fatty acids (P < 0.012) were less for TRT2 than TRT1 with the exception of C22:0 which was greater for TRT1 (P = 0.001). Omega-3 fatty acids, C18:3n3 and C20:5n3, were greater (P < 0.005) for TRT2 than TRT1. The greater of difference between TRT1 and TRT2 occurred C18:2n6 concentration (10.88% and 18.33%, P = 0.001). Pigs of TRT2 had lesser C16:1n7, C16:3n4, C18:1n9, C18:1n7 concentrations (P < 0.006) and greater C20:4n6 and C22:4n6 concentrations than TRT1 (P = 0.001). As observed in the inner backfat fatty acid profile, the IV and omega-6 to omega-3 ratio were greater and the saturated to unsaturated ratio less for TRT2 pigs than to TRT1 pigs (P = 0.001).

Pigs of TRT3 had greater C18:0 concentrations (10.83 to 11.66%) than TRT2 pigs (P = 0.023). Pigs of TRT3 had lower C18:2n6 concentrations than TRT2 pigs (18.33 to 16.25%, P = 0.001). Pigs of TRT3 tended to have less C18:3n3 (P = 0.061) and C20:1n9 (P = 0.100) then TRT2 pigs. Also, C20:4n6, C22:4n6, and C22:0 concentrations were less for TRT3 than TRT2 pigs (P < 0.014). The TRT3 pigs has 3.01 units lesser IV values (P = 0.010) and 1.79 unit omega-6 to omega-3 ratios than TRT2 pigs (P = 0.010). Pigs of TRT3 tended to have greater saturated to unsaturated ratios then TRT2 pigs (P = 0.053).

The comparison of TRT1 vs. TRT3 pigs of the outer backfat layer resulted with the same statistical differences. The comparisons of TRT1 to TRT2 with the exception of C18:2n10,12 which tended (P = 0.101) to be less for TRT3 pigs than TRT1 pigs.

Pigs of TRT4 and TRT5 had greater C14:0 (P = 0.096) and C22:0 (P = 0.004) concentrations than TRT3 pigs. The following unsaturated fatty acid C18:1n7, C18:2n 9,11, and C22:4n6 were greater (P < 0.035) or tended to be greater (C20:1n9, P = 0.096) while C18:2n6 concentration were less (P = 0.022) for TRT4 and TRT5 than TRT3. As observed in the inner backfat layer, no significant differences were observed for IV and the saturated to unsaturated ratio in the outer backfat layer for TRT3 vs. TRT4 and TRT5. However, the omega-6 to omega-3 ratios were less (19.32 to 17.8) for TRT3 than TRT4 and TRT5 (P = 0.010).

The concentration of all saturated fatty acids with the exception of C22:0 were greater for TRT4 and TRT5 (P < 0.006) than TRT6 and TRT7. The following unsaturated fatty acids were greater for TRT6 and TRT7 pigs than TRT4 & TRT5 pigs: C18:1n9, C 18:1n7, C18:3n3, and C20:1n9 (P < 0.016), while C18:2n6 (P = 0.083) and C20:4n6 (P = 0.088) tended to be greater for TRT6 and TRT7 pigs than TRT4 and TRT5 pigs. Pigs of TRT6 and TRT7 had less C18:2n10,12 (P = 0.013) and tended to have less C18:3n4 (P = 0.051) and C22:1 (P = 0.054) than TRT4 and TRT5 pigs. The IV values for TRT6 and TRT7 pigs were 2.27 units greater than TRT4 and TRT5 pigs (P= 0.010). Pigs of TRT4 and TRT6 had greater concentration of unsaturated C16 fatty acids than TRT5 and TRT7 pigs (P < 0.031). The C18:2n6 (15.98 to 15.25, P = 0.025) and C22:0 concentrations (P = 0.016) were greater for TRT5 and TRT7 than TRT4 and TRT6. The concentrations of both omega-6 fatty acids C20:4n6 and C22:4n6 were less for TRT4 and TRT6 than TRT5 and TRT7 (P < 0.023). Feeding beef tallow (TRT4 and TRT6) increased C18:2n9,11 concentration (P = 0.001) and tended to decrease C18:2n10,12 concentrations (P = 0.098). The IV for TRT4 and TRT6 tended to be less than for TRT5 and TRT7 pigs (P = 0.068). The omega-6 to omega-3 ratios were greater for TRT5 and TRT7 pigs than TRT4 and TRT6 pigs (P = 0.010).

Least square means for the belly fatty acid profiles can be found in Table 11. The saturated fatty acids C14:0, C16:0, and C18:0 were all greater in TRT1 than TRT2 (P < 0.041) as were C16:1n7, C18:1n9, and C18:1n7 (P < 0.010). All of the omega-6 fatty acids were greater for TRT2 than TRT1 (P < 0.048) with the greatest difference occurring for C18:2n6 (9.34 to 16.21%, P = 0.001). Similarly, the omega-3 fatty acids (C18:3n3 and C20:5n3) were greater for TRT2 than TRT1 (P < 0.004). The IV, saturated to unsaturated ratio, and the omega-6 to omega-3 ratios for belly fat followed the same treatment differences as the inner and outer backfat layers. The IV value for TRT2 was 9.26 units greater than the IV value for

TRT1 (P = 0.001). The saturated to unsaturated ratio was greater for TRT1 than TRT2 (P = 0.001). The omega-6 to omega-3 ratio was 3.4 units less for TRT1 than TRT2 (P = 0.001).

The concentration of 18:0 was 0.93% greater (P = 0.015) and concentration of C18:2n6 was lesser (P < 0.001) for TRT3 than TRT2. The concentration of unsaturated fatty acids, C18:3n3 (P = 0.014), C20:1n9 (P = 0.091), C20:4n6 (P = 0.001), and C22:4n6 (P = 0.014) were greater for TRT3 than TRT2. The IV were 3.24 units less (P = 0.001) and the omega-6 to omega-3 ratios were less (P = 0.005) for TRT3 than TRT2. The saturated to unsaturated ratio of the belly fat was greater for TRT3 pigs than TRT2 pigs (P = 0.037). The saturated fatty acids C16:0 and C18:0 were greater (P = 0.010) and C20:0 tended to be greater (P = 0.088) for TRT1 than TRT3. The following unsaturated fatty acids: C16:1n7, C18:1n9, and C18:1n7 were less for TRT3 pigs than TRT1 pigs (P < 0.010). All of the omega-6 and omega-3 fatty acids were greater in the belly fat of TRT3 pigs than TRT1 pigs (P < 0.084). The IV were greater for TRT1 pigs than TRT3 pigs (57.09 to 63.11, P = 0.001). The saturated to unsaturated ratios of belly fat were less for TRT1 pigs than TRT3 pigs (P = 0.010). The omega-6 to omega-3 ratios were greater for TRT3 pigs than TRT1 pigs (P =0.010).

The saturated fatty acid C18:0 tended to be greater for the belly fat of TRT3 (P = 0.075) than TRT4 and TRT5. The concentration of C18:1n7 was greater in the belly fat of TRT4 and TRT5 pigs than TRT3 pigs (P = 0.010). The following fatty acids: C18:3n3, C20:1n9, and C22:4n6 all tended to be greater for TRT4 and TRT5 pigs than TRT3 pigs (P < 0.076). No significant differences were observed for IV or the saturated to unsaturated ratio for the contrast of TRT3, TRT4 and TRT5. However, the omega-6 to omega-3 ratiso were greater for TRT3 than TRT4 versus TRT5 pigs (P = 0.010). The following saturated FA's: C14:0, C16:0, and C18:0 were all greater for TRT4 and TRT5 pigs than TRT6 and TRT7 pigs (P < 0.010). The concentration of C20:0 tended to be greater for TRT4 and TRT5 than TRT6 and TRT7 (P = 0.064). The following unsaturated FA's: C18:1n9, C18:1n7, C18:3n3, C20:1n9, and C20:4n6 were all greater for TRT6 and TRT7 pigs than TRT4 and TRT5 pigs (P < 0.017). The concentrations of C18:2n6 and C22:6n3 both tended to be greater (P < 0.091) for TRT6 and TRT7 pigs than TRT4 and TRT5 pigs. The IV and saturated to unsaturated ratio for the belly fat FA profiles followed the same relationship as the inner and outer backfat layers. The IV values were less for TRT4 and TRT5 and saturated to unsaturated ratio greater than TRT6 and TRT7 (P < 0.010). The omega-6 to omega-3 ratio was 1.13 units greater for TRT4 and TRT5 than TRT6 and TRT7. Concentrations of C18:2n6 was 0.86% greater for TRT5 and TRT7 than TRT4 and TRT6 (P = 0.026). The omega-6 fatty acids C20:4n6 and C22:4n6 were greater for TRT5 and TRT7 than TRT4 and TRT6 (P < 0.004). The IV for TRT4 and TRT6 was greater than TRT5 and TRT7 (65.27 vs 63.93, P = 0.048). The omega-6 to omega-3 ratios tended to be greater for TRT5 and TRT7 than TRT4 and TRT6 (P = 0.051).

Least square means for loin fatty acid profiles can be found in Table 12. The fatty acid profiles of the loin were impacted less by diet than the fatty deposits of backfat and belly. Feeding DDGS (TRT2) decreased loin C18:0 (P = 0.005), but increased C18:1n9 (P = 0.018), and C18:2n6 (6.30 and 9.38%, P = 0.001) in comparison to the corn-SBM control (TRT1). The IV for TRT2 were 3.06 units greater than TRT1 (P = 0.012). Pigs of TRT2 had slightly lower saturated to unsaturated ratios than TRT1 pigs (P = 0.060). Concentrations of C18:0 was greater for TRT1 than TRT3 (P= 0.037). The concentration of C18:2n6 was 2.29% greater for TRT3 than TRT1 (P = 0.002). Pigs of TRT3 had 2.99 units greater IV than TRT1 pigs (P = 0.014) and lower saturated to unsaturated ratio (P = 0.098). Pigs of TRT6 and TRT7 had less 0.48% less C18:0 than pigs of TRT4 and TRT5(P = 0.023). Both C18:3n6 and C22:4n6 tended to be less for TRT6 and TRT7 than TRT4 and TRT5 (P < 0.091). However, C20:1n9 and C22:6n3 tended to be greater for TRT6 and TRT7 than TRT4 and TRT5 (P <0.090). No differences were observed for the following contrasts: TRT2 vs. TRT3, TRT3 vs. TRT4 and TRT5, and TRT4 and TRT6 vs. TRT5 and TRT7 for loin fatty acid profiles.

Sex Effects

Gilts were 0.66 lb lighter than barrows (P = 0.029) at the initial BW. From d 0-28 and d 28-56, barrows had greater ADG (P < 0.007) and ADFI (P < 0.001) than gilts. Barrows were heavier than gilts at 56 d (P = 0.001). However, gilts tended to be more efficient during d 28-56 (P = 0.067). No significant differences were observed between barrows and gilts for ADG, ADFI, or G:F for d 56-77. Barrows weighed 11 lb more than gilts on d 77 (P = 0.001). From d 77-103, gilts had 0.22 lb/d greater ADG (P = 0.017) and greater G:F (P = 0.042) than barrows. Overall growth data showed no differences in total gain or ADG for d 0-103 between barrows and gilts. Barrows had greater ADFI than gilts (6.06 and 5.69 lb/d, P = 0.021). However, gilts were significantly more efficient than barrows (0.35 and 0.33 G:F, P = 0.043).

Gilts had 10.6 lb lighter carcass weight and 2.3 percentage units less carcass yield (P = 0.001) than barrows. Gilts were leaner than barrows at all three of the backfat depths measured (P = 0.001). Gilts had 2.1 percentage units greater predicted percent lean than barrows (P = 0.001). Gilts had greater liver (P = 0.030) and combined liver + kidney weight (P = 0.034) than barrows. Barrows had 0.88 lb greater leaf fat than gilts (P = 0.001). When organ tissues were expressed as a percent of BW, gilts had a greater percent of kidney (P = 0.033), liver (P = 0.001), and liver + kidney (P = 0.001) weight than barrows. Barrows tended to have a greater amount of loin lipid content than gilts (P = 0.072). The ham pH tended to be lower for gilts than barrows (P = 0.073). Barrows tended to have a greater Minolta L* (P = 0.095), and had greater Minolta b* values (P = 0.015) than gilts. Increase of loin backfat separation was greater in gilts than barrows (69.09 vs. 44.64%; P = 0.01).

The effect of sex on belly parameters and bacon slices revealed several differences between barrows and gilts. Whole bellies from gilts were wider than whole bellies from barrows (8.1 vs. 7.56 in; P = 0.001). However, no statistical differences were observed in length, green weight, pump weight, brine weight, smoke weight, pump yield, or smoke yield between barrows and gilts. Whole bellies from gilts had greater AVF than barrows (P = 0.033). The amount of webbing was 12.3 mm greater for gilts than barrows (P = 0.044). After cooking the bacon slices, barrows had significantly lighter (P = 0.014) and shorter (P = 0.002) slices than bacon slices from gilts. Barrows had greater bacon length loss (P = 0.003) and weight loss (P = 0.001) on a percentage basis than gilts. Bacon slices from barrows contained less lean than bacon slices from gilts (P = 0.001).

Fatty acid profiles were affected similarly by pig sex in the backfat and belly. Barrows had greater concentration of the saturated fatty acids C14:0 and C16:0, but less C18:0 than gilts. Barrows tend to have greater C16:1n7 , C16:3n4, and C18:1n7 concentrations than gilts. Gilts tended to have greater concentrations of C18:2n6, C18:3n4 and C20:4n6 than barrows. Barrows tended to have greater C22:1 and C22:4n6 concentrations than gilts. There were slight differences between barrows and gilts in backfat IV, saturated to unsaturated ratio, or the n-6:n-3 ratio for the belly and backfat. In the loin, barrows tended to have higher levels of saturated fatty acids (C14:0, C16:0, and C20:0) in the loin compared to gilts. Gilts had less loin C16:1n7, C18:1n7, and C20:4n6 than barrows. There were no sex effects on IV, saturated to unsaturated ratio, or omega-6 to omega-3 ratio in the loin fatty acids.

Discussion

Growth Performance

The addition of CWG to a corn-SBM diet with 20% DDGS decreased ADFI and increased G:F during the first three phases of pig growth. This finding is in agreement with Gatlin et al., (2002); Eggert et al., (2007); and Apple et al., (2008) who added fat to corn-SBM diets. The addition of CWG or BT to a corn-SBM control increased ADG and increased Gain:Feed over the corn-SBM diet with 20% DDGS during the final 26 d of growth. This decrease in performance with the inclusion of DDGS has been noted by others (Fu et al., 2004; Whitney et al., 2006; and Linneen et al., 2007). During the last stage of finishing after the diet switch and from a corn-SBM diet with 20% DDGS to either a corn-SBM or corn-SBM with 5% added fat, ADG significantly increased and resulted with a trend for increased feed efficiency. Eggert et al., (1998); Gatlin et al., (2002); and Weber et al., (2006) all showed that the addition of 5% BT to pig diets had minimal effects on overall pig growth in regards to ADG, ADFI and G:F compared to 0% added fat diets. This increase in ADG was not observed if 5% added fat was fed the first three phases of finishing. However, pigs fed 5% added fat for the duration of the study were more efficient overall. Our data indicated that if the pigs were previously fed a diet with 2% DDGS there was increased growth response to BT in the final 26 d before slaughter with potentially some compensatory gain.

For the duration of the study, barrows consumed more feed and gained more weight more compared to gilts. Gilts consumed less feed and were more efficient which is in agreement with Schinckel et al., (1994), and Thompson et al., (1996), and Eggert et al. (2007).

Carcass Quality

Hot carcass yield decreased for pigs fed corn-SBM with 20% DDGS in comparison to pigs fed corn-SBM (Cook et al., 2005; Whitney et al., 2006; Hinson et al., 2007). Last rib backfat and 10th rib LMA decreased for pigs fed corn-SBM with 20% DDGS compared to a corn-SBM diet which is in agreement with Whitney et al., (2006). Changes in carcass composition and growth occurred even with diets formulated to an equal dig. Lys: calorie ratio. Increased in liver and kidney weights were also observed for pigs fed corn-SBM with 20% DDGS compared to the corn-SBM fed pigs, possibly due in part to an increased crude protein percentage in the corn-SBM with 20% DDGS diet needed which to be metabolized and excreted. After withdrawal of DDGS, pigs fed a corn-SBM diet over the last phase of finishing had decreased liver and kidney weights. These differences in kidney and liver weights agree with previously reported data by Weimer et al. (2008).

Adding 20% DDGS in corn-SBM diets significantly increased the amount of backfat separation between the fat layers and between the inner layer of backfat and loin. Feeding a corn-SBM diet the last phase of finishing without DDGS resulted in a reduction in backfat separation. In a study conducted by Weimer et al. (2008) feeding DDGS significantly increased separation between the backfat layers. Gilts had significantly greater incidence of backfat separation than barrows, similar to that reported by Weimer et al. (2008)

Bacon and Belly Quality

Whole bellies from pigs fed corn-SBM with 20% DDGS had significantly more flex than bellies from pigs fed corn-SBM. This increase in flex is in agreement with Widmer et al., (2008). Bacon slices from pigs fed corn-SBM diets were heavier and resulted in slightly more cracks in the bacon slice than pigs fed corn-SBM with 20% DDGS. Switching diets from corn-SBM with 20% DDGS to a corn-SBM diet the last month of finishing had no affect on bacon and belly parameters. The inclusion of 5% added fat during the last phase of finishing improved belly firmness of pigs fed corn-SBM with 20% DDGS in the previous phases. This conclusion is in agreement with Eggert et al. (1998) in which found that adding beef tallow improved belly firmness in lean pigs.

Fatty Acid Profiles

In all 3 fat depots (inner and outer backfat and belly), the degree of unsaturation increased with feeding corn-SBM with 20% DDGS. Feeding corn-SBM diets with 20% DDGS increased the concentrations of linoleic acid by 70 to 87% in the backfat and belly fat tissues. Feeding corn-SBM based diets with 20% DDGS increased the IV of the backfat and belly fat tissues from 9.2 to 11.3 units. The feeding of 20% DDGS also decreased the saturated to unsaturated ratio and increased the omega-6 to omega-3 ratios. White et al. (2009) found increased IV values for pigs fed 20 to 40 percent DDGS the last 30 d prior to slaughter (IV values of 65.1, 67.8 and 74.3 for 0, 20 and 40% DDGS diets). Similar trends were observed for the LM fatty acids. Switching from corn-SBM with 20% DDGS to corn-SBM the last 26 d prior to slaughter resulted in linoleic acid concentrations, IV values and saturated to unsaturated values which were intermediate to the corn-SBM and corn-SBM-20% a 4 week withdrawal will partially alter the fatty acid profile of adipose tissue through dietary intervention and recover the negative effects associated with feeding 20% DDGS on fat quality.

However, the impact of feeding 20% DDGS on fatty acid measurements (linoleic acid, IV value saturated:unsaturated ratio) were only reduced by 28 to 39 percent by the withdrawal of the 20% DDGS and feeding of the control corn-soybean meal diet. The percentage of reduction in the impact of feeding 20% DDGS was reduced to a slightly greater extent in for the inner backfat layers (35% for 18:2 concentration and 37% for IV) and belly (32% for 18:2 concentration and 35% for IV) than the outer layers of backfat (28 and 30%, respectively). The impact of switching to diet with concentration of linoleic acid was completed by Boyd et al. (1997). The feed diets containing 1.3, 1.7, 2.1, 2.5 and 3.7% linoleic acid from 36 to 118 kg BW. A sixth treatment was a withdrawal program of feeding 3.7% linoleic acid from 36 to 90 kg BW and a diet containing 1.90% linoleic acid from 90 to 118 kg BW. The percent reduction in the impact of feeding a diet containing 3.7% linoleic acid can be estimated if the mean of the 1.7 and 2.1% linoleic acid diets are used to predict the expected fatty acid concentrations had a 1.9% linoleic acid been fed from 36 to 118 kg BW. The estimated percent reductions in outer backfat layer IV values and linoleic acid concentrations by withdrawal the last 28 kg BW gain were 7 and 16%. Much greater percentage reductions were found for inner layer of backfat (53 and 46%) and belly fat (41 and 47%).

It would be expected that the diets fed in later finishing would have greater relative impact to change the fatty acid concentrations of the later making fat depots than the early maturing fat depots (Eggert et al., 1998; Weber et al., 2006). The withdrawl of the 20% DDGS and switching to diets with lesser concentrations of unsaturated fatty acids primarily has its impact by dilution of the fatty acids present at the time of the diet change (Gatlin et al., 2002). The turnover rate of fatty acids such as linoleic acid is very slow in fat tissue (330 d half-like, Anderson et al., 1972).

Withdrawal diets with increased energy concentrations added CWG and beef tallow may allow for greater daily lipid accretion and greater dilution of the more unsaturated fat acids. The CWG fed in this trial contained 14% linoleic acid and had an IV of 58.0. If corn-soybean meal containing 20% DDGS based diets are fed during the entire grow-finishing period, then the concentrations of linoleic acid are and IV values of the CWG will likely increase. Feeding this more unsaturated CWG will further increase the concentrations of linoleic acid and IV values in the pork fat until a plateau is achieved. The fatty acid concentrations of BT is not greatly affected by the feeding of DDGS. Feeding BT, the last 28 day prior to slaughter could reduce the impact of feeding DDGS on pork fat quality.

Adding 5% added fat to a corn-SBM diet decreased the omega-6 to omega-3 ratio in all adipose depots when compared to pigs fed corn-SBM the last phase of finishing and corn-SBM with 20% DDGS in the first three phases. Feeding 5% added fat in combination with corn-SBM with 20% DDGS or during the duration of finishing with corn-SBM at the end significantly increased the IV of all adipose tissues measured.

Pigs fed 5% added fat with a corn-SBM diet the last 4 weeks of finishing deposited significantly more saturated and monounsaturated fatty acids (MUFA) than pigs fed a corn-SBM diet the last phase of finishing in inner layers and outer layer of backfat and belly adipose tissue resulting in decreased IV values. Romans et al. (1995) found that feeding 15% linseeds for 28 d resulted in no changes in the fatty acid profile. Our data would suggest that 26 d does significantly alter the fatty acid concentrations resulting in changes in IV, saturated to unsaturated ratio, and omega-6 to omega-3 ratio.

Eggert et al. (2001) reported that an IV value of 65 taken from the clearplate is acceptable. The Danish acceptable threshold is 70 (Barton and Gade, 1987; Madsen et al., 1992). In contrast, Goodband et al. (2006) and Boyd et al. (1997) suggested that IV values of 70 or 74, respectively, are acceptable. The Swiss pork industry has taken the most proactive approach to the fat quality (Scheeder and Wenk, 1998). In Swiss pork processing plants, a semi-automated method is used to estimate the number of double bonds in the outer layer of backfat. A fat score is established that has a high linear relationship with the IV value (IV value = 1.267 (fat score) – 12.26. Fat tissue is taken, essentially scratched from each carcass and combined for the entire group. Fat scores of 60 to 62 are tolerable (approximate IV of 64). Fat scores of 62 to 64 (IV values of 66.3 to 68.8) are discounted 0.10 SFr per kg carcass weight. Carcasses with fat scores of 64 to 66 and approximate IV values of 68.8 to 71.4, are discounted 0.40 SF4 per kg and fat scores above 66 with IV values of 71.4 are discounted 1.0 SFr per kg carcass weight when the average price is about 4.2 SFr per kg. Pork processors in the United States have not provided pork producers with clearly defined IV targets. Our data suggests that feeding 20% DDGS the entire grow-finish period would result in acceptable IV values according to Boyd et al. (1997) and Goodband et al. (2006).

Table 1. Grower 1 diet formulation and nutrient levels for pigs from d 0-28.

Ingredient, %	Control	20% DDGS	20% DDGS + 5% CWG
Corn	77.065	57.586	52.423
SBM, 48% CP	19.850	19.850	19.850
DDGS	0.000	20.000	20.000
Choice White Grease	0.000	0.000	5.000
Limestone	0.950	1.275	1.260
Dicalcium Phos.	0.900	0.290	0.320
Vitamin Premix[1]	0.150	0.150	0.150
Trace Mineral Premix[2]	0.100	0.100	0.100
L-Lysine-HCL	0.280	0.219	0.302
DL- Methionine	0.060	0.000	0.010
L-Threonine	0.095	0.000	0.040
L-Tryptophan	0.020	0.000	0.015
Salt, CTC, Phytase[3]	0.530	0.530	0.530
Total	100.000	100.000	100.000
Calculated Nutrient Levels			
ME, Kcal/kg	3306.6	3373.1	3579.9
Lysine: Calorie	2.57	2.57	2.57
CP,%	15.78	19.35	19.08
Lys, %	1.01	1.09	1.15
Ca, %	0.65	0.65	0.65
P, %	0.48	0.48	0.47
Phytase. Avail. P, %	0.30	0.30	0.30
Dig. Lys, %	0.85	0.86	0.92
Dig. Met, %	0.27	0.28	0.28
Dig. M+C,%	0.50	0.54	0.54
Dig. Thr, %	0.51	0.52	0.55
Dig. Try, %	0.15	0.15	0.16
Dig, Iso, %	0.53	0.63	0.62
Dig, Val, %	0.58	0.72	0.70
Analyzed Values			
Crude Fat, %	3.11	4.86	10.52
Dietary Fat IV	105.18	114.02	87.303

[1] Vitamin premix supplied per kg of diet:: Vitamin A, 3637 IU; Vitamin D, 364 IU; Vitamin E, 26.4 IU; Menadione, 1.20 mg; Vitamin B_{12}, 21.2 µg; Riboflavin, 4.23 mg; d-Pantothenic Acid, 13.2 mg; Niacin, 19.8 mg.
[2] TM premix supplied per kg of diet: Iron, 97 mg; Zinc, 97 mg; Manganese, 12 mg; Copper, 9 mg; Iodine,0.335 mg, Selenium 3 mg
[3] Other as % of diet: Salt, 0.25; Phytase, 0.08 (Danisco Animal Health, St. Louis, MO; Phytase 600); CTC 50, 0.1(Alpharma Bridgewater, NJ).

Table 2. Grower 2 diet formulation and nutrient levels for pigs form d 28-56.

Ingredient, %	Control	20% DDGS	20% DDGS + 5% CWG
Corn	81.460	61.963	56.283
SBM	15.680	15.680	15.680
DDGS	0.000	20.000	20.000
Choice White Grease	0.000	0.000	5.000
Limestone	1.010	1.330	1.320
Dicalcium Phos.	0.630	0.020	0.050
Vitamin Premix[1]	0.150	0.150	0.150
Trace Mineral Premix[2]	0.100	0.100	0.100
L-Lysine-HCL	0.280	0.217	0.292
DL- Methionine	0.040	0.000	0.000
L-Threonine	0.100	0.000	0.040
L-Tryptophan	0.020	0.010	0.015
Salt, CTC, Phytase[3]	0.530	0.530	0.530
Total	100.000	100.000	100.000
Calculated Nutrient Levels			
ME, Kcal/kg	3315.9	3367.5	3589.5
Lysine: Calorie	2.26	2.26	2.26
CP,%	14.13	17.71	17.42
Lys, %	0.89	0.98	1.02
Ca, %	0.60	0.60	0.60
P, %	0.41	0.41	0.41
Phytase Avail. P, %	0.24	0.24	0.24
Dig. Lys, %	0.75	0.76	0.81
Dig. Met, %	0.24	0.26	0.25
Dig. M+C,%	0.44	0.51	0.49
Dig. Thr, %	0.46	0.47	0.50
Dig. Try, %	0.13	0.14	0.14
Dig, Iso, %	0.46	0.57	0.55
Dig, Val, %	0.51	0.65	0.64
Analyzed Values			
Crude Fat, %	2.68	5.21	9.20
Dietary Fat IV	80.41	108.39	81.63

[1] Vitamin premix supplied per kg of diet:: Vitamin A, 3637 IU; Vitamin D, 364 IU; Vitamin E, 26.4 IU; Menadione, 1.20 mg; Vitamin B_{12}, 21.2 µg; Riboflavin, 4.23 mg; d-Pantothenic Acid, 13.2 mg; Niacin, 19.8 mg.
[2]TM premix supplied per kg of diet: Iron, 97 mg; Zinc, 97 mg; Manganese, 12 mg; Copper, 9 mg; Iodine,0.335 mg, Selenium 0.3 mg
[3] Other as % of diet: Salt, 0.25; Phytase, 0.08 (Danisco Animal Health, St. Louis, MO; Phytase 600); CTC 50, 0.1(Alpharma Bridgewater, NJ).

Table 3. Finisher 1 diet formulation and nutrient levels for pigs from d 56-77.

Ingredient, %	Control	20% DDGS	20% DDGS + 5% CWG
Corn	86.430	66.896	61.775
SBM	10.880	10.880	10.880
DDGS	0.000	20.000	20.000
Choice White Grease	0.000	0.000	5.000
Limestone	1.000	1.250	1.255
Dicalcium Phos.	0.480	0.000	0.000
Vitamin Premix[1]	0.125	0.125	0.125
Trace Mineral Premix[2]	0.075	0.075	0.075
L-Lysine-HCL	0.300	0.234	0.300
DL- Methionine	0.040	0.000	0.000
L-Threonine	0.110	0.000	0.040
L-Tryptophan	0.030	0.010	0.020
Salt, CTC, Phytase[3]	0.530	0.530	0.530
Total	100.000	100.000	100.000
Calculated Nutrient Levels			
ME, Kcal/kg	3323.7	3374.0	3596.6
Lysine: Calorie	1.96	1.96	1.96
CP,%	12.27	15.83	15.54
Lys, %	0.77	0.86	0.90
Ca, %	0.55	0.55	0.55
P, %	0.36	0.39	0.38
Phytase Avail. P, %	0.20	0.23	0.22
Dig. Lys, %	0.65	0.66	0.70
Dig. Met, %	0.22	0.24	0.23
Dig. M+C,%	0.40	0.46	0.45
Dig. Thr, %	0.41	0.41	0.44
Dig. Try, %	0.11	0.11	0.12
Dig, Iso, %	0.39	0.49	0.48
Dig, Val, %	0.44	0.58	0.57
Analyzed Values			
Crude Fat, %	2.96	4.39	9.51
Dietary Fat IV	107.51	111.08	86.88

[1] Vitamin premix supplied per kg of diet: Vitamin A, 2426 IU; Vitamin D, 242 IU; Vitamin E, 17.6 IU; Menadione, 0.8 mg; Vitamin B_{12}, 14.1 µg; Riboflavin, 2.82 mg; d-Pantothenic Acid, 8.8 mg; Niacin, 13.2 mg.
[2]TM premix supplied per kg of diet: Iron, 48.5 mg; Zinc, 48.5 mg; Manganese, 6 mg; Copper, 4.5 mg; Iodine,0.184 mg, Selenium 0.3 mg
[3] Other as % of diet: Salt, 0.25; Phytase, 0.08 (Danisco Animal Health, St. Louis, MO; Phytase 600); Cholorotetracycline, 0.023ppm(Alpharma Bridgewater, NJ).

Table 4. Finisher 2 diet formulation and nutrient levels for pigs from d 77-103.

Ingredient, %	Control	20% DDGS	Control + 5% CWG	Control + 5% BT
Corn	88.720	69.042	83.564	83.570
SBM	9.000	9.000	9.000	9.000
DDGS	0.000	20.000	0.000	0.000
Choice White Grease	0.000	0.000	5.000	0.000
Beef Tallow	0.000	0.000	0.000	5.000
Limestone	0.960	1.140	0.960	0.960
Dicalcium Phos.	0.340	0.000	0.360	0.360
Vitamin Premix[1]	0.125	0.125	0.125	0.125
Trace Mineral Premix[2]	0.075	0.075	0.075	0.075
L-Lysine-HCL	0.230	0.162	0.288	0.285
DL- Methionine	0.000	0.000	0.036	0.035
L-Threonine	0.075	0.000	0.107	0.105
L-Tryptophan	0.020	0.001	0.030	0.030
Salt, CTC, Phytase[3]	0.455	0.455	0.455	0.455
Total	100.000	100.000	100.000	100.000
<u>Calculated Nutrient Levels</u>				
ME, Kcal/kg	3338.4	3383.8	3559.8	3546.3
Lysine: Calorie	1.65	1.65	1.65	1.65
CP,%	11.43	15.03	11.14	11.13
Lys, %	0.67	0.75	0.70	0.70
Ca, %	0.50	0.50	0.50	0.50
P, %	0.33	0.38	0.32	0.32
Phytase Avail. P, %	0.17	0.22	0.17	0.17
Dig. Lys, %	0.55	0.56	0.59	0.59
Dig. Met, %	0.17	0.23	0.20	0.20
Dig. M+C,%	0.34	0.45	0.37	0.36
Dig. Thr, %	0.36	0.39	0.38	0.38
Dig. Try, %	0.09	0.10	0.10	0.10
Dig, Iso, %	0.36	0.46	0.35	0.35
Dig, Val, %	0.41	0.55	0.40	0.40
<u>Analyzed Values</u>				
Crude Fat, %	2.64	4.92	6.02	5.63
Dietary Fat IV	98.03	112.74	61.19	50.12

[1] Vitamin premix supplied per kg of diet: Vitamin A, 2426 IU; Vitamin D, 242 IU; Vitamin E, 17.6 IU; Menadione, 0.8 mg; Vitamin B_{12}, 14.1 µg; Riboflavin, 2.82 mg; d-Pantothenic Acid, 8.8 mg; Niacin, 13.2 mg.
[2]TM premix supplied per kg of diet: Iron, 48.5 mg; Zinc, 48.5 mg; Manganese, 6 mg; Copper, 4.5 mg; Iodine,0.184 mg, Selenium 0.3 mg
[3] Other as % of diet: Salt, 0.25; Phytase, 0.08 (Danisco Animal Health, St. Louis, MO; Cholorotetracycline, 0.023ppm (Alpharma Bridgewater, NJ).

Table 5. The main effect means of feeding corn-SBM based diets with distillers dried grains with solubles (DDGS) with or without supplemental choice white grease(CWG) on pig growth performance.

Diet from d 0-77	Corn-SBM Control	20% DDGS	20% DDGS + 5% CWG	Diet Probability, P<
Number of Pens	8	32	16	
Initial BW, lb	64.1	63.5	63.7	0.40
Day 0-28				
ADG, lb/d	1.82	1.77	1.78	0.72
ADFI, lb/d	3.94^{a}	3.88^{ab}	3.68^{b}	0.05
G:F	0.462^{ab}	0.457^{b}	0.486^{a}	0.04
d 28 BW, lb	115.2	113.0	113.7	0.53
Day 28-56				
ADG, lb/d	2.02	1.96	1.95	0.66
ADFI, lb/d	5.80	5.84	5.45	0.16
G:F	0.351	0.339	0.362	0.21
d 56 BW, lb	171.9	167.9	168.9	0.48
Day 56-77				
ADG, lb/d	2.01	2.01	2.08	0.64
ADFI, lb/d	6.71	6.93	6.32	0.14
G:F	0.305^{ab}	0.296^{b}	0.336^{a}	0.03
d 77 BW, lb	215.9	212.0	214.6	0.52
Day 0-77				
ADG, lb/d	1.97	1.93	1.96	0.60
ADFI, lb/d	5.46	5.50	5.13	0.07
G:F	0.363^{ab}	0.354^{b}	0.385^{a}	0.004
Diets were switched at day 77, the data below only represents how pigs previously fed these treatments performed the last month before slaughter and overall. For the interactive dietary treatment means see Table 4.				
Day 77-103				
ADG, lb/d	2.08	2.09	2.14	0.90
ADFI, lb/d	7.47	7.63	7.30	0.54
G:F	0.281	0.277	0.296	0.43
d 103 BW, lb	270.6	266.9	270.7	0.59
Day 0-103				
ADG, lb/d	1.98	1.95	1.99	0.64
ADFI, lb/d	5.91	5.99	5.63	0.11
G:F	0.337^{ab}	0.328^{b}	0.356^{a}	0.005

There were no dietary treatment by sex interactions (P>0.30).
[ab] Superscripts with different letters differ (P<0.05) based on mean separation using the Duncan's procedure.

Table 6. The effect of feeding corn-soybean meal or corn-soybean meal with 20% DDGS and alternative fat sources during the DDGS withdrawal period during late finishing on period and overall growth performance in grow-finish swine.

Diet	Tr 1[1]	Tr 2[2]	Tr 3[3]	Tr 4[4]	Tr 5[5]	Tr 6[6]	Tr 7[7]		Probability of Contrasts[8], P <					
d (0-77)	Diet 1	Diet 2	Diet 2	Diet 2	Diet 2	Diet 3	Diet 3							
d (77-103)	Diet 1	Diet 2	Diet 1	Diet 4	Diet 5	Diet 4	Diet 5	SE	1	2	3	4	5	6
Day 77-103														
ADG, lb/d	2.08[ab]	1.90[b]	1.98[ab]	2.33[a]	2.16[ab]	2.18[ab]	2.10[ab]	0.123	0.298	0.665	0.539	0.081	0.388	0.321
ADFI, lb/d	7.47	7.88	7.61	7.76	7.29	7.25	7.35	0.364	0.435	0.605	0.790	0.863	0.533	0.617
G:F	0.28[ab]	0.25[b]	0.26[ab]	0.30[a]	0.30[ab]	0.30[a]	0.29[ab]	0.016	0.163	0.609	0.371	0.055	0.810	0.540
d 103 BW, lb	270.6	262.0	268.8	273.7	262.9	271.0	270.5	4.73	0.207	0.320	0.785	0.938	0.616	0.241
Day 0-103														
ADG, lb/d	1.98	1.90	1.97	2.02	1.92	1.99	1.98	0.045	0.231	0.315	0.844	0.971	0.667	0.250
ADFI, lb/d	5.91	6.11	6.02	6.04	5.80	5.63	5.62	0.210	0.508	0.777	0.704	0.691	0.170	0.562
G:F	0.34[ab]	0.32[b]	0.33[ab]	0.34[ab]	0.33[ab]	0.36[a]	0.35[a]	0.010	0.142	0.428	0.489	0.556	0.031	0.651

[a,b,c,] Numbers in the same row with different superscripts differ by P < 0.05 based on means separation using the Duncan's test.

[1] Treatment 1 pigs fed corn-soybean meal control diet d 0-103

[2] Treatment 2 pigs fed corn-soybean meal with 20% DDGS diet from d 0-103

[3] Treatment 3 pigs fed corn-soybean meal with 20% DDGS diet from d 0-77 and corn-soybean meal control d 77-103

[4] Treatment 4 pigs fed corn-soybean meal with 20% DDGS diet from d 0-77 and corn-soybean meal with 5% beef tallow (BT) d 77-103

[5] Treatment 5 pigs fed corn-soybean meal with 20% DDGS diet from d 0-77 and corn-soybean meal with 5% choice white grease (CWG) d 77-103

[6] Treatment 6 pigs fed corn-soybean meal with 20% DDGS and 5% CWG d 0-77 and corn-soybean meal with 5% BT d 77-103

[7]Treatment 7 pigs fed corn-soybean meal with 20% DGGS and 5% CWG d 0-77 and corn-soybean meal with 5% CWG d 77-103

[8] Contrasts of Probability are as follows:

1. Treatment 1 vs Treatment 2
2. Treatment 2 vs Treatment 3
3. Treatment 1 vs Treatment 3
4. Treatment 3 vs Treatments 4 and 5
5. Treatments 4 and 5 vs Treatments 6 and 7
6. Treatments 4 and 6 vs Treatments 5 and 7

Table 7. The effect of feeding corn-soybean meal or corn-soybean meal with DDGS and alternative fat sources on carcass quality measurements in grow finish swine.

Diet	Tr 1[1]	Tr 2[2]	Tr 3[3]	Tr 4[4]	Tr 5[5]	Tr 6[6]	Tr 7[7]		Probability of Contrasts[8], P <					
d (0-77)	Diet 1	Diet 2	Diet 2	Diet 2	Diet 2	Diet 3	Diet 3							
d (77-103)	Diet 1	Diet 2	Diet 1	Diet 4	Diet 5	Diet 4	Diet 5	SE	1	2	3	4	5	6
Parameter														
Live Wt, lb	264.6	258.8	263.3	268.6	259.8	265.4	266.9	4.58	0.378	0.491	0.844	0.873	0.670	0.434
HCW, lb	204.4	195.9	201.9	206.0	199.2	205.6	206.7	4.09	0.146	0.301	0.667	0.889	0.391	0.489
Hot carcass yield, %	77.3[ab]	75.6[b]	76.7[ab]	76.7[ab]	76.6[ab]	77.5[a]	77.4[a]	0.54	0.034	0.164	0.441	0.940	0.129	0.878
Avg. percent lean[9], %	53.4	53.0	53.3	52.2	52.4	52.7	52.1	0.62	0.627	0.754	0.863	0.223	0.925	0.770
10th rib BF, in.	0.82	0.83	0.83	0.90	0.90	0.87	0.91	0.047	0.852	0.926	0.926	0.241	0.895	0.645
Last rib BF, in.	1.20	1.11	1.15	1.18	1.17	1.27	1.20	0.030	0.036	0.333	0.238	0.443	0.065	0.226
Last lumbar BF, in.	0.95	0.94	0.95	0.99	0.97	1.01	1.01	0.040	0.827	0.913	0.913	0.479	0.453	0.772
Loin muscle area, in^2	7.81	7.39	7.68	7.51	7.51	7.64	7.54	0.165	0.081	0.237	0.560	0.427	0.653	0.778
Carcass BF separation[10], %	12.50	68.75	56.25	53.33	56.25	81.25	68.75	---	---	---	---	---	---	---
Organ & Tissue Wt, lb														
Kidney	0.74	0.82	0.69	0.71	0.68	0.71	0.71	0.021	0.011	0.001	0.156	0.906	0.562	0.386
Liver	3.12	3.33	3.16	3.29	3.00	3.12	2.98	0.069	0.035	0.080	0.702	0.883	0.181	0.004
Liver & kidney	3.86	4.15	3.85	4.00	3.68	3.83	3.69	0.078	0.012	0.010	0.955	0.923	0.307	0.005
Leaf fat	2.54	2.56	2.30	2.77	2.67	2.73	2.88	0.170	0.938	0.293	0.329	0.051	0.622	0.869
LM Quality														
Color[11]	2.4	2.5	2.4	2.5	2.3	2.3	2.3	0.14	0.538	0.538	1.000	0.929	0.663	0.385
Marbling[11]	1.6[ab]	1.5[ab]	1.3[b]	1.4[b]	1.3[b]	1.2[b]	1.8[a]	0.13	0.614	0.403	0.184	0.698	0.288	0.049
IMF[12], %	9.75[xy]	8.65[y]	9.43[xy]	9.21[xy]	8.93[xy]	9.99[xy]	10.51[x]	0.620	0.216	0.380	0.713	0.639	0.064	0.855
Firmness[11]	2.5	2.3	2.4	2.5	2.1	2.3	2.4	0.19	0.346	0.555	0.723	0.495	0.802	0.453
Driploss, %	4.1	4.9	4.4	4.6	5.1	5.1	3.9	0.53	0.282	0.464	0.727	0.489	0.532	0.544
pH	5.4	5.4	5.3	5.4	5.4	5.4	5.4	0.03	0.821	0.565	0.727	0.559	0.991	0.972
Minolta L value[13]	47.7	46.9	47.7	47.5	48.4	47.9	47.0	0.60	0.344	0.351	0.990	0.682	0.394	0.959
Minolta a value[14]	10.2[ab]	9.8[b]	10.0[ab]	9.9[b]	10.5[ab]	10.8[a]	9.9[b]	0.26	0.324	0.603	0.638	0.538	0.551	0.650
Minolta b value[15]	3.1[abc]	2.5[c]	2.9[abc]	2.7[bc]	3.6[a]	3.5[ab]	2.7[bc]	0.26	0.074	0.291	0.447	0.341	0.689	0.884

Ham pH	5.5	5.5	5.5	5.4	5.5	5.5	5.5	0.04	0.462	0.626	0.803	0.666	0.230	0.947

[a,b,c] Numbers in the same row with different superscripts differ by P < 0.05 based on means separation using the Duncan's test.
[x,y] Numbers in the same row with different superscripts differ by P < 0.10 based on means separation using the Duncan's test.
[1] Treatment 1 pigs fed corn-soybean meal control diet from d 0-103)
[2] Treatment 2 pigs fed corn-soybean meal with 20% DDGS from d 0-103
[3] Treatment 3 pigs fed corn-soybean meal with 20% DDGS from d 0-77 and corn-soybean meal control d 77-103
[4] Treatment 4 pigs fed corn-soybean meal with 20% DDGS from d 0-77 and corn-soybean meal with 5% BT d 77-103
[5] Treatment 5 pigs fed corn-soybean meal with 20% DDGS from d 0-77 and corn-soybean meal with 5% CWG d 77-103
[6] Treatment 6 pigs fed corn-soybean meal with 20% DDGS and 5% CWG d 0-77 and corn-soybean meal with 5% BT d 77-103
[7]Treatment 7 pigs fed corn-soybean meal with 20% DDGS and 5% CWG d 0-77 and corn-soybean meal with 5% CWG d 77-103
[8] Contrasts of Probability are as follows:

1. Treatment 1 vs Treatment 2
2. Treatment 2 vs Treatment 3
3. Treatment 1 vs Treatment 3
4. Treatment 3 vs Treatments 4 and 5
5. Treatments 4 and 5 vs Treatments 6 and 7
6. Treatments 4 and 6 vs Treatments 5 and 7

[9] Average Percent Lean calculated as follows (Pounds of fat free lean/ divided by HCW). Pounds of fat free lean = 8.588 - (21.896 x 10^{th} rib BF) + (3.005 x 10^{th} rib LEA) + (0.465 x HCW)

[10] Means for back fat separation were analyzed using ProcFREQ procedure and the Cochran-Mantel-Haenszel statistical test, P < 0.005
[11] LM Quality: color (1-6) score of 3 (reddish pink) is ideal; marbling (1-10); firmness (1-5) score of 3 (slightly firm and moist) is ideal
[12] IMF is calculated on a freeze dried loin sample
[13] Minolta L value relates to the intensity of the lightness from the loin surface.
[14] Minolta a value relates to the redness of the loin surface.
[15] Minolta b value relates to the yellowness of the loin surface.

Table 8. The effect of feeding corn-soybean meal or corn-soybean meal with DDGS and alternative fat sources on bacon characteristics and belly bend in grow finish swine.

Diet	Tr 1[1]	Tr 2[2]	Tr 3[3]	Tr 4[4]	Tr 5[5]	Tr 6[6]	Tr 7[7]		Probability of Contrasts[8], P <					
d (0-77)	Diet 1	Diet 2	Diet 2	Diet 2	Diet 2	Diet 3	Diet 3							
d (77-103)	Diet 1	Diet 2	Diet 1	Diet 4	Diet 5	Diet 4	Diet 5	SE	1	2	3	4	5	6
Slice Parameters														
Cracks[9]	4.4[a]	2.8[ab]	2.4[b]	2.8[ab]	3.1[ab]	3.9[a]b	4.0[ab]	0.58	0.067	0.572	0.019	0.441	0.089	0.776
Webbing[10], mm	98.1[y]	109.8[xy]	109.4[xy]	119.6[x]	120.8[x]	109.5[xy]	113.5[xy]	7.82	0.298	0.976	0.312	0.266	0.272	0.740
Separation[11], mm	8.8	12.2	10.0	6.6	8.3	8.3	6.4	2.79	0.390	0.587	0.749	0.458	0.978	0.965
Raw wt, g	32.4[xy]	31.1[y]	31.7[xy]	32.2[xy]	32.1[xy]	34.1[x]	33.4[xy]	1.02	0.378	0.701	0.616	0.730	0.122	0.693
Raw length, mm	209.3	209.2	208.6	211.1	206.9	216.3	215.1	3.47	0.975	0.909	0.884	0.922	0.062	0.440
Cook wt, g	17.6[x]	15.0[xy]	15.9[xy]	15.9[xy]	15.4[xy]	15.4[xy]	14.6[y]	0.98	0.069	0.535	0.222	0.829	0.546	0.497
Cook Length, mm	178.8[xy]	178.4[xy]	180.0[xy]	182.6[x]	179.1[xy]	179.4[xy]	173.7[y]	2.95	0.909	0.702	0.788	0.814	0.154	0.127
Cook Score[12]	2.2[ab]	2.2[ab]	2.1[ab]	2.2[ab]	2.0[b]	2.2[ab]	2.5[a]	0.15	0.976	0.437	0.455	0.752	0.095	0.763
Shrink (length)[13], %	15.0[bc]	15.2[bc]	14.0[bc]	13.5[c]	13.4[c]	17.0[ab]	18.8[a]	0.10	0.901	0.382	0.452	0.660	0.001	0.397
Shrink (weight)[14], %	52.9[bc]	51.8[cd]	50.0[d]	50.8[cd]	52.0[cd]	55.0[ab]	56.0[a]	0.83	0.349	0.132	0.017	0.177	0.001	0.195
Lean Area[15], %	39.8	42.4	43.4	43.6	39.1	39.7	42.5	1.66	0.275	0.667	0.131	0.323	0.869	0.633
Belly Parameters														
Width, in	8.79[ab]	9.17[a]	8.79[ab]	8.67[ab]	8.50[b]	8.83[ab]	8.88[ab]	0.173	0.137	0.137	1.000	0.333	0.129	0.720
Length, in	23.3[ab]	23.1[ab]	23.3[ab]	23.6[a]	22.8[ab]	22.6[b]	23.4[a]	0.26	0.649	0.589	0.933	0.679	0.531	0.881
Green Wt, lb	11.15	10.79	10.74	11.05	10.63	11.14	11.64	0.380	0.499	0.934	0.448	0.836	0.153	0.916
Pump Wt, lb	12.36	12.10	11.98	12.37	11.90	12.43	12.86	0.401	0.645	0.834	0.502	0.756	0.209	0.963
Brine Wt, lb	12.65	12.25	12.25	12.77	12.11	12.63	13.10	0.427	0.512	0.996	0.509	0.718	0.330	0.833
Smoke Wt, lb	11.05	10.84	10.68	11.09	10.47	11.25	11.54	0.395	0.710	0.777	0.513	0.835	0.128	0.678
Average Vertical Flex[16], in	9.19	9.47	9.47	9.44	9.19	9.31	9.41	0.112	0.084	1.000	0.084	0.262	0.678	0.490
Average Lateral Flex[17], in	3.72[a]	2.59[b]	2.59[b]	3.19[ab]	3.09[b]	2.78[b]	3.03[b]	0.188	0.001	1.000	0.001	0.023	0.220	0.680
Total Flex[18], in	25.8[a]	24.1[b]	24.1[b]	25.3[ab]	24.6[ab]	24.2[b]	24.9[ab]	0.41	0.006	1.000	0.006	0.132	0.371	1.000
Vertical Flex[19], %	71.4[b]	78.6[a]	78.5[a]	74.9[a]	75.1[a]	77.1[a]	75.8[a]	1.19	0.001	0.969	0.001	0.020	0.222	0.664
Lateral Flex[20], %	28.6[a]	21.4[b]	21.5[b]	25.1[b]	24.9[b]	22.9[b]	24.2[b]	1.19	0.001	0.969	0.001	0.020	0.222	0.664

Relative Bend[21]	11.25[xy]	10.52[xy]	10.96[xy]	11.17[xy]	11.34[x]	10.30[y]	10.54[xy]	0.369	0.166	0.403	0.574	0.510	0.028	0.579

[a,b,c,d] Numbers in the same row with different superscripts differ by $P < 0.05$ based on means separation using the Duncan's test.
[x,y,z] Numbers in the same row with different superscripts differ by $P < 0.10$ based on means separation using the Duncan's test.
[1] Treatment 1 pigs fed corn-soybean meal control diet from d 0-103
[2] Treatment 2 pigs fed corn-soybean meal with 20% DDGS from d 0-103
[3] Treatment 3 pigs fed corn-soybean meal with 20% DDGS from d 0-77 and corn-soybean meal control d 77-103
[4] Treatment 4 pigs fed corn-soybean meal with 20% DDGS from d 0-77 and corn-soybean meal with 5% BT d 77-103
[5] Treatment 5 pigs fed corn-soybean meal with 20% DDGS from d 0-77 and corn-soybean meal with 5% CWG d 77-103
[6] Treatment 6 pigs fed corn-soybean meal with 20% DDGS and 5% CWG d 0-77 and corn-soybean meal with 5% BT d 77-103
[7] Treatment 7 pigs fed corn-soybean meal with 20% DDGS and 5% CWG d 0-77 and corn-soybean meal with 5% CWG d 77-103
[8] Contrasts of Probability are as follows:

1. Treatment 1 vs Treatment 2
2. Treatment 2 vs Treatment 3
3. Treatment 1 vs Treatment 3
4. Treatment 3 vs Treatments 4 and 5
5. Treatments 4 and 5 vs Treatments 6 and 7
6. Treatments 4 and 6 vs Treatments 5 and 7

[9] Cracks determined by subjective visual appearance while laying on a flat surface
[10] Webbing determined by measuring the physical characteristic along the bacon slice
[11] Separation determined by measuring the physical characteristic along the bacon slice
[12] Cook Score determined by the subjective evaluation of slice appearance (curling, cooked distortion) from 1-5 where 0 = flat slice with no distortion and 5 = extreme curling.
[13] Shrink (length), % = ((raw length - cooked length)/ raw length) x 100.
[14] Shrink (weight), % = ((raw weight – cooked weight)/ raw weight) x 100.
[15] Lean Area calculated by utilizing Adobe photo shop. Lean Area = (Lean Pixels/Total Pixels) x 100.
[16] Average score for vertical flex for both left and right sides of belly. Lower vertical flex scores indicate a firmer belly.
[17] Average score for lateral flex for both left and right sides of belly. Higher lateral flex scores indicate a firmer belly.
[18] Combined score for both vertical and lateral flex scores for left and right sides of belly
[19] Vertical flex expressed as a percentage of Total Flex.
[20] Lateral flex expressed as a percentage of Total Flex.
[21] Relative bend is expressed as Total Flex divided by weight.

Table 9. The effect of feeding corn-soybean meal or corn-soybean meal with DDGS and alternative fat sources on inner backfat fatty acid profiles in grow finish swine.

Diet	Tr 1[1]	Tr 2[2]	Tr 3[3]	Tr 4[4]	Tr 5[5]	Tr 6[6]	Tr 7[7]		Probability of Contrasts[8], P <					
d (0-77)	Diet 1	Diet 2	Diet 2	Diet 2	Diet 2	Diet 3	Diet 3							
d (77-103)	Diet 1	Diet 2	Diet 1	Diet 4	Diet 5	Diet 4	Diet 5	SE	1	2	3	4	5	6
Fatty acid, %														
C14:0	1.54^{ab}	1.41^{c}	1.44^{bc}	1.58^{a}	1.49^{abc}	1.46^{abc}	1.41^{c}	0.038	0.026	0.619	0.079	0.056	0.013	0.049
C16:0	25.39^{a}	23.18^{bc}	23.72^{b}	23.69^{b}	23.56^{b}	22.16^{c}	22.38^{c}	0.390	0.001	0.332	0.004	0.845	0.001	0.915
C16:1n7	2.09^{a}	1.73^{c}	1.82^{bc}	2.00^{ab}	1.86^{bc}	1.99^{ab}	1.84^{bc}	0.058	0.001	0.274	0.002	0.115	0.737	0.019
C16:2n4	0.36^{abc}	0.37^{a}b	0.38^{a}	0.40^{a}	0.32^{c}	0.39^{a}	0.33^{bc}	0.014	0.535	0.652	0.286	0.307	0.926	0.001
C16:3n4	0.31^{abc}	0.29^{bcd}	0.30^{bcd}	0.34^{a}	0.27^{cd}	0.33^{ab}	0.26^{d}	0.014	0.357	0.474	0.837	0.736	0.370	0.001
C18:0	15.50^{a}	12.91^{de}	14.18^{b}	13.71^{bc}	13.21^{cd}	12.37^{e}	12.39^{e}	0.255	0.001	0.001	0.010	0.027	0.001	0.354
C18:1n9	38.21^{a}	35.32^{d}	36.08^{cd}	36.98^{bc}	37.34^{ab}	38.26^{a}	37.96^{ab}	0.365	0.001	0.152	0.010	0.021	0.013	0.933
C18:1n7	2.51^{b}	2.17^{c}	2.26c	2.59^{b}	2.54^{b}	2.80^{a}	2.77^{a}	0.037	0.001	0.075	0.001	0.001	0.001	0.272
C18:2n6	9.28^{d}	17.31^{a}	14.47^{b}	12.88^{c}	14.21^{bc}	13.99^{bc}	15.14^{b}	0.478	0.001	0.001	0.001	0.122	0.039	0.013
C18:3n4	0.11	0.11	0.11	0.12	0.10	0.12	0.11	0.012	0.856	0.797	0.939	0.826	0.887	0.155
C18:3n3	0.30^{d}	0.49^{ab}	0.43^{c}	0.45^{bc}	0.45^{bc}	0.51^{a}	0.50^{a}	0.016	0.001	0.013	0.001	0.274	0.010	0.832
C18:2n 9,11	0.11^{b}	0.12^{b}	0.12^{b}	0.24^{a}	0.14^{b}	0.23^{a}	0.14^{b}	0.011	0.547	0.695	0.833	0.001	0.773	0.001
C18:2n 10,12	0.27^{a}	0.24^{b}	0.23^{bc}	0.22^{bcd}	0.23^{bc}	0.20^{d}	0.21^{cd}	0.010	0.017	0.593	0.004	0.491	0.022	0.238
C20:1n9	0.77^{ab}	0.77^{ab}	0.69^{b}	0.74^{ab}	0.80^{a}	0.82^{a}	0.84^{a}	0.033	0.986	0.078	0.081	0.045	0.098	0.202
C20:4n6	0.47^{e}	0.79^{a}	0.66^{cd}	0.60^{d}	0.69^{bc}	0.66^{cd}	0.74^{ab}	0.023	0.001	0.010	0.001	0.652	0.020	0.010
C20:5n3	0.23^{b}	0.30^{a}	0.29^{a}	0.28^{a}	0.31^{a}	0.31^{a}	0.32^{a}	0.016	0.004	0.817	0.008	0.981	0.094	0.194
C22:0	0.04^{d}	0.06^{bc}	0.05^{cd}	0.06^{bc}	0.07^{ab}	0.07^{ab}	0.08^{a}	0.005	0.002	0.040	0.246	0.007	0.039	0.047
C22:1	0.02	0.02	0.02	0.02	0.02	0.03	0.02	0.010	0.727	0.673	0.942	0.774	0.610	0.608
C22:4n6	0.10^{c}	0.15^{a}	0.13^{ab}	0.12^{bc}	0.15^{a}	0.14^{ab}	0.15^{a}	0.008	0.001	0.037	0.013	0.534	0.090	0.043
C22:5n3	0.06^{y}	0.06^{y}	0.08^{xy}	0.09^{x}	0.08^{xy}	0.09^{x}	0.09^{x}	0.009	0.948	0.107	0.094	0.888	0.687	0.738
Iodine Value[9]	54.47^{e}	65.75^{a}	61.58^{cd}	59.98^{d}	62.48^{c}	63.40^{bc}	64.97^{ab}	0.757	0.001	0.010	0.001	0.714	0.010	0.012
Sat:Unsat[10]	0.77^{a}	0.62^{bcd}	0.68^{b}	0.67^{bc}	0.62^{cd}	0.59^{d}	0.59^{d}	0.020	0.001	0.062	0.003	0.170	0.014	0.145
n6:n3[11]	16.77^{cd}	21.68^{a}	19.19^{b}	16.68^{d}	17.99^{c}	16.30^{d}	17.50^{cd}	0.416	0.001	0.001	0.010	0.010	0.301	0.005

[a,b,c,d,e] Numbers in the same row with different superscripts differ by $P < 0.05$ based on means separation using the Duncan's test.

[x,y,] Numbers in the same row with different superscripts differ by $P < 0.10$ based on means separation using the Duncan's test.

[1] Treatment 1 pigs fed corn-soybean meal control diet from d 0-103

[2] Treatment 2 pigs fed corn-soybean meal with 20% DDGS from d 0-103

[3] Treatment 3 pigs fed corn-soybean meal with 20% DDGS from d 0-77 and corn-soybean meal control d 77-103

[4] Treatment 4 pigs fed corn-soybean meal with 20% DDGS from d 0-77 and corn-soybean meal with 5% BT d 77-103

[5] Treatment 5 pigs fed corn-soybean meal with 20% DDGS from d 0-77 and corn-soybean meal with 5% CWG d 77-103

[6] Treatment 6 pigs fed corn-soybean meal with 20% DDGS and 5% CWG d 0-77 and corn-soybean meal with 5% BT d 77-103
[7]Treatment 7 pigs fed corn-soybean meal 20% DDGS and 5% CWG d 0-77 and corn-soybean meal with 5% CWG d 77-103
[8] Contrasts of Probability are as follows:

1. Treatment 1 vs Treatment 2
2. Treatment 2 vs Treatment 3
3. Treatment 1 vs Treatment 3
4. Treatment 3 vs Treatments 4 and 5
5. Treatments 4 and 5 vs Treatments 6 and 7
6. Treatments 4 and 6 vs Treatments 5 and 7

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

Table 10. The effect of feeding corn-soybean meal or corn-soybean meal with DDGS and alternative fat sources on outer backfat fatty acid profiles in grow finish swine.

Diet	Tr 1[1]	Tr 2[2]	Tr 3[3]	Tr 4[4]	Tr 5[5]	Tr 6[6]	Tr 7[7]	Probability of Contrasts[8], P <						
d (0-77)	Diet 1	Diet 2	Diet 2	Diet 2	Diet 2	Diet 3	Diet 3							
d (77-103)	Diet 1	Diet 2	Diet 1	Diet 4	Diet 5	Diet 4	Diet 5	SE	1	2	3	4	5	6
Fatty acid, %														
C14:0	1.54[a]	1.39[b]	1.44[ab]	1.56[a]	1.49[ab]	1.41[b]	1.39[b]	0.041	0.012	0.366	0.090	0.096	0.004	0.312
C16:0	24.28[a]	22.07[bc]	22.56[b]	22.43[bc]	22.59[b]	21.51[c]	21.54[c]	0.321	0.001	0.282	0.010	0.894	0.004	0.767
C16:1n7	2.42[a]	1.99[b]	2.06[b]	2.19[b]	2.07[b]	2.16[b]	2.00[b]	0.065	0.001	0.427	0.010	0.406	0.425	0.031
C16:2n4	0.41[a]	0.41[a]	0.42[a]	0.43[a]	0.35[b]	0.40[a]	0.34[b]	0.016	0.937	0.601	0.657	0.178	0.249	0.010
C16:3n4	0.40[a]	0.35[cd]	0.35[bcd]	0.39[ab]	0.32[de]	0.38[abc]	0.30[e]	0.013	0.006	0.788	0.011	0.998	0.234	0.001
C18:0	12.87[a]	10.83[cd]	11.66[b]	11.45[bc]	11.26[b]c	10.49[d]	10.77[cd]	0.247	0.001	0.023	0.001	0.315	0.006	0.844
C18:1n9	39.51[a]	36.63[d]	37.31[cd]	37.86[bc]	38.11[bc]	39.32[a]	38.94[ab]	0.359	0.001	0.185	0.001	0.133	0.003	0.857
C18:1n7	2.86[ab]	2.43[d]	2.52[d]	2.78[bc]	2.71[c]	2.98[a]	2.93[a]	0.041	0.001	0.152	0.001	0.001	0.001	0.196
C18:2n6	10.88[d]	18.33[a]	16.25[b]	14.97[c]	15.69[bc]	15.52[bc]	16.27[b]	0.317	0.001	0.001	0.001	0.022	0.083	0.025
C18:3n4	0.10[ab]	0.10[ab]	0.11[ab]	0.13[a]	0.10[ab]	0.10[ab]	0.09[b]	0.011	0.978	0.745	0.766	0.492	0.051	0.110
C18:3n3	0.36[d]	0.53[abc]	0.49[c]	0.51[bc]	0.50[c]	0.55[a]	0.55[ab]	0.012	0.001	0.061	0.001	0.435	0.010	0.431
C18:2n 9,11	0.13[b]	0.14[b]	0.14[b]	0.24[a]	0.14[b]	0.23[a]	0.15[b]	0.011	0.495	0.833	0.373	0.001	0.931	0.001
C18:2n 10,12	0.24[a]	0.22[ab]	0.21[abc]	0.20[bcd]	0.22[abc]	0.18[d]	0.19[cd]	0.009	0.248	0.614	0.101	0.544	0.013	0.098
C20:1n9	0.75[ab]	0.77[ab]	0.69[b]	0.73[b]	0.79[ab]	0.83[a]	0.85[a]	0.032	0.703	0.100	0.202	0.096	0.016	0.215
C20:4n6	0.52[e]	0.84[a]	0.73[bc]	0.67[d]	0.76[bc]	0.72[cd]	0.78[b]	0.018	0.001	0.001	0.001	0.595	0.088	0.001
C20:5n3	0.26[b]	0.32[a]	0.32[a]	0.32[a]	0.33[a]	0.32[a]	0.34[a]	0.015	0.005	0.777	0.011	0.741	0.702	0.467
C22:0	0.05[f]	0.08[cd]	0.06e	0.07[de]	0.08[bc]	0.09[ab]	0.09[a]	0.003	0.001	0.014	0.038	0.004	0.001	0.016
C22:1	0.00	0.02	0.01	0.03	0.01	0.00	0.00	0.007	0.248	0.519	0.605	0.267	0.054	0.305
C22:4n6	0.10[c]	0.16[a]	0.13[b]	0.14[ab]	0.16[a]	0.14[ab]	0.16[a]	0.007	0.001	0.007	0.007	0.035	0.582	0.023
C22:5n3	0.07	0.07	0.08	0.09	0.08	0.09	0.09	0.009	0.794	0.407	0.277	0.781	0.441	0.625
Iodine Value[9]	59.13[e]	69.20[a]	66.19[cd]	64.87[d]	66.17[cd]	67.39[bc]	68.18[ab]	0.559	0.001	0.010	0.001	0.331	0.010	0.068
Sat:Unsat[10]	0.66[a]	0.54[bc]	0.58[b]	0.58[b]	0.57[b]	0.53[c]	0.53[c]	0.012	0.001	0.053	0.001	0.698	0.010	0.901
n6:n3[11]	16.72[d]	21.11[a]	19.32[b]	17.14[d]	18.46[bc]	17.03[d]	17.68[cd]	0.341	0.001	0.010	0.001	0.010	0.197	0.010

[a,b,c,d,e,f] Numbers in the same row with different superscripts differ by P < 0.05 based on means separation using the Duncan's test.

[x,y,] Numbers in the same row with different superscripts differ by P < 0.10 based on means separation using the Duncan's test.

[1] Treatment 1 pigs fed corn-soybean meal control diet from d 0-103

[2] Treatment 2 pigs fed corn-soybean meal with 20% DDGS from d 0-103

[3] Treatment 3 pigs fed corn-soybean meal with 20% DDGS from d 0-77 and corn-soybean meal control d 77-103

[4] Treatment 4 pigs fed corn-soybean meal with 20% DDGS from d 0-77 and corn-soybean meal with 5% BT d 77-103

[5] Treatment 5 pigs fed corn-soybean meal with 20% DDGS from d 0-77 and corn-soybean meal with 5% CWG d 77-103

[6] Treatment 6 pigs fed corn-soybean meal with 20% DDGS and 5% CWG d 0-77 and corn-soybean meal with 5% BT d 77-103
[7]Treatment 7 pigs fed corn-soybean meal 20% DDGS and 5% CWG d 0-77 and corn-soybean meal with 5% CWG d 77-103
[8] Contrasts of Probability are as follows:

1. Treatment 1 vs Treatment 2
2. Treatment 2 vs Treatment 3
3. Treatment 1 vs Treatment 3
4. Treatment 3 vs Treatments 4 and 5
5. Treatments 4 and 5 vs Treatments 6 and 7
6. Treatments 4 and 6 vs Treatments 5 and 7

[9] Iodine Values calculated as follows: IV= (%16:1 * 0.950) + (%18:1 * 0.860) + (%18:2 * 1.732) + (%18:3 * 2.616) + (%20:1 * 0.723); AOAC, 1990.
[10] Saturated to unsaturated fatty acid ratio calculated as follows: (14:0 + 16:0 + 18:0 + 22:0) / (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)
[11] Ratio of n-6 to n-3 calculated as follows: (18:2n6 + 20:4n6 + 22:4n6) / (18:3n3 + 20:5n3 + 22:5n3)

Table 11. The effect of feeding corn-soybean meal or corn-soybean meal with DDGS and alternative fat sources on belly fatty acid profiles in grow finish swine.

Diet	Tr 1[1]	Tr 2[2]	Tr 3[3]	Tr 4[4]	Tr 5[5]	Tr 6[6]	Tr 7[7]		Probability of Contrasts[8], P <					
d (0-77)	Diet 1	Diet 2	Diet 2	Diet 2	Diet 2	Diet 3	Diet 3							
d (77-103)	Diet 1	Diet 2	Diet 1	Diet 4	Diet 5	Diet 4	Diet 5	SE	1	2	3	4	5	6
Fatty acid, %														
C14:0	1.52[ab]	1.41[b]	1.46[ab]	1.55[a]	1.51[ab]	1.44[ab]	1.42[b]	0.038	0.041	0.357	0.245	0.113	0.010	0.458
C16:0	24.94[a]	22.95[bc]	23.36[b]	23.30[b]	23.31[b]	22.24[c]	22.08[c]	0.301	0.001	0.346	0.010	0.892	0.010	0.810
C16:1n7	2.64[a]	2.22[b]	2.31[b]	2.37[b]	2.34[b]	2.41[b]	2.23[b]	0.078	0.010	0.432	0.005	0.627	0.638	0.195
C18:0	13.10[a]	11.19[cd]	12.12[b]	11.85[bc]	11.23[cd]	10.62[d]	10.74[d]	0.258	0.001	0.015	0.010	0.075	0.002	0.340
C18:1n9	40.02[a]	37.35[d]	38.06[cd]	38.47[c]	38.89[bc]	40.11[a]	39.58[ab]	0.362	0.001	0.176	0.010	0.164	0.003	0.873
C18:1n7	3.01[a]	2.58[c]	2.68[c]	2.88[b]	2.89[b]	3.12[a]	3.06[a]	0.043	0.001	0.110	0.001	0.010	0.001	0.580
C18:2n6	9.34[d]	16.21[a]	14.00[bc]	13.32[c]	13.97[bc]	13.75[bc]	14.82[b]	0.371	0.001	0.001	0.001	0.439	0.091	0.026
C18:3n6	0.02[y]	0.03[x]	0.03[xy]	0.03[xy]	0.03[xy]	0.03[x]	0.02[xy]	0.003	0.048	0.792	0.084	0.643	0.887	0.677
C18:3n3	0.31[e]	0.47[abc]	0.42[d]	0.46[bcd]	0.44[cd]	0.49[ab]	0.50[a]	0.013	0.001	0.014	0.001	0.070	0.010	0.798
C20:0	0.23[a]	0.21[ab]	0.21[ab]	0.20[b]	0.21[ab]	0.18[b]	0.18[b]	0.010	0.108	0.919	0.088	0.750	0.064	0.366
C20:1n9	0.73[abc]	0.75[abc]	0.68[c]	0.71[bc]	0.79[ab]	0.83[a]	0.82[a]	0.030	0.643	0.091	0.213	0.076	0.017	0.265
C20:4n6	0.48[f]	0.77[a]	0.65[de]	0.61[e]	0.71[bc]	0.67[cd]	0.75[ab]	0.019	0.001	0.001	0.001	0.514	0.017	0.001
C20:5n3	0.24[b]	0.30[a]	0.29[a]	0.28[a]	0.29[a]	0.29[a]	0.32[a]	0.014	0.004	0.604	0.014	0.923	0.140	0.156
C22:0	0.09	0.09	0.11	0.07	0.09	0.07	0.10	0.013	0.854	0.327	0.246	0.127	0.783	0.138
C22:4n6	0.10[d]	0.14[ab]	0.11[cd]	0.12[bcd]	0.14[ab]	0.13[bc]	0.15[a]	0.007	0.010	0.014	0.161	0.076	0.129	0.004
C22:6n3	0.01[xy]	0.01[y]	0.02[xy]	0.01[y]	0.01[xy]	0.02[xy]	0.02[x]	0.004	0.823	0.187	0.270	0.265	0.068	0.339
Iodine Value[9]	57.09[d]	66.35[a]	63.11[c]	62.63[c]	64.13[bc]	65.22[ab]	66.40[a]	0.655	0.001	0.001	0.001	0.736	0.010	0.048
Sat:Unsat[10]	0.70[a]	0.59[bc]	0.63[b]	0.63[b]	0.60[b]	0.56[c]	0.56[c]	0.013	0.001	0.037	0.010	0.308	0.001	0.280
n6:n3[11]	21.36[cd]	24.76[a]	23.21[b]	21.54[cd]	22.41[bc]	20.54[d]	21.16[d]	0.371	0.001	0.005	0.010	0.010	0.004	0.051

[a,b,c,d,e] Numbers in the same row with different superscripts differ by P < 0.05 based on means separation using the Duncan's test.
[x,y] Numbers in the same row with different superscripts differ by P < 0.10 based on means separation using the Duncan's test.
[1] Treatment 1 pigs fed corn-soybean meal control diet from d 0-103
[2] Treatment 2 pigs fed corn-soybean meal with 20% DDGS from d 0-103
[3] Treatment 3 pigs fed corn-soybean meal with 20% DDGS from d 0-77 and corn-soybean meal control d 77-103
[4] Treatment 4 pigs fed corn-soybean meal with 20% DDGS from d 0-77 and corn-soybean meal with 5% BT d 77-103
[5] Treatment 5 pigs fed corn-soybean meal with 20% DDGS from d 0-77 and corn-soybean meal with 5% CWG d 77-103
[6] Treatment 6 pigs fed corn-soybean meal with 20% DDGS and 5% CWG d 0-77 and corn-soybean meal with 5% BT d 77-103
[7]Treatment 7 pigs fed corn-soybean meal with 20% DDGS and 5% CWG d 0-77 and corn-soybean meal with 5% CWG d 77-103
[8] Contrasts of Probability are as follows:

1. Treatment 1 vs Treatment 2
2. Treatment 2 vs Treatment 3

3. Treatment 1 vs Treatment 3
4. Treatment 3 vs Treatments 4 and 5
5. Treatments 4 and 5 vs Treatments 6 and 7
6. Treatments 4 and 6 vs Treatments 5 and 7

[9] Iodine Values calculated as follows: IV= (%16:1 * 0.950) + (%18:1 * 0.860) + (%18:2 * 1.732) + (%18:3 * 2.616) + (%20:1 * 0.723); AOAC, 1990.
[10] Saturated to unsaturated fatty acid ratio calculated as follows: (14:0 + 16:0 + 18:0 + 20:0 + 22:0) / (16:1n7 + 18:1n9 + 18:1n7 + 18:2n6 + 18:3n6 + 18:3n3 + 20:1n9 + 20:4n6 + 20:5n3 + 22:4n6 + 22:6n3)
[11] Ratio of n-6 to n-3 calculated as follows: (18:2n6 + 18:3n6 + 20:4n6 + 22:4n6) / (18:3n3 + 20:5n3 + 22:6n3)

Table 12. The effect of feeding corn-soybean meal or corn-soybean meal with DDGS and alternative fat sources on loin fatty acid profiles in grow finish swine.

Diet	Tr 1[1]	Tr 2[2]	Tr 3[3]	Tr 4[4]	Tr 5[5]	Tr 6[6]	Tr 7[7]		Probability of Contrasts[8], P <					
d (0-77)	Diet 1	Diet 2	Diet 2	Diet 2	Diet 2	Diet 3	Diet 3							
d (77-103)	Diet 1	Diet 2	Diet 1	Diet 4	Diet 5	Diet 4	Diet 5	SE	1	2	3	4	5	6
Fatty acid, %														
C14:0	1.16	1.15	1.18	1.24	1.20	1.27	1.28	0.050	0.923	0.680	0.752	0.535	0.299	0.777
C16:0	23.47	22.90	23.13	23.38	23.26	23.19	23.37	0.368	0.277	0.652	0.521	0.686	0.919	0.935
C16:1n7	2.92	2.74	2.79	2.84	2.68	2.79	2.62	0.112	0.255	0.748	0.411	0.824	0.665	0.155
C18:0	12.93[a]	12.07[bc]	12.31[abc]	12.31[abc]	12.34[ab]	11.69[c]	12.00[bc]	0.203	0.005	0.407	0.037	0.945	0.023	0.394
C18:1n9	36.39[a]	34.06[b]	35.52[ab]	35.25[ab]	34.38[ab]	35.96[ab]	35.37[ab]	0.667	0.018	0.129	0.367	0.390	0.208	0.282
C18:1n7	3.49	3.34	3.35	3.39	3.30	3.40	3.31	0.080	0.170	0.875	0.222	0.943	0.898	0.284
C18:2n6	6.30[b]	9.38[a]	8.59[a]	8.43[a]	8.71[a]	8.57[a]	9.11[a]	0.499	0.001	0.270	0.002	0.977	0.599	0.415
C18:3n6	0.07[a]	0.06[ab]	0.06[ab]	0.06[ab]	0.06[ab]	0.05[b]	0.05[ab]	0.005	0.581	0.846	0.720	0.426	0.091	0.552
C18:3n3	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.004	0.593	0.713	0.866	0.269	0.302	0.206
C20:0	0.18[x]	0.17[xy]	0.16[xy]	0.16[y]	0.17[xy]	0.16[xy]	0.17[xy]	0.006	0.344	0.636	0.159	0.915	0.996	0.219
C20:1n9	0.57[xy]	0.60[xy]	0.57[xy]	0.54[y]	0.58[xy]	0.59[xy]	0.61[x]	0.020	0.296	0.337	0.931	0.751	0.062	0.209
Unknown 1[9]	0.49	0.43	0.41	0.40	0.43	0.39	0.39	0.047	0.402	0.800	0.277	0.993	0.635	0.715
C20:4n6	1.57[xy]	1.82[x]	1.68[xy]	1.60[xy]	1.74[xy]	1.37[y]	1.47[xy]	0.154	0.258	0.529	0.611	0.961	0.107	0.454
C20:5n3	0.12	0.13	0.14	0.12	0.13	0.13	0.12	0.019	0.587	0.770	0.405	0.593	0.932	0.944
C22:0	0.02	0.03	0.03	0.03	0.05	0.08	0.07	0.023	0.963	0.982	0.982	0.643	0.111	0.987
Unknown 2[9]	4.52	4.96	4.30	4.34	4.82	3.86	3.97	0.427	0.468	0.279	0.716	0.594	0.126	0.496
C22:4n6	1.23[ab]	1.42[a]	1.19[ab]	1.19[ab]	1.29[ab]	1.02[b]	1.03[b]	0.115	0.246	0.171	0.829	0.709	0.063	0.633
C22:6n3	0.09[y]	0.11[xy]	0.10[xy]	0.13[xy]	0.23[xy]	0.47[x]	0.37[xy]	0.137	0.897	0.950	0.946	0.639	0.090	0.100
Iodine Value[10]	48.56[b]	51.62[a]	51.55[a]	51.08[a]	50.62[ab]	51.95[a]	52.15[a]	0.817	0.012	0.952	0.014	0.491	0.151	0.870
Sat:Unsat[11]	0.72[x]	0.68[y]	0.68[xy]	0.69[xy]	0.70[xy]	0.67[y]	0.68[xy]	0.014	0.060	0.809	0.098	0.430	0.200	0.547
n6:n3[12]	43.61	60.11	47.20	47.10	45.54	44.41	49.28	7.033	0.105	0.202	0.720	0.919	0.941	0.815

[a,b,c] Numbers in the same row with different superscripts differ by P < 0.05 based on means separation using the Duncan's test.

[x,y] Numbers in the same row with different superscripts differ by P < 0.10 based on means separation using the Duncan's test.

[1] Treatment 1 pigs fed corn-soybean meal control diet from d 0-103

[2] Treatment 2 pigs fed corn-soybean meal with 20% DDGS from d 0-103

[3] Treatment 3 pigs fed corn-soybean meal with 20% DDGS from d 0-77 and corn-soybean meal control d 77-103

[4] Treatment 4 pigs fed corn-soybean meal with 20% DDGS from d 0-77 and corn-soybean meal with 5% BT d 77-103

[5] Treatment 5 pigs fed corn-soybean meal with 20% DDGS from d 0-77 and corn-soybean meal with 5% CWG d 77-103

[6] Treatment 6 pigs fed corn-soybean meal with 20% DDGS and 5% CWG d 0-77 and corn-soybean meal with 5% beef tallow d 77-103

[7] Treatment 7 pigs fed corn-soybean meal with 20% DDGS and 5% CWG d 0-77 and corn-soybean meal with 5% CWG d 77-103

[8] Contrasts of Probability are as follows:

1. Treatment 1 vs Treatment 2
2. Treatment 2 vs Treatment 3
3. Treatment 1 vs Treatment 3
4. Treatment 3 vs Treatments 4 and 5
5. Treatments 4 and 5 vs Treatments 6 and 7
6. Treatments 4 and 6 vs Treatments 5 and 7

[9] Unknowns 1 and 2 were peaks that were found in the fatty acid profile but not found in the standard
[10] Iodine Values calculated as follows: IV= (%16:1 * 0.950) + (%18:1 * 0.860) + (%18:2 * 1.732) + (%18:3 * 2.616) + (%20:1 * 0.723); AOAC, 1990.
[11] Saturated to unsaturated fatty acid ratio calculated as follows: (14:0 + 16:0 + 18:0 + 20:0 + 22:0) / (16:1n7 + 18:1n9 + 18:1n7 + 18:2n6 + 18:3n6 + 18:3n3 + 20:1n9 + 20:4n6 + 20:5n3 + 22:4n6 + 22:6n3)
[12] Ratio of n-6 to n-3 calculated as follows: (18:2n6 + 18:3n6 + 20:4n6 + 22:4n6) / (18:3n3 + 20:5n3 + 22:6n3)