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Influence of Swine Genotype on Fatty Acid Composition of Phospholipids in Longissimus Muscle¹

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ABSTRACT: Our objective for this study was to determine whether there is a difference in the fatty acid composition of phospholipids in longissimus muscle from pigs of different genotypes. In Exp. 1, 15 Hampshire × Yorkshire-Landrace (YL), 15 Duroc × YL, and 15 Danbred × YL were used. Animals were of similar age and were fed identical diets. In Exp. 2, longissimus muscle samples from pigs of seven genetically different lines were analyzed. In both experiments, saturated fatty acids (SFA, 16:0 and 18:0) constituted approximately 31.5% of the total fatty acids. Monounsaturated fatty acid (MUFA, 18:1 and

20:1) levels ranged from 12.3 to 16.9%, and PUFA (mainly 18:2 and 20:4) accounted for 50.8 to 57.0% of the total fatty acids. Fatty acid composition of muscle phospholipids from Duroc and Hampshire × YL pigs was identical. Muscle phospholipids from Danbred × YL pigs contained more PUFA (approximately 3%, $P < .05$) and less SFA (approximately 2%, $P < .05$) than phospholipids from the two other genotypes. Differences in SFA and PUFA of muscle from the seven lines were of the same order of magnitude. Differences in MUFA content were not significant.

Key Words: Pigmeat, Phospholipids, Genotypes, Fatty Acids

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Introduction

The composition of phospholipids influences quality, nutritive value, and sensory characteristics of meat. Oxidation processes, resulting in rancidity and reduced color stability, are initiated at the membrane level. The fatty acid composition of phospholipids influences the sensitivity to oxidation and, thus, the stability of the membrane (Wu and Sheldon, 1988). Membrane stability also has been implicated as an important determinant of water-holding capacity of meat (Offer and Knight, 1988; Asghar et al., 1991).

Composition of intramuscular lipids in porcine tissue has not been studied extensively. Fatty acid composition of triglycerides, and to a lesser extent of phospholipids, is influenced by age (Clemens et al., 1973), diet (Lin et al., 1989; Melton, 1990; Monahan et al., 1992), and environmental temperature (Fuller et al., 1974). In beef, there is a breed-dependent difference in fatty acid composition of phospholipids (Larick et al., 1989). It is not known whether

genotype influences phospholipid composition of pork muscle.

The objective for this study was to evaluate the fatty acid composition of phospholipids from pork longissimus muscle and to determine whether this composition was influenced by genotype.

Materials and Methods

Materials

Material from two experiments was included. In Exp. 1, 45 pigs, 15 each of Hampshire × Yorkshire-Landrace (YL), Duroc × YL, and Danbred × YL crosses, were used. Pigs were produced at a University of Tennessee farm. Animals were of similar age, reared under the same conditions, and fed identical diets (a corn-soybean meal diet with approximately 18% CP and < 5% fat). The fatty acid composition of the diet was not determined. At approximately 110 kg live weight, the animals were slaughtered at the University of Tennessee, Knoxville meat laboratory. Carcasses were chilled at 0 to 2°C for 24 h. Subsequently, one loin from each carcass was excised and deboned. At the level of the 10th costae, a slice of 2.54 cm in thickness was collected. Samples were carefully trimmed of all visible fat, packaged in self-sealing

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freezer bags, and frozen at -20°C until analysis (within 3 mo).

In Exp. 2, material from seven PIC lines (Pig Improvement Company, Franklin, KY) was used. Animals were reared by PIC. They were of similar age, kept under the same conditions, and fed identical diets. At a live weight of 110 kg, animals were slaughtered at a commercial slaughter plant. Carcasses were chilled for 1.5 h in a blast chiller (30 min at -22°C , 30 min at -40°C , 30 min at -20°C) and then at 1 to 3°C . At approximately 24 h postmortem, loins were excised and deboned. Loins were sampled, packaged, and frozen as described under Exp. 1. Three days after freezing, samples were put into iceboxes with ice and shipped frozen to the University of Tennessee, Knoxville, by overnight mail. There, samples were stored at -20°C until analysis (within 3 mo).

Methods

Frozen samples were powdered with liquid nitrogen. Lipids were extracted using a Folch-type extraction as described by Melton et al. (1979). Phospholipids were separated from the triglycerides on a 12-mL silicic acid column using chloroform methanol (1:1) and 100% methanol as eluent (Bakir et al., 1993). Eluted samples were dried before esterification. Fatty acid composition of the phospholipids was determined by preparing fatty acid methyl esters (AOCS, 1993). These esters were analyzed using a Shimadzu GC-9A (Shimadzu, Kyoto, Japan) gas chromatograph, equipped with a flame ionization detector, on a 30-m \times .25-mm fused capillary SP2330 column (Supelco, Bellefonte, PA), with a film thickness of .20 μm . The injector and detector temperatures were maintained at 250°C . Column oven temperature was programmed from 150 to 220°C , at $2^{\circ}\text{C}/\text{min}$. Helium carrier gas flow was 2 mL/min. Sample size injected was 2 μL . A Shimadzu CR501 integrator was used for the calculation of peak areas. The individual fatty acid peaks were identified by comparing retention times with standard fatty acid mixtures (AOCS GLC reference mixture no. 5, no. 6, and no. 3A, Alltech Associates, Deerfield, IL, and other PUFA mixtures to produce a standard containing all identified fatty acids). Peak areas of identified fatty acids were used to determine the relative percentage fatty acid composition of the total fatty acids. The percentage of saturated fatty acids (SFA) was calculated by adding 16:0 and 18:0, and monounsaturated fatty acids (MUFA) consisted of 16:1, 18:1, and 20:1. The percentage of PUFA was calculated by summing the remaining fatty acids.

Statistical Analysis

Analysis of variance for a randomized complete block design was computed using the GLM procedure

of SAS (1992). When the F-test was significant, differences between means were determined with Fisher's Least Significant Difference test.

Results and Discussion

Results of Exp. 1 are presented in Table 1. The prevalent fatty acids ($> 10\%$) were 16:0, 18:0, 18:1, and 20:4. In all three genotypes, the fatty acid 18:2 predominated. When comparing concentrations of individual fatty acids, none of the differences between sire-lines was significant. However, when comparing the total amounts of SFA, MUFA, and PUFA, there was a significant difference: in longissimus muscle from Danbred \times YL pigs, the concentration of SFA was 2% lower and the concentration of PUFA was 3% higher than in longissimus muscle from Duroc \times YL and Hampshire \times YL ($P < .05$).

In Exp. 2, a larger variety of genotypes was studied. Results are presented in Table 2. Again, there were significant differences between lines. In contrast to Exp. 1, there were significant differences in concentrations of the individual fatty acids 16:0, 18:0, 18:3 ($n-3$), 20:5 ($n-3$), 22:4 ($n-6$), and 22:5 ($n-3$). Also, differences in SFA and PUFA content were significant. The SFA content was similar to that in Exp. 1. However, MUFA content was lower and PUFA content was higher in Exp. 2 than in Exp. 1.

Numerous factors influence the fatty acid composition of phospholipids, and it is difficult to compare the results of the two experiments. One of the main factors affecting fatty acid composition of phospholipids is the composition of dietary fat (Lin et al., 1989; Asghar et al., 1991; Monahan et al., 1992; Pan and Storlien, 1993). The differences between Exp. 1 and 2 may be related to diet, genetics, and(or) to environmental temperature (Fuller et al., 1974). However, within each experiment, the differences between the genotypes cannot be due to environmental conditions. Thus, results of this study indicate that there is a genetic difference in fatty acid composition of muscle phospholipids. Possibly, this difference is related to a difference in fiber type of the longissimus muscle (Pearson and Young, 1989).

Values obtained in this study are similar to those reported by Sharma et al. (1987). Cava et al. (1997) reported very different percentages. However, they studied Iberian pigs, an autochthonous pig in Spain, that is rather different from regularly used commercial pigs.

It is not known whether differences of the magnitude of 3 to 5% are large enough to result in differences in sensitivity to oxidation and, thus, differences in membrane stability that would influence flavor and drip loss from the muscle. Monahan et al. (1992) found differences in fatty acid composition of phospholipids from muscle of pigs fed soy vs tallow that were of similar magnitude to those observed in

Table 1. Percentage fatty acid composition of phospholipids from longissimus muscle of different pig crosses with Yorkshire Landrace (Experiment 1; n = 15 per cross)

Fatty acid	Sire ^b			Pooled SEM
	Danbred	Duroc	Hampshire	
16:0	17.2	19.1	18.9	.7
16:1	.8	.7	.6	.1
18:0	12.7	13.4	13.1	.4
18:1	15.6	15.6	16.0	.4
18:2	34.9	33.6	34.0	.5
18:3(<i>n</i> -6)	.4	.3	.4	.02
18:3(<i>n</i> -3)	.5	.4	.4	.02
20:1	.3	.3	.3	.01
20:2	.5	.5	.5	.04
20:3	1.4	1.4	1.2	.04
20:4	12.2	11.5	11.3	.4
20:5(<i>n</i> -3)	.4	.4	.3	.02
22:4(<i>n</i> -6)	1.7	1.6	1.6	.08
22:5(<i>n</i> -3)	1.0	1.0	.8	.05
22:6(<i>n</i> -3)	.4	.5	.4	.02
SFA ^a	29.9 ^z	32.4 ^y	32.1 ^y	.7
MUFA ^a	16.3	16.9	16.9	.5
PUFA ^a	53.8 ^z	50.7 ^y	50.8 ^y	.6

^aSFA = saturated fatty acids; MUFA = monounsaturated fatty acids; PUFA = polyunsaturated fatty acids.

^bCrossed with Yorkshire Landrace sows.

^{y,z}Within a row, means lacking a common superscript differ ($P < .05$).

our present study. Those differences significantly affected oxidation and flavor (Monahan et al., 1992). This suggests that the 3 to 5% variation in fatty acid composition of phospholipids may affect membrane stability. Thus, fatty acid composition of phospholipids should be taken into account when studying oxidation-

related quality aspects, such as flavor and water-holding capacity, and the effect of antioxidants, such as vitamin E. Use of different genotypes of pigs and differences in environment and diet may explain the variability in results obtained in studies on the effect of vitamin E supplementation on drip loss (Asghar et

Table 2. Percentage fatty acid composition of phospholipids from longissimus muscle of seven pig lines (Experiment 2)

Fatty acid	Genetic line							Pooled SEM
	1 (n = 10)	2 (n = 10)	3 (n = 10)	4 (n = 9)	5 (n = 8)	6 (n = 9)	7 (n = 8)	
16:0	16.7 ^{zy}	18.1 ^y	16.8 ^{zy}	16.9 ^{zy}	15.6 ^z	15.9 ^z	17.0 ^z	.4
18:0	14.0 ^z	14.2 ^z	14.1 ^z	14.5 ^z	17.0 ^y	14.7 ^z	15.3 ^z	.5
18:1	14.1	14.9	12.7	14.1	12.0	12.3	13.8	.6
18:2	34.1	33.1	34.7	34.1	32.8	34.5	33.8	.8
18:3(<i>n</i> -6)	.2	.2	.3	.3	.2	.2	.2	.03
18:3(<i>n</i> -3)	.3 ^z	.3 ^z	.3 ^z	.3 ^z	.5 ^y	.5 ^y	.5 ^y	.02
20:1	.2	.3	.2	.3	.2	.2	.3	.02
20:2(<i>n</i> -6)	.5	.5	.5	.5	.5	.6	.5	.04
20:3(<i>n</i> -6)	1.4	1.4	1.5	1.5	1.6	1.7	1.5	.10
20:4(<i>n</i> -6)	14.0	13.0	14.2	13.3	14.4	14.1	12.7	.6
20:5(<i>n</i> -3)	.5 ^z	.5 ^z	.5 ^z	.5 ^z	.6 ^z	.7 ^y	.7 ^y	.04
22:4(<i>n</i> -6)	1.8 ^{zx}	1.5 ^{yw}	1.7 ^{yx}	1.6 ^{yxw}	2.0 ^z	1.6 ^{yxw}	1.4 ^w	.07
22:5(<i>n</i> -3)	1.6 ^{zx}	1.6 ^z	1.7 ^{zx}	1.6 ^z	1.9 ^{yx}	2.1 ^y	1.7 ^{zx}	.07
22:6(<i>n</i> -3)	.6	.7	.7	.7	.8	.9	.8	.06
SFA ^a	30.7 ^z	32.2 ^y	30.9 ^z	31.3 ^{zy}	32.6 ^y	30.5 ^z	32.0 ^{zy}	.4
MUFA ^a	13.6	15.2	13.1	14.3	12.3	12.5	14.1	.6
PUFA ^a	55.8 ^{zx}	52.6 ^y	56.0 ^{zx}	54.4 ^{zyx}	55.0 ^{zyx}	57.0 ^x	53.9 ^{zy}	.8

^aSFA = saturated fatty acids; MUFA = monounsaturated fatty acids; PUFA = polyunsaturated fatty acids.

^{w,x,y,z}Within a row, means lacking a common superscript differ ($P < .01$).

al., 1991; Warner, 1994; Cheah et al., 1995; Cannon et al., 1996).

Compared with beef (Larick et al., 1989), phospholipids in pork contain more PUFA (18:2 and 20:4) and less SFA (16:0 and 18:0). The fatty acid composition of chicken phospholipids (Lin et al., 1989) is similar to that of pork.

Implications

Fatty acid composition of phospholipids seems to depend on the pig population studied. The diet also influences the fatty acid composition. Thus, future studies concerning oxidation-related phenomenon and the effect of vitamin E or other antioxidants should be designed to determine the fatty acid composition of the phospholipids in the muscle.

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