Effects of Feeding Poultry Fat and Finishing with Supplemental Beef Tallow on Pork Quality and Carcass Composition

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Introduction

Recycling of trimmed fat from pork, poultry and beef, and processed plant oils, into hog feed adds value to these low-value products and is a common practice in today's industry. However, feeding of fat may translate into variability in the fat and meat products produced. Problems with soft fat and soft, exudative lean have been attributed to dietary fat, particularly in high lean-growth genotypes. Our main objective with this trial was to compare different qualities of rendered poultry fat on the quality of fat and meat products in two lines of hogs. Quality grades of the poultry fat were based on fatty acid composition and contamination by *trans* fatty acids. Half of the pigs also received replacement beef tallow from 176 to 253 lb, to determine if tallow will improve the quality of the meat in pigs fed poultry fat. By comparing high and low quality poultry fat, we are able to determine whether meat quality problems are associated with differences in fatty acid profiles of dietary fat. Furthermore, we will determine if different genotypes are more susceptible to dietary fat quality because of differences in natural rates of fat accretion and composition. Supplemental beef tallow will provide practical information as to whether quality problems associated with poultry fat can be reversed by feeding a more saturated fat source.

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. One hundred twenty gilts were randomly assigned to a 2 x 5 factorial arrangement of genotype and diet (Table 1). Pigs were selected at 88 lb live weight and fed a conventional corn-soybean meal diet with or without 5% added fat until slaughter at 253 lb. The dietary treatments included no fat supplement (NF), high quality poultry fat (HQ; low in polyunsaturated fats and free fatty acids), and low quality poultry fat (LQ; high in polyunsaturated fats and free fatty acids). Two additional diets were identical to HQ and LQ except that poultry fat was replaced with 5% beef tallow at 176 lb (HQT and LQT, respectively). Diets were formulated to have equivalent lysine:calorie ratios and were offered on an ad-libitum basis. Upon reaching the assigned slaughter weight, pigs were transported to the Purdue Meat Laboratory for slaughter, tissue collection and carcass evaluation.

At exsanguination, outer, middle and inner layers of backfat, belly fat and loin were collected and snap frozen in liquid nitrogen until assayed for lipid and fatty acid composition. Forty-five-minute pH of the *longissimus dorsi* was recorded. 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. Standardized loin slices were obtained for drip loss and for chemical analyses of fat and CLA. Bellies were removed from the carcasses, measured for thickness and subjectively graded for firmness.

Results and Discussion

Growth Traits

As expected, AVE pigs were less feed efficient than LEAN pigs (Table 2). Pigs fed no supplemental fat were less feed efficient than pigs fed diets supplemented with fat (Table 3). This too was expected, due to the increase in caloric density when rations are supplemented with fat. Although not statistically significant, there was a tendency for both AVE pigs and NF-fed pigs to have higher average daily feed intakes. Neither genotype nor diet had a significant effect on average daily gain.

Pork Quality and Carcass Composition

As expected, LEAN gilts had larger loin eye areas, less backfat, thinner bellies, lower belly firmness scores and lower marbling scores of the loin muscle at the 10th rib than AVE gilts (Table 2). Surprisingly, LEAN gilts demonstrated less drip loss and received higher scores for loin firmness than did AVE gilts (Table 2). Genotype did not affect loin color scores or 45-minute pH.

Dietary fat had a significant effect on subjective loin quality, as HQ-fed pigs received lower color scores and HQT-fed pigs received higher marbling scores (Table 3). The dietary treatments did not affect loin firmness, backfat thickness, belly thickness, 45-minute pH, drip loss or loin eye area. Although not statistically significant, finishing with tallow did appear to improve belly firmness when compared to finishing with poultry fat (Table 3). However, results in Table 7 suggest that the negative effects of poultry fat and the positive effects of beef tallow on belly firmness only occurred in LEAN pigs. The belly firmness of AVE pigs was not affected by any of the dietary treatments. Compared to the NF diet, diets supplemented with any type of fat tended to increase backfat thickness. Overall, feeding poultry fat, with or without finishing with beef tallow, appeared to have minimal impact on pork quality or carcass composition.

Fatty Acid Composition

It is apparent from Table 4 that differences in fatty acid composition exist across fat depots. Thus, further considerations of fatty acid composition will be depot-specific. Across all diets, the genotype never significantly affected total saturated (SFA) or unsaturated (UFA) fatty acids of any depot (Table 5). However, in every depot, the fat of AVE pigs tended to contain higher amounts of monounsaturated fatty acids (MUFA) and lower amounts of polyunsaturated fatty acids (PUFA).

Compared to the NF treatment, feeding poultry fat increased total UFA and decreased total SFA in both outer and inner layers of backfat (Table 6). This is especially apparent in the inner layer, which may indicate a higher rate of fat accretion at this depot. Finishing with beef tallow had no effect on these depots. Diet had no significant effect on the SFA or UFA composition of either middle layer backfat or loin muscle. In the belly, HQ and LQ diets increased the percent total UFA compared to the NF treatment (Table 6). However, finishing with tallow appeared to have an effect at this depot, as the percent total UFA for tallow-fed pigs was approaching the level observed in NF-fed pigs. Thus, as hypothesized, percent total UFA or the ratio of SFA:UFA may provide an indication of belly firmness.

A number of genotype x diet interactions were found for the fatty acid composition of the different fat depots. Compared to the NF treatment, all four poultry fat diets increased the percent total UFA in the outer layer of backfat of AVE pigs (Table 7). There was no effect of diet on the percent UFA of the outer layer in the LEAN line, and no effect of feeding tallow in either line. In the middle layer, feeding poultry fat increased the percent UFA in the AVE line, and percent UFA was further increased in this line when pigs were finished with beef tallow (Table 7). For the LEAN line, poultry fat *decreased* the percent UFA in the middle layer, and finishing with beef tallow had no effect. Feeding poultry fat tended to increase the percent UFA of inner layer backfat for both lines, and tallow had no effect on this depot. Compared to the NF treatment, feeding poultry fat increased the percent UFA of AVE and LEAN bellies. Finishing with beef tallow had no effect on AVE bellies, but caused the fatty acid composition of LEAN bellies to return to the level of NF-fed lean pigs (Table 7). These changes in fatty acid composition are reflected in belly firmness scores, as AVE pigs were not affected by diet, while tallow compensated for the effects of poultry fat in LEAN pigs. Tallow returned the percent UFA to “normal” for LEAN pigs, but the level of UFA was still significantly higher than “normal” for AVE pigs. However, despite differences in fatty acid composition, both LEAN and AVE tallow-fed pigs had acceptably firm bellies.

Thus, feeding poultry fat appeared to be detrimental to the fatty acid composition of AVE genotypes, and beef tallow was unable to compensate for the change in composition. Actually, beef tallow had a detrimental effect on middle layer backfat of AVE pigs. In LEAN pigs, poultry fat was detrimental to the fatty acid composition of all depots except middle layer backfat, in which it was beneficial. Finishing with beef tallow was able to compensate for the effects of poultry fat on fatty acid composition *and* firmness of LEAN bellies, but did not affect the firmness of AVE bellies. Furthermore, tallow-fed LEAN pigs had bellies that were comparably firm to AVE pig bellies even though they remained significantly different in terms of fatty acid composition. Thus, levels of saturated fatty acids and SFA:UFA appear to be good indicators of belly firmness for LEAN pigs, but not for AVE pigs.

Continued selection for leanness has altered the biology of adipose tissue in the pig. 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. Thus, the differential response of these divergent genotypes to dietary fat could be due to a host of factors. 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. Differences in the effects of feeding poultry fat 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. Investigations of both of these possibilities are in progress and will be reported in future articles. Overall, the *quality* of the poultry fat (HQ vs. LQ) had little effect. Future analyses will also consider the effect of individual fatty acids on pork quality and carcass composition.

Value of Research to Swine Industry

The use of animal by products in pig rations has increased in recent years. Strict monitoring of the products fed and knowledge of how these products affect meat and fat quality will be necessary to develop programmed feeding regimens that will assure a consistent, high quality meat product. Although the literature contains a number of trials investigating supplemental fat, much of that research was done over 20 years ago, and thus on much fatter genetics. The effects of supplemental fat on pork quality and carcass composition must be reevaluated, as the biology of adipose has been changed by continued selection for leanness. We have demonstrated that the effects of feeding poultry fat and finishing with beef tallow are both genotype and depot specific.

Table 1. Design of the trial.

	AVERAGE (n=60)					**LEAN (n=60)**				
	NF	**HQ**		**LQ**		**NF**	**HQ**		**LQ**	
88 – 176 lb	n=12	n=24		n=24		n=12	n=24		n=24	
	↓	↙	↘	↙	↘	↓	↙	↘	↙	↘
	NF	**HQ**	**HQT**	**LQ**	**LQT**	**NF**	**HQ**	**HQT**	**LQ**	**LQT**
176 – 253 lb	n=12	n=12	n=12	n=12	n=12	n=12	n=12	n=12	n=12	n=12

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

	AVE	LEAN	SE	Sig.*
Average daily gain (lb)	1.62	1.64	0.02	Not sig.
Average daily feed intake (lb)	4.19	4.05	0.05	Not sig.
Feed efficiency	2.59	2.49	0.02	P<.01
First rib backfat (in.)	1.38	1.11	0.03	P<.01
Last rib backfat (in.)	0.93	0.66	0.02	P<.01
Last lumbar backfat (in.)	0.84	0.63	0.02	P<.01
10th rib fat depth (in.)	0.85	0.56	0.03	P<.01
10th rib outer layer (in.)	0.39	0.30	0.01	P<.01
10th rib middle layer (in.)	0.31	0.20	0.01	P<.01
10th rib inner layer (in.)	0.15	0.06	0.01	P<.01
Loin color**	2.82	2.71	0.06	Not sig.
Loin firmness**	3.12	3.37	0.09	P<.05
Loin marbling**	1.94	1.30	0.06	P<.01
Loin eye area (sq.in.)	6.59	7.20	0.11	P<.01
% drip loss (24 hour)	5.69	3.90	0.40	P<.01
45-minute pH	6.38	6.41	0.03	Not sig.
Belly firmness***	2.83	2.56	0.09	P<.05
Belly thickness (in.)	1.83	1.67	0.03	P<.01
Outer belly fat layer (in.)	0.49	0.34	0.02	P<.01
Middle belly fat layer (in.)	0.36	0.37	0.01	Not sig.
Muscle (in.)	0.28	0.18	0.01	P<.01

*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.

	NF	HQ	LQ	HQT	LQT	SE	Sig.*
Average daily gain (lb)	1.59	1.67	1.61	1.65	1.64	0.03	Not sig.
Average daily feed intake (lb)	4.30	4.11	4.14	4.04	4.02	0.08	Not sig.
Feed efficiency	2.71	2.47	2.58	2.47	2.48	0.04	P<.01
First rib backfat (in.)	1.19	1.23	1.28	1.28	1.24	0.04	Not sig.
Last rib backfat (in.)	0.79	0.79	0.79	0.79	0.80	0.03	Not sig.
Last lumbar backfat (in.)	0.68	0.74	0.76	0.73	0.75	0.03	Not sig.
10th rib fat depth (in.)	0.68	0.72	0.72	0.72	0.71	0.04	Not sig.
10th rib outer layer (in.)	0.34	0.35	0.35	0.33	0.36	0.01	Not sig.
10th rib middle layer (in.)	0.23	0.26	0.27	0.26	0.24	0.02	Not sig.
10th rib inner layer (in.)	0.10	0.11	0.10	0.12	0.11	0.01	Not sig.
Loin color**	2.80	2.55	2.72	2.96	2.79	0.09	P<.05
Loin firmness**	3.36	3.14	3.14	3.46	3.10	0.14	Not sig.
Loin marbling**	1.68	1.66	1.42	1.83	1.50	0.10	P<.05
Loin eye area (sq.in.)	6.80	7.01	6.97	6.79	6.91	0.17	Not sig.
% drip loss (24 hour)	4.97	5.50	4.94	4.22	4.33	0.63	Not sig.
45-minute pH	6.35	6.41	6.41	6.46	6.34	0.05	Not sig.
Belly firmness***	2.72	2.50	2.58	2.92	2.77	0.14	Not sig.
Belly thickness (in.)	1.73	1.74	1.69	1.81	1.77	0.05	Not sig.
Outer belly fat layer (in.)	0.39	0.43	0.42	0.43	0.43	0.03	Not sig.
Middle belly fat layer (in.)	0.34	0.39	0.37	0.36	0.37	0.02	Not sig.
Muscle (in.)	0.24	0.23	0.24	0.24	0.20	0.02	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. Differences in fatty acid composition between individual backfat layers, belly fat and loin.

	Outer Layer	Mid. Layer	Inner Layer	Belly Fat	Loin	SE	Sig.
% Total Saturated Fatty Acids (SFA)	33.91	35.92	36.86	35.82	36.74	0.52	P<.01
% Total Unsaturated Fatty Acids (UFA)	64.41	62.90	61.43	62.62	60.87	0.43	P<.01
SFA : UFA	0.53	0.58	0.60	0.57	0.61	0.01	P<.01
% Total Mono-Unsat. Fatty Acids (MUFA)	46.66	45.59	45.06	47.24	43.16	0.45	P<.01
% Total Poly-Unsat. Fatty Acids (PUFA)	17.76	17.31	16.37	15.37	17.72	0.47	P<.01

Table 5. Effects of genotype on the fatty acid composition of individual backfat layers, belly fat and loin muscle.

	AVE	LEAN	SE	Sig.*
Outer Layer Backfat				
% Total Saturated Fatty Acids (SFA)	34.04	33.78	0.68	Not sig.
% Total Unsaturated Fatty Acids (UFA)	64.20	64.62	0.64	Not sig.
SFA : UFA	0.54	0.52	0.02	Not sig.
% Total Mono-Unsat. Fatty Acids (MUFA)	47.29	46.02	0.37	P<.05
% Total Poly-Unsat. Fatty Acids (PUFA)	16.90	18.61	0.65	Not sig.
Middle Layer Backfat				
% Total Saturated Fatty Acids (SFA)	35.84	36.00	1.08	Not sig.
% Total Unsaturated Fatty Acids (UFA)	62.19	63.62	0.68	Not sig.
SFA : UFA	0.58	0.57	0.02	Not sig.
% Total Mono-Unsat. Fatty Acids (MUFA)	46.78	44.40	0.73	P<.05
% Total Poly-Unsat. Fatty Acids (PUFA)	15.41	19.22	0.73	P<.01
Inner Layer Backfat				
% Total Saturated Fatty Acids (SFA)	37.43	36.29	0.64	Not sig.
% Total Unsaturated Fatty Acids (UFA)	60.89	61.97	0.63	Not sig.
SFA : UFA	0.62	0.59	0.02	Not sig.
% Total Mono-Unsat. Fatty Acids (MUFA)	45.50	44.62	0.39	Not sig.
% Total Poly-Unsat. Fatty Acids (PUFA)	15.39	17.36	0.59	P<.05
Belly Fat				
% Total Saturated Fatty Acids (SFA)	35.68	35.96	0.54	Not sig.
% Total Unsaturated Fatty Acids (UFA)	62.69	62.54	0.43	Not sig.
SFA : UFA	0.57	0.58	0.01	Not sig.
% Total Mono-Unsat. Fatty Acids (MUFA)	48.08	46.41	0.55	P<.05
% Total Poly-Unsat. Fatty Acids (PUFA)	14.62	16.13	0.60	Not sig.
Loin Muscle				
% Total Saturated Fatty Acids (SFA)	37.73	35.76	0.75	Not sig.
% Total Unsaturated Fatty Acids (UFA)	60.04	61.70	0.66	Not sig.
SFA : UFA	0.63	0.58	0.02	Not sig.
% Total Mono-Unsat. Fatty Acids (MUFA)	43.50	42.82	1.00	Not sig.
% Total Poly-Unsat. Fatty Acids (PUFA)	16.55	18.88	0.80	Not sig.

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

Table 6. Effects of diet on fatty acid composition of individual backfat layers, belly fat and loin muscle.

	NF	HQ	LQ	HQT	LQT	SE
Outer Layer Backfat						
% Total Saturated Fatty Acids (SFA)	37.52 [a]	32.97 [b]	32.87 [b]	33.20 [b]	32.97 [b]	1.08
% Total Unsaturated Fatty Acids (UFA)	61.19 [b]	65.89 [a]	65.25 [a]	64.75 [a]	64.99 [a]	1.01
SFA : UFA	0.62 [a]	0.50 [b]	0.51 [b]	0.52 [b]	0.51 [b]	0.03
% Total Mono-Unsat. Fatty Acids (MUFA)	46.31 [ab]	47.65 [a]	44.64 [b]	47.97 [a]	46.70 [ab]	0.59
% Total Poly-Unsat. Fatty Acids (PUFA)	14.88 [b]	18.24 [ab]	20.61 [a]	16.77 [ab]	18.29 [ab]	1.03
Middle Layer Backfat						
% Total Saturated Fatty Acids (SFA)	36.82 [a]	35.35 [a]	38.41 [a]	34.38 [a]	34.66 [a]	0.71
% Total Unsaturated Fatty Acids (UFA)	61.41 [a]	63.68 [a]	62.18 [a]	64.01 [a]	63.23 [a]	1.07
SFA : UFA	0.61 [a]	0.56 [a]	0.62 [a]	0.54 [a]	0.55 [a]	0.03
% Total Mono-Unsat. Fatty Acids (MUFA)	45.21 [ab]	46.69 [ab]	42.58 [b]	47.53 [a]	45.94 [ab]	1.16
% Total Poly-Unsat. Fatty Acids (PUFA)	16.20 [a]	16.99 [a]	19.60 [a]	16.48 [a]	17.29 [a]	1.16
Inner Layer Backfat						
% Total Saturated Fatty Acids (SFA)	42.62 [a]	35.04 [b]	35.78 [b]	34.28 [b]	36.94 [b]	1.01
% Total Unsaturated Fatty Acids (UFA)	56.62 [b]	63.90 [a]	62.46 [a]	63.54 [a]	60.63 [a]	1.00
SFA : UFA	0.75 [a]	0.55 [b]	0.57 [b]	0.54 [b]	0.61 [b]	0.03
% Total Mono-Unsat. Fatty Acids (MUFA)	44.22 [b]	45.74 [ab]	43.81 [b]	46.98 [a]	44.55 [b]	0.61
% Total Poly-Unsat. Fatty Acids (PUFA)	12.41 [b]	18.16 [a]	18.66 [a]	16.57 [a]	16.08 [a]	0.93
Belly Fat						
% Total Saturated Fatty Acids (SFA)	37.95 [a]	35.33 [ab]	34.19 [b]	35.28 [ab]	36.36 [ab]	0.86
% Total Unsaturated Fatty Acids (UFA)	60.58 [b]	64.23 [a]	64.10 [a]	62.51 [ab]	61.66 [ab]	0.68
SFA : UFA	0.63 [a]	0.55 [b]	0.54 [b]	0.57 [ab]	0.59 [ab]	0.02
% Total Mono-Unsat. Fatty Acids (MUFA)	45.64 [a]	48.47 [a]	48.15 [a]	47.52 [a]	46.43 [a]	0.87
% Total Poly-Unsat. Fatty Acids (PUFA)	14.94 [a]	15.76 [a]	15.94 [a]	15.00 [a]	15.23 [a]	0.93
Loin Muscle						
% Total Saturated Fatty Acids (SFA)	37.53 [a]	35.48 [a]	37.34 [a]	36.58 [a]	36.78 [a]	1.17
% Total Unsaturated Fatty Acids (UFA)	59.72 [a]	62.77 [a]	60.26 [a]	61.03 [a]	60.60 [a]	1.05
SFA : UFA	0.63 [a]	0.57 [a]	0.62 [a]	0.60 [a]	0.61 [a]	0.03
% Total Mono-Unsat. Fatty Acids (MUFA)	43.03 [a]	42.50 [a]	41.65 [a]	45.06 [a]	43.56 [a]	0.58
% Total Poly-Unsat. Fatty Acids (PUFA)	16.69 [a]	20.26 [a]	18.61 [a]	15.97 [a]	17.04 [a]	1.26

[a,b] Means with different superscripts (within a row) are significantly different at $P<.05$.

Table 7. Genotype x diet interactions for total saturated and unsaturated fatty acids of individual backfat layers.

	AVERAGE					LEAN						
	NF	HQ	LQ	HQT	LQT	NF	HQ	LQ	HQT	LQT	SE	Sig.
Outer Layer Backfat												
% Total Saturated Fatty Acids (SFA)	41.33	33.34	31.18	31.74	32.62	33.71	32.61	34.59	34.66	33.33	1.52	P<.01
% Total Unsaturated Fatty Acids (UFA)	57.45	65.35	66.40	66.34	65.48	64.94	66.44	64.10	63.15	64.50	1.42	P<.01
SFA : UFA	0.73	0.51	0.47	0.48	0.50	0.52	0.49	0.54	0.55	0.52	0.04	P<.01
Middle Layer Backfat												
% Total Saturated Fatty Acids (SFA)	41.72	34.15	38.59	31.33	33.41	31.92	36.55	38.23	37.42	35.92	2.41	P<.05
% Total Unsaturated Fatty Acids (UFA)	56.30	64.64	60.33	65.72	63.94	66.53	62.71	64.04	62.30	62.51	1.51	P<.01
SFA : UFA	0.75	0.53	0.64	0.48	0.53	0.48	0.59	0.60	0.60	0.58	0.05	P<.01
Inner Layer Backfat												
% Total Saturated Fatty Acids (SFA)	43.06	36.71	36.14	34.66	36.59	41.47	33.37	35.42	33.90	37.28	1.42	Not sig.
% Total Unsaturated Fatty Acids (UFA)	55.85	62.24	62.50	63.14	60.71	57.40	65.56	62.42	63.95	60.55	1.40	Not sig.
SFA : UFA	0.77	0.59	0.58	0.55	0.60	0.72	0.51	0.57	0.53	0.62	0.03	Not sig.
Belly Fat												
% Total Saturated Fatty Acids (SFA)	39.31	35.89	33.83	33.67	35.71	36.58	34.77	34.56	36.89	37.02	1.20	Not sig.
% Total Unsaturated Fatty Acids (UFA)	59.05	64.09	64.20	63.93	62.20	62.11	64.37	63.99	61.10	61.12	0.96	Not sig.
SFA : UFA	0.67	0.56	0.53	0.53	0.58	0.59	0.54	0.54	0.60	0.61	0.03	Not sig.
Belly Quality												
Belly Firmness**	2.83	2.83	2.82	2.83	2.83	2.62	2.16	2.34	3.00	2.71	0.21	Not sig.

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