

Correlated Response in Fatty Acid Composition after Five Generations of Selection for Intramuscular Fat in Duroc Pigs

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Jeremy Burkett, graduate research assistant; Tom Baas, associate professor of animal science; Donald Beitz, professor of animal science; Clint Schwab, graduate research assistant; Nick Berry, graduate research assistant; Shu Zhang, graduate research assistant

Summary and Implications

After five generations of selection for IMF using real-time ultrasound, the select line pigs had more IMF. Selection for IMF has, however, resulted in slightly more backfat and less loin muscle area. A correlated response to selection for IMF has yielded a response in pork flavor and overall fatty acid composition. Genetic selection for IMF may be feasible without ramifications on nutritional value of pork.

Introduction

Improving overall consumer satisfaction and healthfulness of pork should be one of the most important goals for the producers of meat animals. With increasing meat consumption in the world, other aspects of nutritional properties of meat, such as the quantity and quality of animal fat (lipids), also have become more important. Several studies have indicated that intramuscular lipid content (IMF) can be the single most important meat quality characteristic in the determination of a consumer's overall eating experience. In order to study the correlated responses of fatty acid composition to selection for IMF based on real-time ultrasound, loin samples from a large-scale selection experiment involving purebred Duroc swine were utilized. The objective of this study was to evaluate differences in fatty acid composition among Duroc pigs selected for increased IMF for five generations.

Materials and Methods

Using semen from Duroc boars available in regional U.S. boar studs, 2 generations of random mating were conducted to expand the population and produce the base generation of 56 litters. Littermate pairs of gilts from the base generation were randomly designated to either the control (CL) or select line (SL). Littermate pairs of females were then mated to the same boar (via natural mating or AI) to establish sufficient genetic ties between lines before selection was initiated. At weaning, up to 4 boars in each SL litter (when available) were randomly selected to remain intact to increase selection intensity. Selection was based on EBV for IMF estimated by fitting a two-trait animal model and the full relationship matrix in MATVEC. In the SL, the top 10 boars and top 50% of gilts were used to produce the

next generation. One boar from each sire family and 50 gilts representing all sire families were selected randomly to maintain the CL.

Standard carcass collection procedures were followed to obtain carcass composition and meat quality measurements on all available barrows and randomly selected gilts within generation five. After harvest at Hormel Foods (Austin, MN), a section of bone-in loin containing the 10th to 12th ribs was removed from the carcass and transported to the Iowa State University Meat Laboratory for 48 hr measures of meat quality. A 3.2 mm slice from the 10th rib face was then removed and utilized for percent lipid content analysis. Longissimus muscle samples (n=175, 136 barrows, and 39 gilts) collected from generation 5 pigs in the CL (n=102) and SL (n=73) were used to determine the fatty acid profiles of the IMF.

A trained sensory panel with 3 members evaluated cooked loin quality attributes on the 11th rib section. Three 1.3 cm³ cubes were removed from the center of the 11th rib sample and evaluated by the trained sensory panel for juiciness, tenderness, chewiness, flavor, and off-flavor using an end-anchored, 10-point scoring system (AMSA, 1995). Sample evaluations were averaged across panelists for analysis.

Total lipids were extracted from the longissimus samples by using chloroform and methanol (2:1, vol:vol) mixture (Folch et al., 1957). Lipids were methylated directly with acetyl chloride and methanol according to Lepage and Roy (1986). Fatty acid methyl esters (FAME) were quantified by a Varian 3400 gas chromatograph equipped with a Supelco SP-2380 (100 m x 0.25 mm i.d. x 0.20 µm film thickness) and a flame ionization detector. Fatty acid compositions were calculated by using the peak areas and were expressed on a weight percentage basis. Data were analyzed using a fixed linear model containing main effects of line gender, and carcass contemporary group and the covariate of total lipid within line. Healthfulness was measured by calculating the atherogenic index (AI) (Ulbricht and Southgate, 1991). The formula ranks the fatty acids by their propensity to cause atherogenesis.

$$AI = (4 \times 14:0 + 16:0) / (\Sigma MUFA + \Sigma PUFA)$$

Results and Discussion

A difference of 1.95% was observed for the EBV of IMF in favor of SL in this project. Through five generations of selection, a 68% improvement in IMF has been realized (5.15% vs. 3.07%). A difference of 4.37 mm greater backfat at the tenth rib and 5.84 cm² less loin muscle area was found in the SL (Table 1).

There were no differences ($P > 0.05$) in SFA, MUFA, MUFA:SFA, and atherogenic index (AI) between CL and

SL pigs (Table 2). A significant decrease ($P < 0.01$), however, was detected in total essential fatty acid composition (18:2+18:3n3) and PUFA in the SL when compared to the CL pigs. This difference could be the result of greater de novo synthesis of fatty acids in the SL, resulting in a dilution effect of the essential fatty acids as based on more total lipid. These results suggest that selection for increased intramuscular fat could lead to improved meat quality without affecting nutritional value.

A general trend for more desirable sensory scores was observed for the SL within the current study; however, statistically significant ($P < 0.05$) differences were only detected for measures of pork flavor intensity and incidence of off-flavor (Table 3). Select line pigs had better flavor and decreased off-flavor when compared to the CL pigs. The differences in off-flavor could be attributed to the increase in PUFA in the CL.

Table 1. Least squares means for estimated breeding value for intramuscular fat and carcass traits from generation 5 of a selection experiment for increased intramuscular fat in Duroc swine.

Trait ^a	Line		Difference	Pr > F
	SL	CL		
EBV for IMF	1.70	-0.25	1.95	<0.0001
CIMF, %	5.15	3.07	2.08	<0.0001
LMA, cm ²	39.17	45.01	-5.84	<0.0001
BF10, mm	24.47	20.10	4.37	0.0070

^aEstimated breeding value for intramuscular fat; carcass intramuscular fat (CIMF); loin muscle area (LMA); tenth-rib backfat (BF10).

Table 2. Least squares means for fatty acid composition of pork from generation 5 of a selection experiment for increased intramuscular fat in Duroc swine.

Trait ^a	Line		Pr = F	Percent Change
	SL	CL		
SFA	41.84	41.95	0.3947	0%
MUFA	49.17	48.60	0.0892	1%
PUFA	8.13	8.50	<0.0001	-4%
AI	0.59	0.59	0.7306	0%
Essential FA	7.5	7.9	<0.0001	-5%

^aSaturated fatty acids (SFA); mono-unsaturated fatty acids (MUFA); poly-saturated fatty acids (PUFA); atherogenic index (AI).

Table 3. Least squares means for sensory panel evaluation from generation 5 of a selection experiment for increased intramuscular fat in Duroc swine.

Trait ^a	Line		Difference	Pr > F
	SL	CL		
Flavor score	4.33	3.63	0.70	0.0040
Off-flavor score	1.27	1.85	-0.58	0.0251

^aTrained sensory panel evaluations of flavor (1 = little pork flavor, bland; 10 = extremely flavorful, abundant pork flavor), and off-flavor (1 = no off-flavor; 10 = abundant non-pork flavor).