Title: Assessment of the effects of diets containing DDGS with supplemental tallow on fat digestibility, growth performance, carcass and fat quality in growing-finishing pigs-**NPB #08-015** **revised**

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Industry Summary:

The use of dried distillers grains with solubles (DDGS) in swine diets has increased dramatically in recent years due to the increased availability and cost competitiveness of this corn co-product compared to corn and soybean meal. Due to high ingredient prices, pork producers are using DDGS at levels up to 40% in growing-finishing diets to minimize feed costs. However, when high inclusion rates of DDGS are included in the diet, pork fat quality is reduced. Dried distiller's grains with solubles contains approximately 10% corn oil, and a large proportion of the fatty acids in corn oil are polyunsaturated, especially linoleic acid (C18:2). The fatty acid composition of grower-finisher swine diets has a significant effect on the fatty acid composition of pork fat. Therefore, feeding increasing levels of DDGS results in reduced pork fat firmness. Soft pork fat is a concern for pork processors because it may lead to challenges related to carcass handling and fabrication, processing yields, shelf-life, product attractiveness, and acceptability in certain export markets. Tallow is a readily available, relatively low cost feed fat source that is low in polyunsaturated fatty acids and high in saturated fatty acids relative to corn oil. We hypothesized that adding a saturated fat source (e.g. tallow) to grower-finisher diets containing a high level (30%) of DDGS may alleviate the negative effects of DDGS on pork fat firmness. Therefore, the objective of this study was to assess the effects of fat source (tallow and corn oil from DDGS) independently, and in combination, on growth performance, carcass quality, and pork fat quality and apparent ileal fatty acid digestibility.

Two separate experiments were conducted to meet the objectives. The first experiment utilized 315 mixed sex pigs 71.4 ± 1.5 lbs that were housed in one of 40 pens and were assigned to one of four dietary

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treatments throughout the 81day grower-finisher period. Dietary treatments consisted of: 1) a corn-soybean meal control (C); 2) a corn-soybean meal diet containing 5% supplemental beef tallow (T); 3) a corn-soybean meal diet containing 30% DDGS (D); and 4) a corn-soybean meal diet containing 5% tallow and 30% DDGS (DT). All diets were formulated to contain a constant SID Lys: ME ratio. A three-phase feeding program was utilized with phase changes occurring when the average body weight (BW) of the pigs within each pen was within 5 lbs of the target weight for the phase change. Diet phase changes were made at 130 and 200 lbs BW. All pigs were harvested in a single group at a commercial plant.

Final BW was not affected due to dietary treatment (Table 1). Likewise, ADG did not differ among treatments. However, pigs fed T and DT consumed less feed compared to pigs fed C and D ($P < 0.01$). The reduction in feed intake was due to the high caloric density of diets containing tallow (T and DT). Furthermore, feed intake was also slightly reduced when feeding pigs D or DT ($P < 0.04$). The addition of DDGS may decrease the palatability, and therefore, feed intake of the diet. Feed to gain ratio was reduced for pigs fed T and DT ($P < 0.01$).

Effects of dietary treatment on carcass characteristics are shown in Table 1. Hot carcass weight was greater for pigs fed T and DT compared to pigs fed C and D ($P < 0.01$). The addition of 30% DDGS to the diets did not alter carcass yield, but adding 5% tallow to diets increased carcass yield. Backfat depth was reduced in D and DT carcasses ($P < 0.02$) compared to carcasses of pigs that were not fed DDGS containing diets, and was increased for pigs fed T and DT ($P < 0.01$) compared to pigs not fed tallow. Loin depth did not differ among treatments. However, calculated carcass fat free lean percentage was greater for pigs fed 30% DDGS diets compared to no DDGS ($P < 0.05$), but less for pigs fed 5% tallow containing diets ($P < 0.01$) compared to diets not containing tallow.

Table 2 shows the effects of tallow and DDGS on pork fat quality. As expected, feeding diets containing 30% DDGS (D and DT) resulted in softer pork fat as indicated by a greater belly flop angle ($P < 0.01$), and these results are consistent with previous research results. More specifically, the iodine value (IV), which is the ratio of unsaturated to saturated fatty acids, was increased while feeding D or DT ($P < 0.01$) regardless of fat depot site. There was a DDGS × tallow interaction ($P < 0.03$) for the IV of the belly fat. This indicates that when tallow was included in the 30% DDGS diets, the IV of belly fat decreased; however, when diets contained no DDGS, and 5% tallow is added, the IV increased. Polyunsaturated fatty acids (PUFA) were significantly higher in belly and backfat for pigs fed D and DT compared to C and T ($P < 0.01$). Similarly, monounsaturated fatty acids (MUFA) were greater for pigs fed T and DT in both fat locations. However, in backfat, MUFA levels were significantly decreased for pigs consuming D and DT ($P < 0.01$) compared to those pigs not fed DDGS containing diets.

In summary, feeding a combination diet of 5% tallow and 30% DDGS did not negatively impact growth performance. However, pork fat quality is not improved with the addition of tallow (saturated fat source) to diets containing DDGS (unsaturated fat source). Furthermore, the addition of tallow to DDGS diets does not improve belly firmness, even though it does reduce IV in belly fat, but not in backfat.

Table 1. Effects of dietary tallow and DDGS on pig growth performance

	Tallow		DDGS					
	0%	5%	30%	30%		P value		
Trait	CON	T	D	DT	PSE	DDGS	Tallow	DDGS×Tallow
Growth Performance								
Initial BW, lb	72.1	70.4	71.8	71.4	1.54	NS	NS	NS
Final BW, lb	248.4	252.5	248.2	249.7	2.46	NS	NS	NS
Overall ADG, lb	2.23	2.30	2.23	2.22	0.02	NS	NS	NS
Overall ADFI, lb	6.09	5.71	6.08	5.40	0.07	< 0.04	<0.01	<0.06
Overall F:G	2.74	2.49	2.73	2.43	0.03	NS	<0.01	NS
Carcass Characteristics								
Hot Carcass Weight, lb	195.29	201.97	194.77	197.03	2.30	<0.08	<0.01	NS
Carcass yield, %	78.77	79.55	78.34	79.35	0.19	NS	NS	NS
Backfat Depth, in	0.79	0.86	0.75	0.80	0.02	<0.02	<0.01	NS
Loin Depth, in	2.75	2.64	2.64	2.65	0.04	NS	NS	NS
Fat Free Lean, %	49.88	48.90	49.86	49.51	0.15	<0.05	<0.01	<0.05

NS = Non-significant

Table 2. Effects of dietary tallow and DDGS on pork fat quality

	Tallow		DDGS					
	0%	5%	30%	30%				
Trait	CON	T	D	DT	PSE	DDGS	Tallow	DDGS×Tallow
Belly								
Belly flop angle, o	125.8	115.3	72.6	63.1	9.98	<0.01	NS	NS
Iodine Value	59.0	64.2	71.2	67.9	1.87	<0.01	NS	<0.03
SFA, %	38.9	34.1	34.1	32.4	1.09	<0.01	<0.01	NS
MUFA, %	51.1	57.5	48.6	56.2	2.10	NS	<0.01	NS
PUFA, %	8.5	9.2	17.2	16.1	1.23	<0.01	NS	NS
Backfat								
Iodine Value	56.7	61.9	68.3	71.8	1.40	<0.01	<0.01	NS
SFA,	42.8	37.9	39.8	33.1	1.60	<0.01	<0.01	NS
MUFA, %	48.4	54.0	42.7	47.1	1.01	<0.01	<0.01	NS
PUFA, %	8.9	9.9	18.1	18.5	1.00	<0.01	NS	NS

NS = Non-significant

The second experiment was conducted using two replications of 24 pigs (initial BW of 55 lbs) that were surgically fitted with a T-cannula to determine apparent fatty acid digestibility of diets containing 3 levels of tallow and 2 levels of DDGS. Pigs were fed one of six diets consisting of corn-soybean meal with 1) 0% tallow, 0% DDGS (CON); 2) 5% tallow, 0% DDGS (5T); 3) 10% tallow, 0% DDGS (10T); 4) 0% tallow, 30% DDGS (30D); 5% tallow, 30% DDGS (5T30D); and 6) 10% tallow, 30% DDGS (10T30D) for a total of 8 replications per treatment. Celite was used as an indigestible marker. Pigs were fed their respective diet at a daily level equal to 3 times the maintenance energy requirement. This amount was divided into two equal meals supplied twice per day. Each pig was fed their diet for a 5 day adaptation period, followed by 3 days of feces collection, and 2 days ileal digesta collection. Digestibility of fatty acids was calculated using the index method as follows:

$$Digestibility, \% = 100 - [100 \times \left(\frac{concentration\ of\ index\ in\ feed\ \times concentration\ of\ component\ in\ feces}{concentration\ of\ index\ in\ feces\ \times concentration\ of\ component\ in\ feed}\right)]$$

Digestion of fat occurs along the small intestine and absorption is nearly complete once digtesta reaches the ileum. Fecal fatty acid digestibility values (Table 3) were higher than ileal fatty acid digestibility values It is well documented that fecal digestibility values are greater compared to ileal digestibility values when tallow is included in the diet (Duran-Montge et al., 2007, Ozimeck et al., 1984). Fecal values may be higher because unsaturated fatty acids are hydrogenated by gut microflora as suggested by Jorgensen et al (2000). Fecal fatty acid digestibility did not differ among dietary treatments for PUFA. However, a significant interaction between tallow and DDGS levels existed for MUFA digestibility values. Fecal MUFA digestibility was high, ranging from 88.2 to 96.5%, and MUFA digestibility was highest for 5T and 10T and lowest for CON and 30D. Likewise, a tallow × DDGS interaction ($P < 0.01$) was detected for fecal SFA. Fecal SFA digestibility was low, ranging from 64.8 to 85.4%. It was lowest for 30D, 5T30D, and 10T30D, yet highest for 5T and 10T. For ileal digestibility, C18:2 digestibility was moderate, ranging from 56.6 to 76.7%. Linoleic acid (C18:2) digestibility was lowest for 10T30D and highest for CON. Ileal MUFA digestibility ranged from 74.4 to 86.0% and was lowest for CON, but highest for 10T, and the addition of 30% DDGS tended to decrease digestibility ($P < 0.06$) compared to diets not containing DDGS. Ileal PUFA digestibility ranged from 57.4 to 77.3% which is similar to C18:2 digestibility. PUFA digestibility was lowest for 10T30D and greatest for CON. Ileal SFA digestibility ranged from 66.3 to 80.0% for 10T30D and 10T, respectively.

The results from the second experiment shed light on the digestibility of several important fatty acids relative to their presence and concentrations in pork fat. These values are useful in understanding the importance of dietary fatty acid level, their digestibility, and their impact on the concentration of fatty acids in carcass fat depots. Although ileal SFA had similar digestibility values compared to MUFA or PUFA, deposition of SFA into pork fat was low. However, the amount of SFA in these diets was relatively small compared to MUFA or PUFA levels. Therefore, the amount of fat deposited in pork adipose tissue is a reflection of the dietary concentration of a particular fatty acid.

Table 3. Fecal and Ileal digestibility of MUFA, PUFA, and SFA in tallow and DDGS diets.

	0% DDGS			30% DDGS						
Tallow	0%	5%	10%	0%	5%	10%		P-value		
Trt	CON	5T	10T	30D	5T30D	10T30D	PSE	DDGS	Tallow	DDGS × Tallow
Fecal Digestibility										
MUFA	88.2[a]	95.0[bcx]	96.4[be]	89.2[dfg]	91.4[bdfhi]	93.3[bfhjy]	0.44	<0.01	<0.01	<0.01
PUFA	97.9	96.6	96.9	97.2	96.1	96.6	0.60	NS	NS	NS
SFA	65.4[a]	80.7[bc]	85.4[be]	64.8[df]	66.3[df]	66.7[df]	1.54	<0.01	<0.01	<0.01
MUFA	74.4[a]	79.09	86.0[bc]	75.3[d]	77.0[d]	77.3[d]	1.98	<0.06	<0.01	<0.07
PUFA	77.3[a]	59.1[c]	62.6[e]	66.5[fg]	65.9[bfh]	57.4[bdh]	3.63	NS	<0.01	0.03
SFA	76.0[a]	74.6[c]	80.0[e]	79.9[g]	68.2[bfh]	66.3[bdfh]	1.77	<0.01	<0.01	<0.01

Scientific Abstracts:

Effects of tallow and DDGS on pig performance, carcass characteristics, and pork fat quality. J. M. Pomerenke[1*], G. C. Shurson[1], S. K. Baidoo[2], and L. J. Johnston[3], [1] University of Minnesota, St. Paul, [2]Southern Research and Outreach Center, Waseca, and [3]West Central Research and Outreach Center, Morris.

A study was conducted to determine the effect of supplementing 5% beef tallow to grower-finisher diets containing 30% corn dried distillers grains with solubles (DDGS) on pig performance and carcass characteristics. Crossbred pigs (n=315) were blocked by initial BW (32.4 ± 1. 9 kg) and assigned randomly to 1 of 4 dietary treatments in a 3-phase feeding program using a 2 × 2 factorial arrangement of treatments. Pigs were housed in a confinement facility containing 40 pens with 7 to 8 pigs per pen to provide 10 replications per treatment. Gilts and barrows were housed separately, but fed common diets formulated to contain similar available P and Standardized Ileal Digestible Lys:ME across treatments. Diets consisted of a conventional corn-soybean meal diet (C), C containing 30% DDGS (D), C containing 5% tallow (T), and C with 30% DDGS and 5% tallow (DT). For fat quality characteristics, one pig from each pen was selected based being the closest to average pen BW (n = 20 barrows and 20 gilts). Data were analyzed using the Proc Mixed functions of SAS with random effect of block and fixed effects of DDGS, tallow, gender, and DDGS×tallow. Barrows had higher ADG, ADFI, and backfat, and lower G:F, and carcass lean % than gilts ($P < 0.01$). Overall ADG did not differ among treatments, but ADFI was higher for pigs fed C and D (2.8 and 2.8 kg, respectively) due to lower caloric density compared with T and DT (2.6 and 2.5 kg, respectively; $P < 0.01$). Consequently, pigs fed T and DT had higher ($P < 0.01$) G:F (0.40 and 0.41, respectively) than those fed C and D (0.37 and 0.37, respectively). Carcass yield was greater for pigs fed T and DT (79.5 and 79.4%, respectively) compared with pigs fed C and D (78.8 and 78.3%, respectively; $P < 0.01$). Backfat depth was reduced for pigs fed DDGS diets ($P < 0.02$), but increased for pigs fed tallow diets ($P < 0.01$). Hunter L* and b* values for backfat and belly fat were greater ($P < 0.01$) for pigs fed C and T diets compared to pigs fed D and DT. Similarly, Japanese Color Score for belly fat was higher for pigs fed D and DT. Pigs fed D and DT exhibited softer bellies compared to pigs fed C and T as indicated by belly flop angle. An interaction between DDGS and tallow was observed for belly fat iodine value (IV), indicating that tallow decreases IV when DDGS was included in the diet, but tallow increased IV when no DDGS was included. SFA was highest for C, but was reduced for T, D, and DT in the belly fat. Belly MUFA was similar for D and DT but lower for C and D. Belly and backfat PUFA were highest with D and DT compared to C and T. ($P < 0.01$) Backfat IV increased ($P < 0.01$) when either DDGS or tallow were fed.

Backfat SFA was lowest for DT compared to all other diets. In summary, adding 5% tallow to 30% DDGS diets improved G:F and carcass yield, but increased backfat depth and reduced the percentage of carcass lean. In conclusion, adding 5% tallow to diets containing 30% DDGS did not improve pork fat firmness.

Table 1. Effects of tallow and DDGS on pork fat quality

	Tallow		DDGS					
	0%	5%	30%	30%				
Trait	C	T	D	DT	PSE	DDGS	Tallow	DDGS×Tallow
Belly								
Belly flop angle, °	125.84[a]	115.27[c]	72.60[b,d]	63.14[b,d]	9.98	<0.01	NS	NS
Iodine Value	59.01[a]	64.22[x]	71.22[b,y]	67.88[b]	1.87	<0.01	NS	<0.03
SFA, %	38.93[a]	34.05[b]	34.13[b]	32.40[b]	1.09	<0.01	<0.01	NS
MUFA, %	51.08	57.47[a]	48.65[b]	56.24[a]	2.10	NS	<0.01	NS
PUFA, %	8.51[a]	9.19[a]	17.23[b]	16.08[b]	1.23	<0.01	NS	NS
Backfat								
Iodine Value	56.72[a]	61.90[b]	68.31[c]	71.78[c]	1.40	<0.01	<0.01	NS
SFA,	42.79[a]	37.89	39.77[a]	33.11[b]	1.60	<0.01	<0.01	NS
MUFA, %	48.39[a,d]	53.96[b]	42.66[c]	47.12[d]	1.01	<0.01	<0.01	NS
PUFA, %	8.89[a]	9.92[a]	18.05[b]	18.45[b]	1.00	<0.01	NS	NS

Keywords: DDGS, tallow, pork fat quality

Effects of dietary tallow and DDGS on fatty acid digestibility. J. M. Pomerenke[1*], G. C. Shurson[1], S. K. Baidoo[2], and L. J. Johnston[3]
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An experiment was conducted to determine the ileal and fecal digestibility of fatty acids in diets containing 2 levels of DDGS (0 or 30%) and 3 levels of tallow (0, 5, or 10%). A total of 24 barrows were surgically fitted with a T-cannula at the distal ileum. Pigs were randomly assigned one of six different dietary treatments. Diets were formulated to have a constant SID Lys to ME ratio. Celite was added to the diets at 0.3% as an indigestible marker. Dietary treatments consisted of the following: corn-soybean meal conventional diet (CON), conventional diet plus 5% tallow (5T), conventional diet plus 10% tallow (10T), corn-soybean plus 30% DDGS (30D, conventional diet plus 30% DDGS and 5% tallow (5T30D, and conventional diet plus 30% DDGS and 10% tallow (10T30D). Eight replications per treatment were achieved by randomizing diets among pigs for a second collection period. Feed was supplied to barrows at a daily level equivalent to 3 times the ME requirement. This amount was divided into two equal meals which were supplied at 8:00 and 16:00 hr. Each pig was fed their respective diet for a 5 d adaptation period, followed by a 3-d fecal and 2-d digesta collection period. Collections lasted from 8:00 to 12:00 hr and from 16:00 to 20:00 hr. All samples were immediately frozen at -18ºC. Digesta samples were pooled within pig and freeze dried for analysis. Digestibility was determined using the index method. In general, fecal digestibility was greater compared to ileal digestibility for all fatty acids. Interactions between DDGS and tallow were observed for all fatty acids ($P < 0.05$) except fecal C18:2 and fecal PUFA digestibility, which were not affected by dietary treatment. Fecal MUFA digestibility was high, ranging from 88.2 to 96.5%, and was higher for 5T and 10T and lowest for CON and 30D. Conversely, fecal SFA digestibility was low, ranging from 64.8 to 85.4%. It was lower for 30D, 5T30D, and 10T30D compared to 5T and 10T. Ileal C18:2 digestibility was moderate, ranging from 56.6 to 76.7%.

Digestibility of C18:2 was lowest for 10T30D and highest for CON. Ileal MUFA digestibility ranged from 74.4 to 86.0% and was lowest for CON, but highest for 10T, and the addition of 30% DDGS tended to decrease digestibility ($P < 0.06$) compared to diets not containing DDGS. Ileal PUFA digestibility ranged from 57.4 to 77.3% which is similar to C18:2 digestibility. PUFA digestibility was lowest for 10T30D and greatest for CON. Ileal SFA digestibility ranged from 66.3 to 80.0% for 10T30D and 10T, respectively. In summary, the digestibility of fatty acids from tallow and DDGS are reflected in the fatty acid composition of pork fat.

Introduction

Due to feed ingredient price volatility, dried distillers grains with solubles (DDGS) is often an economical alternative feed ingredient used in swine diets. It is often added at a rates ranging from 20-30% without reducing pig performance while still capturing the economic advantages DDGS offers. Under the right economic conditions, DDGS may be used at higher levels (as much as 40%) in some grower-finisher swine diets. However, results from many studies have shown that feeding high levels of DDGS increases the incidence of soft pork fat (Xu et al., 2010, Ulery et al., 2010, Benz et al., 2008). Furthermore, as the dietary level of DDGS increases, the iodine value (IV) and level of polyunsaturated fatty acids (PUFA) increase (Xu et al., 2010). Fortunately, the growth performance response from feeding grower-finisher diets containing up to 30% DDGS growth performance is fairly consistent, with most research results showing that the addition of DDGS does not change ADG, ADFI, or G:F (Stein and Shurson, 2009,). Additionally, loin depth, backfat depth, and carcass lean largely remain unchanged due to the addition of DDGS to grower-finisher swine diets (Stein and Shurson, 2009). However, carcass yield may be reduced, and belly firmness is reduced when feeding DDGS diets. It is well documented that pork fat becomes softer with increasing dietary levels of DDGS, because DDGS contains nearly 60% linoleic acid, which is one of the most prevalent polyunsaturated fatty acids (PUFA) in pork fat (Xu et al., 2010). Unsaturated fats are preferentially deposited in pork fat depots. Soft pork fat is a major concern for pork processors as it creates challenges associated with processing and fabrication, processing yields, shelf-life, product attractiveness, and acceptability in certain export markets. Several alternative feeding strategies currently exist to prevent pork fat quality issues when feeding DDGS to growing-finishing pigs. Some of those include removing DDGS from the diet prior to harvest, feeding wheat and barley based diets, utilizing reduced oil corn co-products, adding CLA, adding crude glycerol, or formulating diets based on the iodine product value. However, not all of these strategies are readily available nor economically feasible for pork producers. Beef tallow is readily available fat source that is high in saturated fatty acids compared to other common animal fat sources. Furthermore, pork fat firmness may be improved by adding a more saturated fat source to the diet. However, no research studies have been conducted to investigate the effects of increasing DDGS level and supplemental tallow on growth performance, carcass characteristics, pork fat quality, and fatty acid digestibility. Therefore, the objective of this research project was to assess the quantitative effects of feeding different dietary levels of DDGS with supplemental tallow on growth performance, carcass quality, and pork fat quality; and to determine the effects of increasing levels of DDGS on apparent ileal fat and fatty acid digestibility for tallow and DDGS.

Materials & Methods

Animals and Facilities

The experimental protocol was approved by the Institutional Animal Care and Use Committee at the University of Minnesota. Two separate experiments were conducted at the University of Minnesota's Southern Research and Outreach Center. Experiment 1 was a growth performance and carcass composition study using growing-finishing pigs, while experiment 2 was a fatty acid digestibility study involving growing pigs to evaluate the effects of adding tallow and/or DDGS on fatty acid digestibility.

In Experiment 1, a total of 315 mixed sex pigs were housed in an environmentally controlled grower-finisher facility. Pigs were blocked by initial body weight (6.8 ± 1.1 kg), and were fed a common nursery diet until they reached approximately 30 kg in BW when block were randomly assigned dietary treatments. Barrows and gilts were housed in separate pens (7-8 pigs/pen). All pens (n = 40) contained totally slatted concrete flooring, a self-feeder with 2 feeding spaces, and a cup drinker.

For Experiment 2, twenty-four barrows were surgically fitted with a simple "T" cannula at the distal ileum following a modified procedure based on the work of Jendenza et al.(2011) and Dilger et al. (2004). Barrows were housed individually in metabolism crates in an environmentally controlled building.

Dietary Treatments and Feeding

For Experiment 1, when the average BW of each pen was approximately 30 kg, pens were randomly assigned to 1 of 4 dietary treatments for 10 pens per treatment.   Diets consisted of a conventional corn-soybean meal control (C), C plus 5% beef tallow (T), C with the addition of 30% DDGS (D), and C with the combination of 5% beef tallow and 30% DDGS (DT; Table 1). Pigs were fed according to a 3-phase feeding program with diets changing by phase when average pig BW in each pen of 60 or 90 kg BW was reached. Pigs had *ad libitum* access to feed and water for the duration of the 81 d experiment.

For Experiment 2, six different dietary treatments were formulated to contain 2 levels of DDGS (0 or 30%) and 3 levels of tallow (0, 5, 10%). Diets consisted of the following: corn-soybean meal conventional control diet (CON), CON plus 5% tallow at the expense of corn (5T), CON plus 10% tallow (10T), CON plus 30% DDGS (30D), CON plus 30% DDGS and 5% tallow (5T30D), and CON plus 30% DDGS and 10% tallow (10T30D; Table 2). Nutrient levels met or exceeded nutrient requirements for 40 kg pigs according to NRC (1998). Celite was added to all diets as in index marker at 0.3%.   Feed was supplied to the pigs at a daily level equivalent to 3 times their maintenance energy requirement (106 kcal ME/kg BW $^{0.75}$). This daily amount was divided into two equal meals supplied at 8:00 and 16:00 hr. Each pig was fed their corresponding diet for a 5-d adaptation period before a 3-d feces and 2-d digesta collection. Pigs had *ad libitum* access to water.

For both experiments, all diets were formulated based on a standardized ileal digestible (SID) Lys and available phosphorus basis. Other SID amino acid requirements were met for barrows and gilts based on a lean tissue gain of 350 g/d (NRC, 1998). Dietary levels of ME and SID Lys did vary across treatments, however, the SID Lys:ME was maintained constant for all treatments (Table 1 and 2).

Performance, carcass, and pork fat quality measurements (Experiment 1)

Individual pig weight and pen feed disappearance were measured to determine ADG, ADFI, and G:F at two week intervals. Carcass measurements were taken at a commercial abattoir when the average BW of all pigs was 113 kg. Hot carcass weight was determined on-line. All carcass measurements were obtained from the right side of the carcass. Last rib backfat thickness and loin depth was determined based on the AUS (animal ultrasound) was measured prior to harvest, and used with hot carcass weight to calculate the percentage of carcass fat free lean according to procedures described by NPPC (2000). For pork fat quality measurements, one pig per pen was selected based on BW closest to the average pen weight. Belly length and thickness were measured and recorded as described by Scramlin et al. (2008). The degree of belly firmness was assessed by draping the belly skin side down over a smoke stick. Distance between the inner edges was recorded. The degree of firmness was calculated based on the follow equation (Xu et al, 2010): Degree = $(\cos^{-1}[(0.5(L^2)-$

D^2)/(0.5(L^2))]), where L is half the belly length and where D is the distance between the two ends. Prior to measurement, bellies were squared up and approximately 57.6 cm long but belly width was not recorded.

Fat samples were collected from the belly and backfat for fatty acid analysis and IV calculation. Belly tissue cores were collected at the midline. Back fat samples were collected at the 10th rib on the right side of the carcass. Belly and backfat were measured for color lightness (L*), redness (a*), and yellowness (b*) of color using a HunterLab Miniscan with a D65 illuminant at 10° (Hunter Associates Laboratory, Inc., Reston, VA). Belly and backfat samples were evaluated for visual fat color by 8 panelists using the NPPC (2000) Japanese fat color scale (1 = white to 4= yellow). Once fat color scores were obtained, samples were packed in sealed sample bags, and frozen (-20°C) until fatty acid analysis was performed. Fat was extracted based on a modified Folch (1957) method where a 2:1 chloroform:methanol mixture was used for fat extraction. Extracted fat was methylated to fatty acid methyl esters for gas chromatography according to modifications based on the work of Metcalfe and Schmitz (1961). Fatty acid profile was determined utilizing gas chromatography according to the AOCS (1998). Iodine value was calculated utilizing the following equation (AOCS, 1998): (C16:1 ×0.95) + (C18:1 ×0.86) + (C18:2 × 1.732) + (C18:3 × 2.616) + (C20:1 × 0.785) + (C22:1 × 0.723).

Fatty Acid Digestibility Measurements (Experiment 2)

Feces were collected using the grab sample technique on d-6, 7, and 8, immediately after the morning and evening feedings. Rectal palpation was performed to ensure a fresh fecal sample was collected. Fecal samples were pooled by animal and diet and immediately frozen at -18°C until analysis could be conducted. Fecal samples were dried in a 55°C forced draft oven and ground to pass through a 1mm screen prior to analysis.

Ileal digesta samples were collected on d 9 and 10 for 2- four hr periods throughout collection days. Collections lasted from 8:00 to 12:00 h and from 16:00 to 20:00 h. Immediately following a feeding, cannulas were opened, and a 500 ml Whirl-pak bag containing 10 ml of a 10% formic acid solution was attached to the cannula barrel with a rubber band. Bags were removed when half-full or at 30 min intervals, whichever came first. All samples were immediately frozen at -18°C. Digesta samples were pooled within pig and freeze dried for analysis.

Acid insoluble ash was determined according to AOAC (1998) procedures. Fatty acid analysis were performed commercially (Lipid Technologies, LLC, Austin, MN) using gas chromatography to separate fatty acid methyl esters according to the AOCS (1998) method Ce 1-62. Fatty acid digestibility values were calculated based on the index method using the following equation:

$$Digestibility, \% = 100 - [100 \times \left(\frac{concentration\ of\ index\ in\ feed\ \times concentration\ of\ component\ in\ feces}{concentration\ of\ index\ in\ feces\ \times concentration\ of\ component\ in\ feed}\right)]$$

Statistical Analysis

For Experiment 1, data were analyzed in a randomized complete block design utilizing the Mixed Procedure of SAS (SAS Inst. Inc., Cary, NC). Dietary treatments were arranged in a 2 × 2 factorial with random effect of block and fixed effects of gender, DDGS, tallow, and DDGS × tallow. The significance level was declared at $P < 0.05$ and trends are described at $0.10 > P > 0.05$. Pen served as the experimental unit for data analysis. The pdiff option with Tukey adjustment was used for comparison of treatment least squares means.

For Experiment 2, data were analyzed utilizing the Mixed procedure of SAS (SAS Inst. Inc., Cary, NC) in a completely randomized design. Dietary treatments were arranged in a 2 × 3 factorial. The statistical model included fixed effects of DDGS, tallow, and DDGS × tallow.

Results and Discussion

Experiment 1

Results from this study (Table 3, 4, 5) suggest that feeding 30% DDGS does not impact ADG, G:F, carcass yield, loin depth, or belly thickness. However, the addition of 30% DDGS does cause a reduction in ADFI, tends to reduce HCW, decreases backfat depth, and increases percentage of carcass fat-free lean. Furthermore, DDGS inclusion reduces belly firmness, increases the iodine value, PUFA concentration, and C18:2 levels, and alters fat color characteristics. The inclusion of 5% tallow does not impact ADG, carcass yield, loin depth, or belly firmness. However, tallow inclusion did reduce ADFI, improve G:F, increase HCW and backfat depth, but reduced the percentage of carcass fat-free lean. Feeding diets containing 5% tallow and 30% DDGS had no effect on improving belly firmness or fat quality characteristics.

Final BW and overall ADG did not differ among treatments (Table 3). Overall ADFI was greater for pigs fed C and D diets compared to pigs fed T and DT ($P < 0.01$), and pigs fed D and DT consumed less feed than pigs fed C and T ($P < 0.04$). Likewise, overall gain efficiency was improved with the addition of tallow ($P < 0.01$) compared to diets that didn't contain tallow. Growth performance results are consistent with previous findings where Senne et al. (1995) fed diets containing 30% DDGS and showed no differences in growth performance.

Similarily, Widmer et al. (2008) fed diets containing 10 or 20% DDGS and showed no effect on ADG, ADFI, or G:F compared to pigs fed control diets. In contrast, Whitney et al. (2006) fed diets containing up to 30% DDGS which resulted in reduced ADG and ADFI compared to diets containing lesser amounts of DDGS. Linneen et al. (2008) reported a depression in ADG and ADFI when pigs were fed diets containing up to 20% DDGS. Ulery et al., (2010) fed growing finishing pigs 45% DDGS and 0 or 5% beef tallow and found that adding beef tallow improved ADG and F:G. Increasing dietary fat in the diet improves average daily gain, reduces daily feed consumption, and improves gain:feed ratio when fed corn oil (Allee et al., 1971). Likewise, Linneen et al., (2008) reported that ADG and G:F improved linearly as the level of added fat (choice white grease) increased from 0, 3, or 6%. Allee et al., (1971) found that the addition of tallow to caused a tendency for pigs to gain faster and more efficiently. Feoli et al. (2007) reported that for every 1 percentage unit of fat added to a diet containing DDGS feed conversion improved by about 2%. Reductions of ADFI in this experiment were caused primarily by increased caloric density of the diets containing tallow.

Hot carcass weight was greater for pigs fed T and DT ($P < 0.01$) compared to pigs not fed tallow, and pigs fed D and DT tended ($P < 0.08$) to have lighter HCW compare to pigs not fed D or DT (Table 4). Carcass yield percentage and loin depth did not differ across treatments. A significant interaction for percentage of carcass fat free lean (FFL) was observed ($P < 0.05$). When tallow was included in the diet, percentage FFL was reduced compared to pigs not fed tallow; however, the inclusion of DDGS and tallow improved the percentage of carcass FFL. Hot carcass weight and dressing percentage have been shown to decrease as the concentration of DDGS increases (Whitney et al., 2006, Linneen et al., 2008). However, Fu et al. (2004) and Widmer et al. (2008) did not detect any differences in backfat, loin depth, carcass lean percentage, or carcass yield as a result of feeding diets containing DDGS. It remains unclear as to why carcass yield is an inconsistent response when DDGS diets are fed, but it may be related to the relatively high fiber content in DDGS, causing an increase in visceral mass, this reducing carcass yield.

Belly firmness, as measured by the belly flop angle was reduced for pigs fed D or DT ($P < 0.01$) compared to pigs fed diets not containing DDGS, but the addition of tallow to the diets did not improve belly firmness because firmness was similar for pigs fed D and DT (Table 5). It is well documented that the addition of DDGS to swine diets negatively impacts pork fat quality. As DDGS level increases in the diet, the degree of belly firmness decreases (Whitney et al, 2006, Widmer et al., 2008, Xu et al., 2010). However, tallow addition to sorghum DDGS diets did not improve belly firmness (Ulery et al., 2010). Bellies tended ($P < 0.07$) to be thicker for pigs fed diets containing tallow. Likewise, bellies tended to be slightly shorter for pigs fed T and DT ($P < 0.04$). Palmitic acid (C16:0) was lower in both belly and backfat for pigs fed T and DT ($P < 0.01$) compared to pigs fed C and D. In the backfat, palmitic acid tended ($P < 0.07$) to be lower for pigs fed diets containing DDGS. Pigs fed D and DT had lower levels ($P < 0.04$) of palmitoleic acid (C16:1) in belly fat, but no differences among dietary treatments for C16:1 were observed in the backfat. In belly fat, but not backfat, stearic acid (C18:0) was lower ($P < 0.02$) for pigs fed D and DT, and in backfat, but not belly fat, C18:0 was reduced ($P < 0.01$) for pigs fed T and DT. Oleic acid (C18:1) increased in both belly and back fat when pigs were fed T and DT ($P < 0.001$). Similarly, pigs fed D and DT had lower concentrations of C18:1 in backfat ($P < 0.01$), and tended to be lower belly fat ($P < 0.08$). Linoleic acid (C18:2) concentrations were higher when pigs consumed D or DT ($P < 0.01$). Saturated fatty acids were lower in both fat depots with the addition of T and DT ($P < 0.01$) or D and DT ($P < 0.01$). Diets T and DT caused an increase in MUFA levels in both fat depots ($P < 0.01$). In the backfat, pigs fed D and DT had lower MUFA concentrations ($P < 0.01$). Polyunsaturated fatty acids increased ($P < 0.01$) in D and DT. Xu et al. (2010) found that PUFA concentrations and IV increase in pork fat depots while feeding DDGS. Likewise, Feoli et al., (2007) found that supplemental dietary tallow did not improve fat quality as measured by the iodine value of the jowl fat. Feeding D and DT caused a significant reduction in Hunter a*, b*, and L* in belly and backfat ($P < 0.02$). In backfat, b* tended to decrease with the addition of T or DT. Japanese color scores (1 = white, 4 = yellow) were higher when pigs were fed D or DT ($P < 0.03$) in both belly and backfat.

Experiment 2

No information exists on the fatty acid digestibility of DDGS. In this experiment, fecal digestibility was generally greater compared to ileal digestibility of fatty acids (Table 6). It is well documented that fecal digestibility values are greater compared to ileal digestibility values when tallow is included in the diet (Duran-Montge et al., 2007, Ozimeck et al., 1984). Fecal values may be higher since unsaturated fatty acids are hydrogenated by gut microflora as suggested by Jorgensen et al (2000). However, ileal digestibility is superior to fecal digestibility values when fish oil, rapeseed oil, or coconut oil is fed (Jorgensen et al., 2000). Ileal digestibility values are more indicative of fatty acid digestibility of the diet because fatty acids are digested in the small intestine, and nearly all fatty acids are absorbed in the ileum. Significant DDGS ×x tallow interactions were observed for fecal C16:0, C16:1, C18:0, C18:1, MUFA, and SFA digestibility. Likewise, significant interactions between DDGS and beef tallow ($P < 0.04$) were observed for ileal C16:0, C16:1. C18:0, C18:2, PUFA, and SFA digestibility.

For fecal C16:0, when DDGS was not included in the diet, but tallow was included, fecal digestibility increased. However, when diets contained both DDGS and tallow, digestibility was decreased. For C16:0 ileal digestibility, coefficients were higher when the diet excluded DDGS. For C16:0, digestibility of CON was intermediate between 5T and 10T, yet similar to 30D. For diets that contained 30% DDGS, the addition of tallow decreased C16:0 digestibility. It is well documented that saturated fatty acids, or fats from animal origin, tend to have a lower ileal digestibility than unsaturated fatty acids from vegetable origin (Jorgenson et al., 1992, Overland et al., 1994). For fecal C18:0, digestibility was greater when tallow was included in the diet, but when DDGS and tallow were included in the diet, fecal digestibility was reduced. Furthermore, when DDGS was not present in the diet and tallow was added, ileal digestibility of C18:0 increased, but when DDGS and tallow both added to the diet, digestibility decreased.

For fecal C16:1 digestibility, digestibility coefficients were lowest for CON, but increased when tallow was included in the diet (5T and 10T). Furthermore, adding DDGS (30D, 5T30D, 10T30D) improved C16:1 digestibility compared to CON. When DDGS was not present in the diet and tallow was added, ileal digestibility of 16:1 increased, but digestibility decreased when DDGS and tallow were combined in the diet.

For fecal C18:1, CON had the lowest digestibility, and the inclusion of tallow, but not DDGS (5T and 10T) increased C18:1 digestibility of the feces. Conversely, pigs fed 30D exhibited a digestibility similar pigs fed diets that did not contain DDGS but contained tallow (5T and 10T). However, the addition of both DDGS and tallow (5T30D and 10T30D) lowered digestibility of C18:1. There tended ($P < 0.09$) to be an interaction between DDGS and tallow for C18:1 ileal digestibility.

Fecal C18:2 digestibility was not different among treatments. For C18:2 and PUFA, ileal digestibility was greatest for CON, but was reduced for 5T and 10T. The addition of DDGS improved C18:2 digestibility, but digestibility was reduced when 10% tallow was included. Ileal digestibility of C18:2 has been reported to range from 75.4 to 99.0% (Jorgensen et al., 1993, Jorgensen et al., 2000), which is higher than the range of 56.6 to 96.2% for C18:2 in the present study. This difference may be attributed to different analytical methods methods used as suggested by Duran-Montge (2007). However, due to its relatively high digestibility, C18:2 is found in pork fat depots in high concentrations.

With increasing dietary levels of tallow (with or without DDGS), fecal MUFA digestibility increased. However, when DDGS and increasing levels of tallow were added together to diets, fecal digestibility was not as great compared to when DDGS was not present in the diet. There tended ($P < 0.07$) to be an interaction between DDGS and tallow for MUFA ileal digestibility. When DDGS was not present and tallow was added, ileal digestibility of MUFA increased. But when DDGS was included in the diet with supplemental tallow, digestibility values were similar. For PUFA, fecal digestibility was not different among dietary treatments. However, ileal digestibility was greatest for CON (77.8%), but was reduced for to 65.9% and 57.4%, respectively, in pigs fed 5T30D and 10T30D.

With the level of tallow increased in diets without DDGS, fecal SFA digestibility increased. However, when DDGS and increasing levels of tallow were added to the diet, fecal digestibility was not as great compared to when DDGS was not present in the diet. For ileal SFA digestibility, pigs fed CON had intermediate digestibility compared with pigs fed 5T and 10T, but ileal digestibility of pigs fed 30D was similar those fed 10T. However, when tallow was increased in diets containing DDGS (5T30D and 10T30D), ileal digestibility of SFA decreased.

Many interactions between DDGS and tallow were observed for fecal and ileal fatty acid digestibility. The fiber content of the DDGS may be a contributing factor to fatty acid digestibility. Just (1982) showed that as crude fiber increased in the diet, apparent fat digestibility decreased. The ileal digestibility values are lower in this study compared to other reports, especially for linoleic acid. These results will be useful for understanding the importance of dietary fatty acid level in growing-finishing pig diets relative to developing nutritional strategies to minimize the negative effects of feeding diets containing DDGS on pork fat quality. Although 16:0 and 18:0 had similar digestibility values compared to mono- or polyunsaturated fatty acids, these two fatty acids were not found in appreciable quantities in pork fat depots, due to the extremely small amounts of these fatty acids in the diets. Even though ileal digestibility was lower for C18:2 (the primary fatty acid in

DDGS) compared to C18:0 digestibility, pigs fed DDGS containing diets had a higher concentration of C18:2 in their fat depots. It is the amount of C18:2 consumed that makes such a profound difference in the levels deposited in adipose tissue.

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Table 1. Composition and calculated nutrient analysis of experiment 1 diets (as-fed basis)

	Phase 1 (66 to 132 lbs)				Phase 2 (132 to 198 lbs)				Phase 3 (198 to 250 lbs)			
Ingredient, %	**C**	**T**	**D**	**DT**	**C**	**T**	**D**	**DT**	**C**	**T**	**D**	**DT**
Corn	71.85	64.05	47.00	39.50	79.45	72.40	54.90	47.65	84.48	79.30	61.80	54.65
Soybean Meal	25.50	28.30	20.75	23.25	18.10	20.15	13.0	15.25	11.00	13.20	6.10	8.25
DDGS	0	0	30.00	30.00	0	0	30.00	30.00	0	0	30.00	30.00
Beef Tallow	0	5.00	0	5.00	0	5.00	0	5.00	0	5.00	0	5.00
Limestone	0.70	0.70	1.30	1.30	0.55	0.55	1.15	1.15	0.57	0.55	1.15	1.15
Dicalcium Phosphate	1.00	1.00	0	0	0.95	0.95	0	0	1.00	1.00	0	0
Salt	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
L-lysine	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
VTM premix	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Calculated nutrient analysis												
ME, kcal/kg	3.32	3.53	3.31	3.53	3.33	3.54	3.32	3.53	3.33	3.54	3.33	3.54
Crude Fat, %	3.57	3.35	5.79	5.57	3.64	3.43	5.87	5.65	3.70	3.49	5.93	5.71
Linoleic Acid, g/100g	1633.7	1500.8	2906.4	3086.3	1543.7	1775.9	2750.3	2981.3	1982.4	2105.0	3354.7	3279.0
SID Lys, %	0.95	1.01	0.96	1.01	0.77	0.81	0.76	0.81	0.59	0.63	0.59	0.63
SID Lys:ME (g/kcal of ME)	2.86	2.86	2.90	2.86	2.31	2.29	2.29	2.30	1.77	1.78	1.77	1.78

Table 2. Composition and calculated nutrient analysis of experiment 2 diets (as-fed basis)

	0% DDGS			30% DDGS		
Tallow	**0%**	**5%**	**10%**	**0%**	**5%**	**10%**
Treatment:	**CON**	**5T**	**10T**	**30D**	**5T30D**	**10T30D**
Ingredient, %						
Corn	70.65	64.73	58.81	54.58	48.67	42.72
Soybean Meal	25.62	26.39	27.17	10.99	11.76	12.59
DDGS	0	0	0	30	30	30
Beef Tallow	0	5.00	10.00	0	5.00	10.00
Limestone	0.75	0.75	0.74	0.81	0.80	0.80
Dicalcium Phosphate	1.36	1.37	1.37	1.52	1.53	1.53
Salt	0.30	0.30	0.30	0.30	0.30	0.30
Celite	0.30	0.30	0.30	0.30	0.30	0.30
L-lysine	0.32	0.39	0.47	0.64	0.71	0.79
VTM premix	0.50	0.50	0.50	0.50	0.50	0.50
L-threonine	0.11	0.17	0.23	0.18	0.23	0.26
L-tryptophan	0.03	0.03	0.03	0.12	0.13	0.13
DL-methionine	0.06	0.07	0.08	0.06	0.07	0.08
Total	100	100	100	100	100	100
Calculated nutrient analysis						
ME, kcal/kg	3323.46	3537.68	3751.92	3307.43	3521.90	3735.98
Crude Fat, %	3.20	7.01	10.54	6.65	9.41	13.78
Linoleic Acid, g/100g	1604.7	1616.8	1626.9	2644.9	2735.2	2933.0
SID Lys, %	1.09	1.16	1.23	1.09	1.16	1.23
SID Lys:ME (g/kcal of ME)	3.28	3.28	3.28	3.30	3.30	3.29

Table 3. Effects of feeding diets containing 5% tallow and 30% DDGS on pig growth performance of growing finishing pigs

	Tallow		**DDGS**						
	0%	**5%**	**30%**	**30%**					
Trait	**CON**	**T**	**D**	**DT**	**PSE**	**DDGS**	**Tallow**	**Gender**	**DDGS×Tallow**
Initial BW, kg	32.70	31.95	32.59	32.38	0.70	NS	NS	NS	NS
Final BW, kg	112.69	114.55	112.59	113.27	1.158	NS	NS	<0.01	NS
Phase 1 ADG, kg	0.99	1.01	0.96	1.01	0.02	NS	<0.02	<0.09	NS
Phase 1 ADFI, kg	2.22	2.13	2.29	2.02	0.04	NS	<0.01	<0.05	<0.04
Phase 1 G:F	0.45	0.47	0.42	0.50	0.01	NS	<0.01	NS	<0.01
Phase 2 ADG, kg	1.04	1.11	1.07	1.02	0.02	NS	NS	<0.01	<0.02
Phase 2 ADFI, kg	2.98	2.81	2.87	2.65	0.04	<0.01	<0.01	<0.01	NS
Phase 2 G:F	0.35	0.39	0.37	0.39	0.01	NS	<0.01	NS	<0.10
Phase 3 ADG, kg	1.00	1.01	0.99	1.00	0.02	NS	NS	<0.01	NS
Phase 3 ADFI, kg	3.06	2.77	3.11	2.69	0.06	NS	<0.01	<0.01	NS
Phase 3 G:F	0.33	0.37	0.32	0.37	0.01	NS	<0.01	NS	NS
Overall ADG, kg	2.76	2.59	2.76	2.45	0.03	NS	NS	<0.01	NS
Overall ADFI, kg	1.01[a]	1.04[c]	1.01[d,e]	1.01[b.d.f]	0.01	< 0.04	<0.01	<0.01	<0.06
Overall G:F	0.37[a]	0.40[b,c]	0.37[d,e]	0.41[b,f]	<0.01	NS	<0.01	NS	NS

[a,b; c,d; e,f]Within a row, means without a common superscript differ (P < 0.05)

NS = non-significant

Table 4. Effects of feeding diets containing 5% tallow and 30% DDGS on carcass characteristics of finishing pigs

	Tallow		DDGS						
	0%	5%	30%	30%					
Trait	CON	T	D	DT	PSE	DDGS	Tallow	Gender	DDGS×Tallow
Hot Carcass Weight, kg	88.6[a]	91.6[b,x]	88.4[y]	89.4[y]	1.05	<0.08	<0.01	<0.01	NS
Carcass yield, %	78.8[a]	79.6[b,c]	78.3[d,e]	79.4[f]	0.19	NS	<0.01	NS	NS
Backfat Depth, cm	2.00[a]	2.19[b,c,x]	1.91[d]	2.04[y]	0.05	<0.02	<0.01	<0.01	NS
Loin Depth, cm	6.99	6.71	6.71	6.74	0.11	NS	NS	NS	NS
Fat Free Lean, %	49.88[a]	48.90[b,c]	49.86[d]	49.51[d]	0.15	<0.05	<0.01	<0.01	<0.05

[a,b; c,d; e,f] Means within a row without a common superscript differ ($P < 0.05$)
[x,y] Means within a row without a common superscript differ ($0.05 < P < 0.10$)
NS = non-significant

Table 5. Effects of feeding diets containing 5% tallow and 30% DDGS on pork fat quality

	Tallow		**DDGS**						
	0%	**5%**	**30%**	**30%**		**P-value**			
Trait	**CON**	**T**	**D**	**DT**	**PSE**	**DDGS**	**Tallow**	**Gender**	**DDGS× Tallow**
Belly									
Belly flop angle, °	125.84^{a}	115.27^{c}	72.60^{b,d}	63.14^{b,d}	9.98	<0.01	NS	NS	NS
Belly thickness, cm	3.34^{x}	3.64	3.61^{y}	3.75	0.12	NS	<0.07	<0.04	NS
Belly length, cm	58.28	57.34	58.23	56.46	0.63	NS	<0.04	NS	NS
C 16:0, %	23.29^{a}	20.39^{b}	22.13	20.15^{b}	0.91	NS	<0.01	NS	NS
C 16:1, %	2.98	3.07	2.40	2.46	0.29	<0.04	NS	NS	NS
C 18:0, %	13.63^{a,x}	12.20	11.61^{y}	11.37^{b}	0.56	<0.02	NS	NS	NS
C 18:1, %	45.23^{a}	50.90^{b}	43.36^{a}	47.54		<0.08	<0.01	NS	NS
C 18:2, %	8.49^{a}	8.85^{a}	16.41^{b}	15.67^{b}	1.12	<0.01	NS	NS	NS
IV	59.01^{a}	64.22^{x}	71.22^{b,y}	67.88^{b}	1.87	<0.01	NS	<0.05	<0.03
SFA, %	38.93^{a}	34.05^{b}	34.13^{b}	32.40^{b}	1.09	<0.01	<0.01	NS	NS
MUFA, %	51.08	57.47^{a}	48.65^{b}	56.24^{a}	2.10	NS	<0.01	NS	NS
PUFA, %	8.51^{a}	9.19^{a}	17.23^{b}	16.08^{b}	1.23	<0.01	NS	NS	NS
Backfat									
C 16:0, %	24.49^{a}	21.99^{b}	23.60^{c}	20.32^{b,d}	0.66	<0.07	<0.01	NS	NS
C 16:1, %	1.60	1.59	1.88	1.09	0.27	NS	NS	NS	NS
C 18:0, %	18.04^{a}	14.15^{b}	16.70	14.25^{b}	0.88	NS	<0.01	NS	NS
C 18:1, %	43.90^{a,x}	46.64^{a,y}	39.86^{b}	44.82^{a}	0.78	<0.01	<0.01	NS	NS
C 18:2, %	8.81^{a}	9.65^{a}	18.04^{b}	18.40^{b}	0.98	<0.01	NS	NS	NS
IV	56.72^{a}	61.90^{b}	68.31^{c}	71.78^{c}	1.40	<0.01	<0.01	NS	NS
SFA,	42.79^{a}	37.89	39.77^{a}	33.11^{b}	1.60	<0.01	<0.01	NS	NS
MUFA, %	48.39^{a,d}	53.96^{b}	42.66^{c}	47.12^{d}	1.01	<0.01	<0.01	NS	NS
PUFA, %	8.89^{a}	9.92^{a}	18.05^{b}	18.45^{b}	1.00	<0.01	NS	NS	NS

$^{a,b;\ c,d;\ e,f}$ Means within a row without a common superscript differ ($P < 0.05$)

^{x,y} Means within a row without a common superscript differ ($0.05 < P < 0.10$)

NS = non-significant

Table 6. Fecal and ileal digestibility of fatty acids in diets containing 0, 5, or 10% tallow and 0 or 30% DDGS in growing pigs

	0% DDGS			**30% DDGS**						
Tallow	**0%**	**5%**	**10%**	**0%**	**5%**	**10%**		**P-value**		
Treatment:	**CON**	**5T**	**10T**	**30D**	**5T30D**	**10T30D**	**PSE**	**DDGS**	**Tallow**	**DDGS × Tallow**
Fecal Digestibility										
C 16:0, %	88.00[a,x]	89.63[c]	90.75[e]	86.42[dfg]	82.16[bdfh]	82.44[bdfh]	0.73	<0.01	<0.01	<0.01
C 16:1, %	96.31[a]	99.19[bc]	98.75[be]	98.34[bdg]	97.26[dfh]	97.72[bdf]	0.22	NS	<0.01	<0.01
C 18:0, %	-36.79[a]	67.38[bc]	78.43[bde]	12.83[dfx]	40.15[df]	43.30[dfy]	9.04	<0.01	<0.01	<0.01
C 18:1, %	95.14[a]	97.47[b]	98.03[bc]	97.65[b]	96.12[d]	97.48[b]	0.41	NS	<0.01	<0.01
C 18:2, %	98.15	96.90	97.14	97.61	96.62	97.13	0.59	NS	NS	NS
MUFA	88.18[a]	94.97[bcx]	96.40[be]	89.18[dfg]	91.36[bdfhi]	93.32[bfhjy]	0.44	<0.01	<0.01	<0.01
PUFA	97.86	96.64	96.88	97.16	96.06	96.57	0.60	NS	NS	NS
SFA	65.36[a]	80.70[bc]	85.41[be]	64.78[df]	66.29[df]	66.70[df]	1.54	<0.01	<0.01	<0.01
Ileal Digestibility										
C 16:0, %	78.61[a]	75.53[c]	81.43[de]	77.62[ce]	69.66[bdfhi]	68.43[bdfhi]	1.22	<0.01	<0.01	<0.01
C 16:1, %	81.21[a]	93.29[b]	94.94[bc]	92.87[b]	90.70[b]	89.90[bd]	1.17	NS	<0.01	<0.01
C 18:0, %	73.49[x]	72.78	76.89	86.09[ay]	64.82[b]	63.58[b]	3.73	NS	NS	<0.01
C 18:1, %	71.28[a]	78.57	85.44[bc]	74.80[d]	76.30[d]	79.26[d]	2.05	<0.05	<0.02	<0.09
C 18:2, %	76.67[ax]	57.89[b]	61.00[y]	66.17[c]	65.32	56.57[bd]	3.77	NS	<0.01	<0.04
MUFA	74.42[a]	79.09	85.95[bc]	75.33[d]	77.01[d]	77.34[d]	1.98	<0.06	<0.01	<0.07
PUFA	77.28[a]	59.09[c]	62.61[e]	66.48[fg]	65.87[bfh]	57.37[bdh]	3.63	NS	<0.01	0.03
SFA	76.00[a]	74.56[c]	79.99[e]	79.88[g]	68.23[bfh]	66.29[bdfh]	1.77	<0.01	<0.01	<0.01

[a,b; c,d; e,f] Means within a row without a common superscript differ ($P < 0.05$)
[x,y] Means within a row without a common superscript differ ($0.05<P < 0.10$)
NS = non-significant