Effects of Supplementing with Soybean Oil and Finishing with Beef Tallow on Pork Quality and Carcass Composition

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Carcass quality reflects the physical and chemical properties of both fat and lean, and these are affected by a number of factors including diet and genetics. We hypothesize that an optimal fatty acid profile in animal fat is required to assure consistent quality of products, and that variability in the quality of dietary fats and genetic differences in tolerance to dietary fat leads to inconsistency in carcass quality. In this trial, soybean oil (SBO) was fed to two divergent genotypes of gilts in an effort to enrich their fat with 18:2 (n-6) and 18:3 (n-3) poly-*unsaturated* fatty acids. These fatty acids are believed to negatively influence fat firmness when found in high concentrations, and do naturally occur in pig fat at such levels. Following removal of SBO, changes in the concentration of these fatty acids, coupled with changes in adipose cell volume, will allow us to calculate the rate of *depletion* of fatty acids from adipose cells. Similarly, the rate of fatty acid *accretion* into adipose triglycerides can be calculated by supplementing with beef tallow, a highly *saturated* fat. Estimates of these rates, and knowledge of how genotype influences synthesis and breakdown rates, will provide valuable information for the development of feeding strategies that will ensure a desired fatty acid composition endpoint.

Materials and Methods

A study of pork quality and carcass composition of two divergent genotypes was conducted. These genotypes represent average (AVE) and the upper 5th percentile for percent lean (LEAN) for U.S. pigs. At 100 lb live weight, 72 gilts were allotted to a 2 x 2 x 3 factorial arrangement of genotype, diet and slaughter weight (Table 1). All pigs received a conventional corn-soybean meal diet with 10% added soybean oil during the pre-trial period (100 to 176 lb). At 176 lb, 6 gilts of each genotype were slaughtered to provide baseline measures of fatty acid composition. From 176 lb until slaughter, pigs received either no supplemental fat (NF) or 5% beef tallow (BT). At 205, 235, and 264 lb liveweight, six pigs from each genotype x diet combination were transported to the Purdue Meat Laboratory for slaughter, tissue collection and carcass evaluation.

At exsanguination, middle layer backfat, belly fat and loin were collected and snap frozen in liquid nitrogen until assayed for lipid and fatty acid composition. At 24 hours postmortem, standard carcass measurements such as backfat depths, loin eye area, and subjective loin eye quality (color, firmness/wetness and marbling) were taken. Bellies were removed from the carcasses, measured for thickness and subjectively graded for firmness. The turnover rate of preformed adipose tissue triglycerides will be determined by quantifying both the depletion of unsaturated fatty acids following removal of soybean oil from the ration, and the accretion of saturated fatty acids following supplementation with beef tallow.

Results and Discussion

Growth Traits

This trial reconfirmed the expectation that leaner genotypes are more feed efficient. During both the pre-trial (100 to 176 lb) and on-test (176 lb to slaughter) phases of feeding, AVE pigs had higher average daily feed intake (ADFI) and lower feed efficiency (FE) than did LEAN pigs (Table 2). Genotype had no effect on average daily gain (ADG). Pigs fed 5% beef tallow were more feed efficient than pigs with no supplemental fat in their diets (Table 3). We would expect this, as tallow increases the caloric density of the diet, requiring less consumption for the same gain.

Pork Quality and Carcass Composition

As expected, LEAN gilts had less 10th rib backfat, greater loin eye area, thinner bellies, lower marbling scores of the loin muscle at the 10th rib, and lower belly firmness scores than AVE gilts (Table 2). Genotype did not affect loin color or loin firmness evaluations. Pigs fed BT had thicker bellies than pigs fed NF (Table 3). Dietary fat did not affect backfat depth, loin eye area, loin color or marbling evaluations of the loin. A genotype x diet interaction existed for belly firmness, as the beef tallow diet caused the bellies of AVE pigs to be less firm and the bellies of LEAN pigs to be more firm (Table 5). As slaughter weight increased, so did backfat, marbling scores, middle layer belly fat, belly firmness and loin eye area (Table 4). Slaughter weight had no effect on loin color, loin firmness or dressing percentage. A diet x slaughter weight interaction existed for belly firmness, as increased slaughter weight caused an increase in the belly firmness of pigs fed no supplemental fat, but had no effect on pigs fed beef tallow (Table 6). Following removal of the SBO from the diets, belly firmness increased faster in LEAN pigs, but AVE pigs still had significantly firmer bellies at the typical slaughter weights (Table 7). Overall, genotype appeared to have greater effects on pork quality and carcass composition than did dietary fat. Supplementing with beef tallow benefited only LEAN pigs, but perhaps not enough to compensate for the effects of feeding SBO. Finishing with beef tallow worsened belly firmness in AVE pigs and appeared to interfere with the improvement of belly firmness that is typically observed as slaughter weight increases.

Fatty Acid Composition

Backfat of AVE pigs contained more mono-unsaturated fatty acids (MUFA), less poly-unsaturated fatty acids (PUFA), and significantly higher ratios of total saturated : total unsaturated fatty acids (SFA:UFA) and SFA:PUFA than did backfat of LEAN pigs (Table 2). Although not statistically significant, a trend for AVE pigs to have more SFA is apparent. Belly fat of AVE pigs contained more MUFA and less PUFA than did the belly fat of LEAN pigs (Table 2). The backfat of pigs fed BT diets was less saturated and had a lower SFA:PUFA ratio (Table 3). *There were no main effects of diet on the fatty acid composition of belly fat.* As slaughter weight increased, so did levels of SFA and MUFA in the backfat (Table 4). Concurrently, levels of UFA and PUFA decreased. The effects of increasing slaughter weight on the fatty acid composition of bellies were less than what was observed in backfat (Table 4).

Finishing with beef tallow had no effect on SFA:UFA of belly fat but did improve the belly firmness of LEAN pigs, whereas tallow decreased SFA:UFA and worsened belly firmness in AVE pigs (Table 5). The improvement in belly firmness of LEAN pigs may be due to the effect of beef tallow on belly thickness (Table 5). Belly firmness improved as slaughter weight increased, but no significant, concurrent increases in SFA, SFA:UFA or MUFA of belly fat were observed for either dietary treatment (Table 6). Total belly fat SFA increased as slaughter weight increased for AVE pigs, but not for LEAN pigs, even though both genotypes improved in belly firmness (Table 7). It is likely that rates of fat maturation, differences in the relative growth of individual backfat layers, utilization of fat from carbohydrate vs. dietary fat sources, and the rates of fat accretion and depletion have all been affected by genetic selection for leanness. In other words, continued selection for leanness has altered the biology of adipose tissue in the pig. Thus, the differential response of these divergent genotypes to dietary fat could be due to genetic differences for any of these factors. Differences in the effects of feeding soybean oil and beef tallow between genotypes, and across depots, may be due to differences in gene expression or to differences in the timing and rates of depot growth. The number of genotype x diet interactions observed in this trial will indicate which facets of adipose biology have been affected and direct our future efforts.

Overall, none of the fatty acid composition traits discussed in this report appear to be good indicators of belly firmness. Future analyses will investigate the role of individual fatty acids in belly firmness. This data does suggest that differences in rates of adipose turnover will be found across both genotypes and depots. The inability of diet to have much of an effect on belly fat composition may be due to differences in rates of fat accretion and depletion.

Value of Research to Swine Industry

Neither total saturates nor the ratio of saturates to unsaturates appear to be good indicators of belly firmness. Rather, it appears that genotype has the greatest effect on belly firmness, and that firmness consistently increases as slaughter weight increases. Finishing with 5% beef tallow did improve the firmness of LEAN bellies, but not to the firmness level of AVE bellies. Despite being a highly saturated source of supplemental fat, tallow actually decreased the level of saturates in AVE pigs and lessened their belly firmness. Thus, while supplemental fat can improve pig growth without affecting pork quality, considerations for its use to improve belly quality should be genotype-specific. Changes in the level of individual fatty acids over time and their effect on quality and composition are in progress, and will be described in future reports.

Table 1. Design of the trial.

	10 % Soy Bean Oil, 100 to 176 lb			
Kill wt.	AVE		LEAN	
176 lb	n = 6		n = 6	
	No fat	5% BT	No fat	5% BT
205 lb	n = 6	n = 6	n = 6	n = 6
235 lb	n = 6	n = 6	n = 6	n = 6
264 lb	n = 6	n = 6	n = 6	n = 6

Table 2. Effects of genotype on pig growth, pork quality and carcass composition.

	AVE	LEAN	SE	Sig.*
Pre-trial Growth (100 to 176 lb)				
Average daily gain (lb)	1.90	1.86	0.03	Not sig.
Average daily feed intake (lb)	4.95	4.49	0.11	P<.01
Feed efficiency	2.62	2.41	0.04	P<.01
On-test Growth (176 lb to slaughter)				
Average daily gain (lb)	1.89	1.97	0.07	Not sig.
Average daily feed intake (lb)	6.14	5.50	0.19	P<.05
Feed efficiency	3.27	2.85	0.09	P<.01
Pork Quality and Carcass Composition				
First rib backfat (in.)	1.40	1.34	0.04	Not sig.
Last rib backfat (in.)	0.85	0.78	0.03	Not sig.
Last lumbar backfat (in.)	0.78	0.69	0.03	P<.05
10th rib fat depth (in.)	0.83	0.64	0.03	P<.01
10th rib outer layer (in.)	0.36	0.32	0.01	P<.05
10th rib middle layer (in.)	0.32	0.25	0.02	P<.01
10th rib inner layer (in.)	0.15	0.07	0.01	P<.01
Loin color**	2.78	2.63	0.08	Not sig.
Loin firmness**	3.13	2.89	0.10	Not sig.
Loin marbling**	1.75	1.28	0.07	P<.01
Loin eye area (sq.in.)	6.46	7.13	0.20	P<.05
Dressing percentage	74.12	74.80	0.45	Not sig.
Belly firmness***	2.24	1.53	0.08	P<.01
Belly thickness (in.)	1.02	0.88	0.03	P<.01
Outer belly fat layer (in.)	0.50	0.43	0.01	P<.01
Middle belly fat layer (in.)	0.30	0.23	0.02	P<.01
Lean streak (in.)	0.22	0.23	0.01	Not sig.
Fatty Acid Comp. of Middle Layer Backfat				
% Total Saturated Fatty Acids (SFA)	32.77	30.53	0.77	Not sig.
% Total Unsaturated Fatty Acids (UFA)	65.53	65.82	1.38	Not sig.
SFA : UFA	0.52	0.46	0.03	P<.05
% Total Mono-Unsat. Fatty Acids (MUFA)	37.64	35.29	0.86	P<.05
% Total Poly-Unsat. Fatty Acids (PUFA)	27.89	30.53	0.88	P<.05
Fatty Acid Composition of Belly Fat				
% Total Saturated Fatty Acids (SFA)	31.61	29.86	0.89	Not sig.
% Total Unsaturated Fatty Acids (UFA)	64.95	65.04	1.72	Not sig.
SFA : UFA	0.50	0.46	0.02	Not sig.
% Total Mono-Unsat. Fatty Acids (MUFA)	40.75	37.97	1.14	P<.05
% Total Poly-Unsat. Fatty Acids (PUFA)	24.19	27.08	1.08	P<.05

*Not sig. = not significant, P>.05.
**NPPC Scoring System.
Color: 1 = pale, pinkish gray; 5 = dark, purplish red.
Firmness: 1 = very soft and very watery; 5 = very firm and dry.
Marbling: 1 = devoid to practically devoid; 5 = moderately abundant or greater.
***1 = soft, unsliceable; 3 = very firm.

Table 3. Effects of diet on pig growth, pork quality and carcass composition.

	No Fat	Tallow	SE	Sig.*
On-test Growth (176 lb to slaughter)				
Average daily gain (lb)	1.92	1.95	0.07	Not sig.
Average daily feed intake (lb)	6.03	5.62	0.19	Not sig.
Feed efficiency	3.23	2.89	0.09	P<.05
Pork Quality and Carcass Composition				
First rib backfat (in.)	1.39	1.34	0.04	Not sig.
Last rib backfat (in.)	0.82	0.81	0.03	Not sig.
Last lumbar backfat (in.)	0.75	0.71	0.03	Not sig.
10th rib fat depth (in.)	0.72	0.75	0.03	Not sig.
10th rib outer layer (in.)	0.34	0.35	0.01	Not sig.
10th rib middle layer (in.)	0.27	0.30	0.02	Not sig.
10th rib inner layer (in.)	0.10	0.12	0.01	Not sig.
Loin color**	2.63	2.79	0.08	Not sig.
Loin firmness**	2.92	3.10	0.10	Not sig.
Loin marbling**	1.49	1.54	0.07	Not sig.
Loin eye area (sq.in.)	6.97	6.61	0.20	Not sig.
Dressing percentage	74.32	74.61	0.45	Not sig.
Belly firmness***	1.89	1.87	0.08	Not sig.
Belly thickness (in.)	0.90	1.00	0.03	P<.05
Outer belly fat layer (in.)	0.45	0.48	0.01	Not sig.
Middle belly fat layer (in.)	0.23	0.29	0.02	P<.05
Lean streak (in.)	0.22	0.23	0.01	Not sig.
Fatty Acid Comp. of Middle Layer Backfat				
% Total Saturated Fatty Acids (SFA)	32.70	30.55	0.77	P<.05
% Total Unsaturated Fatty Acids (UFA)	65.87	65.48	1.38	Not sig.
SFA : UFA	0.49	0.48	0.03	Not sig.
% Total Mono-Unsat. Fatty Acids (MUFA)	36.97	35.94	0.86	Not sig.
% Total Poly-Unsat. Fatty Acids (PUFA)	28.90	29.53	0.88	Not sig.
Fatty Acid Composition of Belly Fat				
% Total Saturated Fatty Acids (SFA)	31.12	30.32	0.89	Not sig.
% Total Unsaturated Fatty Acids (UFA)	64.58	65.43	1.72	Not sig.
SFA : UFA	0.48	0.47	0.02	Not sig.
% Total Mono-Unsat. Fatty Acids (MUFA)	39.10	39.64	1.14	Not sig.
% Total Poly-Unsat. Fatty Acids (PUFA)	25.48	25.79	1.08	Not sig.

*Not sig. = not significant, P>.05.

**NPPC Scoring System.

Color: 1 = pale, pinkish gray; 5 = dark, purplish red.

Firmness: 1 = very soft and very watery; 5 = very firm and dry.

Marbling: 1 = devoid to practically devoid; 5 = moderately abundant or greater.

***1 = soft, unsliceable; 3 = very firm.

Table 4. Effects of slaughter weight on pork quality and carcass composition.

	176 lb†	205 lb	235 lb	264 lb	SE	Sig.*
Pork Quality and Carcass Comp.						
First rib backfat (in.)	1.24	1.29	1.34	1.47	0.05	P<.05
Last rib backfat (in.)	0.65	0.71	0.80	0.95	0.03	P<.01
Last lumbar backfat (in.)	0.64	0.62	0.69	0.89	0.04	P<.01
10th rib fat depth (in.)	0.61	0.65	0.72	0.83	0.03	P<.01
10th rib outer layer (in.)	0.30	0.32	0.33	0.37	0.01	P<.05
10th rib middle layer (in.)	0.22	0.25	0.28	0.33	0.02	P<.05
10th rib inner layer (in.)	0.09	0.09	0.10	0.14	0.01	P<.05
Loin color**	2.59	2.63	2.73	2.76	0.09	Not sig.
Loin firmness**	3.08	3.19	2.90	2.95	0.12	Not sig.
Loin marbling**	1.25	1.52	1.29	1.73	0.08	P<.01
Loin eye area (sq.in.)	5.34	6.06	6.71	7.61	0.24	P<.01
Dressing percentage	72.52	74.48	75.24	73.68	0.56	Not sig.
Belly firmness***	1.17	1.71	1.78	2.16	0.10	P<.01
Belly thickness (in.)	0.82	0.89	0.96	1.00	0.03	Not sig.
Outer belly fat layer (in.)	0.32	0.45	0.46	0.47	0.02	Not sig.
Middle belly fat layer (in.)	0.23	0.22	0.26	0.31	0.02	P<.05
Lean streak (in.)	0.28	0.21	0.24	0.22	0.02	Not sig.
Fatty Acid Composition of Backfat						
% Total Saturated Fatty Acids (SFA)	27.22	30.58	29.91	35.00	0.91	P<.05
% Total Unsat. Fatty Acids (UFA)	72.78	67.93	64.28	62.96	1.66	Not sig.
SFA : UFA	0.37	0.45	0.44	0.53	0.02	Not sig.
% Total Mono-UFAs (MUFA)	32.18	34.78	35.65	40.05	1.03	P<.05
% Total Poly-UFAs (PUFA)	40.60	33.16	28.63	22.91	1.05	P<.05
Fatty Acid Composition of Belly Fat						
% Total Saturated Fatty Acids (SFA)	30.14	29.47	31.17	33.12	1.01	Not sig.
% Total Unsat. Fatty Acids (UFA)	70.12	68.31	68.05	66.00	1.96	Not sig.
SFA : UFA	0.44	0.43	0.46	0.50	0.02	Not sig.
% Total Mono-UFAs (MUFA)	36.82	38.81	41.40	43.32	1.30	Not sig.
% Total Poly-UFAs (PUFA)	33.05	29.50	26.64	22.68	1.23	P<.05

†176 lb pigs were not included in the statistical comparison of slaughter weight.
*Not sig. = not significant, P>.05.
**NPPC Scoring System.
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Marbling: 1 = devoid to practically devoid; 5 = moderately abundant or greater.
***1 = soft, unsliceable; 3 = very firm.

Table 5. Genotype x diet interactions for belly firmness and the fatty acid composition of belly fat.

	AVERAGE		LEAN			
	No Fat	5% BT	No Fat	5% BT	SE	Sig.*
Belly firmness**	2.45	2.02	1.34	1.71	0.11	P<.01
Belly thickness (in.)	0.95	1.09	0.84	0.91	0.04	Not sig.
Belly Fat						
% total SFA	32.37	31.77	30.04	30.73	0.70	Not sig.
% total UFA	66.34	67.38	67.98	68.19	0.88	Not sig.
SFA : UFA	0.49	0.47	0.45	0.45	0.02	P<.05
% total MUFA	41.75	43.30	38.48	41.07	0.64	P<.01
% total PUFA	24.59	24.50	29.50	27.16	1.07	P<.01

*Not sig. = not significant, P>.05.
**1 = soft, unsliceable; 3 = very firm.

Table 6. Diet x slaughter weight interactions for belly firmness and the fatty acid composition of belly fat.

		No Fat			5% Beef Tallow				
	176 lb†	205 lb	235 lb	264 lb	205 lb	235 lb	264 lb	SE	Sig.*
Belly firmness**	1.17	1.53	1.83	2.33	1.89	1.73	1.98	0.14	P<.05
Belly Fat									
% total SFA	30.14	29.11	31.45	33.04	29.71	30.87	33.18	1.45	Not sig.
% total UFA	70.12	67.87	67.73	65.88	68.92	68.37	66.07	2.71	Not sig.
SFA : UFA	0.44	0.43	0.47	0.50	0.43	0.45	0.50	0.03	Not sig.
% total MUFA	36.82	36.84	40.94	42.57	40.78	41.80	43.91	1.78	Not sig.
% total PUFA	33.05	31.03	26.79	23.31	28.14	26.57	22.16	1.75	Not sig.

†176 lb pigs were not included in the statistical comparison of slaughter weight.
*Not sig. = not significant, P>.05.
**1 = soft, unsliceable; 3 = very firm.

Table 7. Genotype x slaughter weight interactions for belly firmness and the fatty acid composition of belly fat.

	AVERAGE				LEAN					
	176 lb	205 lb	235 lb	264 lb	176 lb	205 lb	235 lb	264 lb	SE	Sig.*
Belly firmness**	1.33	1.53	1.83	2.33	1.00	1.89	1.73	1.98	0.14	P<.05
Belly Fat										
% total SFA	26.73	30.36	31.74	34.14	31.49	28.47	30.60	32.09	1.39	Not sig.
% total UFA	44.00	68.07	67.49	65.03	61.72	68.72	68.61	66.92	2.70	Not sig.
SFA : UFA	0.71	0.45	0.47	0.53	0.53	0.42	0.45	0.48	0.03	Not sig.
% total MUFA	18.09	41.28	42.05	44.24	35.48	36.34	40.69	42.23	1.78	P<.05
% total PUFA	25.92	26.79	25.44	20.78	26.24	32.92	27.92	24.69	1.77	Not sig.

*Not sig. = not significant, P>.05.
**1 = soft, unsliceable; 3 = very firm.