Influence of Breed, Gender, and Halothane Genotype on Lipids of *longissimus dorsi* Muscle of Pigs

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Summary and Implications

The objective of this study was to determine the effect of breed, gender, and halothane genotype on the amount of phospholipid, triacylglycerol, and total lipid in *longissimus dorsi* (LD) of market pigs. There were breed and gender effects ($P<0.05$) for total lipid concentration in the LD, with barrows and gilts averaging 2.88 and 2.21 g lipid per 100 grams meat, respectively. The Yorkshire, Hampshire, Landrace, and Chester White breeds had the least amount of total lipid and were not different from each other. The Duroc and Berkshire breeds had the greatest total lipid and were not different from each other. There were no breed or gender effects for phospholipids; however, the triacylglycerol data nearly mirrored the patterns observed for total lipid data. Therefore, differences noted in total lipid are explained by differing amount of triacylglycerol and not differing amount of phospholipid. There were no differences noted for halothane genotype with respect to amount of total lipid, phospholipid, or triacylglycerol. In conclusion, as total lipid increases, triacylglycerol increases during growth while phospholipid remains constant.

Introduction

Trends in the pork industry over the last 20 years have been to produce a much leaner carcass. While the amount of fat is important with respect to eating quality and healthfulness of the product, the composition of fat (lipids) also is important in determining the physiochemical character of the meat. The two main types of lipids, by weight, in the LDs are phospholipids and triacylglycerols. The majority of the lipid, even in lean tissue from relatively lean animals, is triacylglycerol. On average, total lipids from trimmed pork tissue contain less than 25% phospholipid. Other minor components include cholesterol, cholesteryl esters, sphingolipids, and free fatty acids. The fatty acid composition of phospholipids and triacylglycerols differ greatly. Phospholipids are found primarily in cell membranes and are important in maintaining cell integrity. The fatty acids in phospholipids are on average longer in chain length and more unsaturated (more double bonds). These characteristics are important in maintaining a "fluid" cell membrane that allows for integration and movement of critical cellular proteins that function as structural components or cell surface receptors. Triacylglcyerols, however, function as an energy store with some limited function related to "padding" and protecting critical organs. The fatty acid composition of triacylglycerols, which is much less complex than that of phospholipids, is rich in 16 and 18 carbon fatty acids that are, for the most part, saturated or monounsaturated.

Based on the divergent roles and fatty acid composition of triacylglycerols and phospholipids, we predict more variability in amount and composition of the triacylglycerol fraction when compared with the phospholipid fraction.

Materials and Methods

Pigs (n=769) from the 1994 and 2001 National Barrow Show Sire Progeny Tests were used in this study. The test included purebred Berkshire (86), Chester White (76), Duroc (140), Hampshire (53), Landrace (86), Poland China (53), Spotted (40), and Yorkshire (140) barrows (453) and gilts (316). These pigs were from 100 sires and 367 dams. The halothane (Hal 1843TM) genotype was determined by DNA typing. Diets were uniform within test and across breeds. Pigs were slaughtered at 105 kg body weight, and samples of the LD were obtained from each carcass at the 10th rib. Pork loin slices were collected and sealed in plastic bags 24 hours after harvest at the packing plant and transported to Iowa State University. The samples were frozen at -20º C until analysis. Prior to lipid extraction, loin samples were trimmed of connective tissue and extramuscular fat. Samples were ground in a common electric kitchen grinder, and aliquots were taken for dry matter determination and for total lipid extraction.

Total lipids were extracted with chloroform and methanol. The organic solvent was evaporated with a stream of nitrogen gas, and the lipid was quantified gravimetrically. Lipid phosphorus was determined by wet ashing the total lipid extract followed by the addition of molybdate salt and ascorbic acid to determine the amount of phosphate and thus phospholipid in the sample. For our calculations, we assumed that the mass of the total lipid extract was either phospholipid or triacylglycerol and we could therefore calculate the triacylglycerol mass by subtracting the phospholipid mass from the total lipid extract mass.

The statistical analysis was conducted by using SAS (1999). A mixed linear model was used to analyze all data (PROC MIXED, SAS, 1999). The model included test, gender, halothane genotype, breed, and breed by gender interaction as fixed effects, whereas sire and dam within breed were included as random effects.

Results and Discussion

Total lipid extract was greater in LDs from barrows compared with those from gilts (Table 1a), and there were breed differences in percentages of lipid in the total lipid extract (Table 1b). The breed differences noted in the amount of total lipid are consistent with other published results. No differences in lipid composition based on halothane genotype were noted in total lipid or in phospholipids and triacylglycerols (data not shown). This lack of differences may be the result of limited numbers of carrier pigs in the study.

Table 1a. Lipid content of *longissimus dorsi* from barrows and gilts.

Gender	Lipid Content (% of wet weight)
Barrows	2.88 ± 0.08 [a]
Gilts	2.21 ± 0.09 [b]

[a, b] Column means with different superscripts differ ($P<0.05$).

Table 1b. Lipid content of *longissimus dorsi* from pigs of different breeds.

Breed	Lipid Content (% of wet weight)
Yorkshire	2.07 ± 0.14[a]
Duroc	3.27 ± 0.13[b]
Hampshire	2.09 ± 0.20[a]
Spotted	2.27 ± 0.22[a]
Chester White	2.68 ± 0.17[c]
Poland China	2.81 ± 0.17[c]
Berkshire	3.01 ± 0.13[b,c]
Landrace	2.16 ± 0.16[a]

[a, b, c] Column means with different superscripts differ ($P<0.05$).

On average, less that 20% of the total lipid was determined to be phospholipid and, therefore, greater than 80% of the total lipid was calculated to be triacylglycerol (calculated from data in Tables 1 and 2). There were no breed or gender differences in the amount of phospholipid per gram of tissue; therefore, the triacylglycerol fraction differed because of gender and breed (Tables 2a and 2b).

Table 2a. Triacylglycerol and phospholipids content of *longissimus dorsi* from barrows and gilts.

Gender	Triacylglycerol (% of wet weight)	Phospholipid (% of wet weight)
Barrows	2.40 ± 0.08[a]	0.49 ± 0.01
Gilts	1.73 ± 0.09[b]	0.48 ± 0.01

[a, b] Column means with different superscripts differ ($P<0.05$).

The relatively consistent concentration of phospholipid in total lipid extract compared with the highly variable amount of triacylglycerol can be visualized when the samples are sorted by increasing amount of total lipid (Figure 1.). The lack of variability in phospholipid content compared with the great variability in triacylglycerol content is indicative of phospholipids being crucial building blocks of cellular membranes and because slight variation in membrane composition could lead to big differences in terms of cellular fitness and survival. A thorough analysis of fatty acid composition of both lipid fractions will be conducted on this data set in the near future for presentation at national meetings and publication.

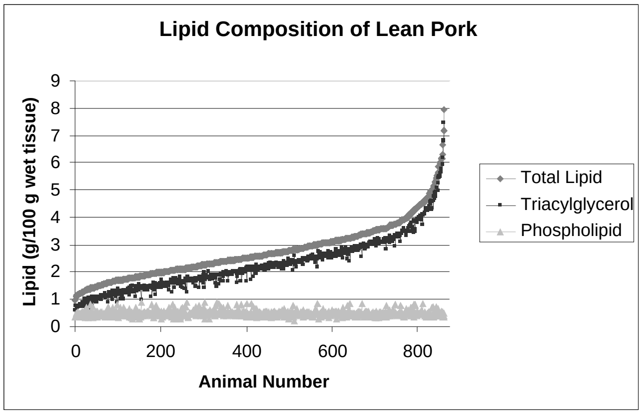
Table 2b. Triacylglycerol and phospholipids content of *longissimus dorsi* from pigs of different breeds.

Gender	Triacylglycerol (% of wet weight)	Phospholipid (% of wet weight)
Yorkshire	1.61 ± 0.14[a]	0.47 ± 0.01
Duroc	2.79 ± 0.13[b]	0.48 ± 0.01
Hampshire	1.58 ± 0.20[a]	0.52 ± 0.02
Spotted	1.75 ± 0.22[a,c]	0.53 ± 0.02
Chester White	2.21 ± 0.17[c,d]	0.47 ± 0.02
Poland China	2.35 ± 0.18[b,d]	0.46 ± 0.02
Berkshire	2.53 ± 0.13[b,d]	0.48 ± 0.01
Landrace	1.67 ± 0.16[a]	0.49 ± 0.02

[a, b, c, d] Column means with different superscripts differ ($P<0.05$).

The results from this research to date emphasize the need to focus on the triacylglycerol fraction of LD of pigs for several reasons. Based on literature values and preliminary fatty acid composition data from this experiment, triacylglycerols contain a greater percentage of the saturated fatty acids and the phospholipids contain more polyunsaturated fatty acids that do not have a negative impact on human heart health. Furthermore, the triacylglycerol fraction is the most abundant lipid by mass in the total lipid extract, even when very lean pigs are considered. And finally, because of the greater variability in the concentration of triacylglycerol, we can assume that there is more natural genetic variability for this trait and swifter changes could be made to this lipid through selective breeding.

Figure 1. Comparison of the concentration of triacylglycerol, phospholipid, and total lipid in *longissimus dorsi* of pigs.



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