G/5 EFFECT OF BREED AND DIET ON FATTY ACID COMPOSITION OF PORCINE ADIPOSE TISSUE

Hedrick, H. B., Francisco J. Villegas,
T. L. Veum, K. L. McFate and M. E. Bailey
Food Science and Nutrition Department
University of Missouri, Columbia, Missouri 65201, U.S.A.

Introduction

The chemical and physical characteristics of porcine adipose tissue are important factors that contribute to pork quality. Variation in firmness of pork backfat has been reported to be influenced by rate of gain (Shorland and De la Mare, 1945), live weight (Allen, Bray and Cassens, 1967), sex (Shorland, Hansen and Hogan, 1945) and degree of finish (Martin et al., 1972). Fatty acid composition and distribution have been reported to vary among anatomical locations (Hilditch, 1944; Sink, et al., 1964). Several investigators (Chacko and Perkins, 1965; Sink et al., 1964; Koch et al., 1968; Hilditch, Lea and Pedelty, 1939) have reported selective deposition of fatty acids in porcine subcutaneous and perirenal adipose tissues. The evidence indicates preferential deposition of unsaturated fatty acids in the perirenal fat, and in the outside layer of backfat rather than in the inside backfat layers. The level and composition of dietary lipid affects the characteristics of resulting depot fats of the pig (Hankins and Ellis, 1926; Christensen, 1964; Dahl and Persson, 1965; Wahlstrom et al., 1971; Brooks, 1971).

The objective of the present study was (1) to observe variations in fatty acid composition of porcine adipose tissue attributable to breed of animal and diet.

Experimental Procedures

Two feeding trials were conducted. Trial I consisted of 32 purebred pigs (16 Duroc and 16 Hampshire) which were randomly divided into four groups. Each group contained 2 barrows and 2 gilts from each breed. Trial II included 32 barrows (8 Duroc, 8 Hampshire, 8 Yorkshire and 8 Crossbred - DxHxY) randomly assigned to two groups with four pigs from each breed per group. An equal number of pigs was selected from four litters of each breed for each trial. The average initial weight of pigs in each group for both trials was approximately 31 kilograms.

The diets formulated for the growing and finishing periods are presented in table 1 and the experimental design is illustrated in table 2. In Trial I, during the period of gain from 31 to 45 kg live weight, whole roasted soybeans comprised 0% of Diet 1, fed to Group 1; 11.8% of Diet 2, Group 2; and 26.0% of Diet 3, Groups 3 and 4. During the period of gain from 46 to 102 kg live weight, whole roasted soybeans comprised 0% of Diet 4, fed to Group 1; 9.0% of Diet 5, Group 2; and 20.0% of Diet 6, Group 4. Group 3 received Diet 6 comprised of 20.0% whole roasted soybeans during the period of gain from 46 to 79 kg live weight and from 80 to 102 kg live weight, Group 3 received Diet 4 which was comprised of 0% whole roasted soybeans. In Trial II, from 31 to 54 kg live weight, whole roasted soybeans comprised 0% of Diet 1, fed to Group 1; and 26.1% of Diet 3 fed to Group 2. From 55 to 102 kg live weight, whole roasted soybeans comprised 0% of Diet 4 fed to Group 1 and 19.5% of Diet 6 fed to Group 2.

Pigs in both trials were housed in 4 x 3 m concrete floored pens bedded with wood shavings with access to an outside concrete feeding area. Feed and water were provided _ad libitum_. Both trials were conducted during the period from December to March.

Pigs were removed from experiment at weekly intervals when they attained a live weight of approximately 102 kilograms. After an approximate 16 hour fast, the pigs were slaughtered and the carcasses chilled for 24 hours at 4 C. Carcasses were processed into wholesale cuts and backfat samples excised from the right 10th-12th thoracic vertebrae area of the carcass. Care was taken to obtain a cross section of the three backfat layers. The backfat samples were divided into first, second and third layers at the visible connective tissue septum. The samples of fat were cut into small cubes and placed in 25 x 100 mm test tubes. Samples were then rendered in an oil bath at a constant temperature of 120 C for five hours. The rendered fat was then filtered through a layer of sodium sulfate to remove residual water, then centrifuged to separate liquid fat from the residue. The liquid fat was decanted into glass vials and the vials were flushed with nitrogen, capped and stored at -20 C. The maximum period of storage was three months. In Trial II, samples of perirenal fat were also obtained and stored under similar conditions.

Methyl esters were prepared by interesterification with boron-trifluoride methanol (14%) by the method of Morrison and Smith (1964) as modified by Tsai (1969). An internal standard, methyl laurate, was added to the esterification solution (25% BF_3-methanol, 20% benzene and 55% methanol) in the proportion of 2 mg of methyl laurate per ml of esterification reagent. The individual fatty acid peaks were identified by comparing their retention times with those of known methyl ester standards. Standard fatty acid methyl esters were obtained from Applied Science Laboratory Inc., P. O. Box 440, State College, Pennsylvania, 16801. Only those fatty acids whose

Covariance analysis was employed to further analyze the fatty acid data to adjust for differences in rate of gain. The results of these analyses showed that similar differences in fatty acid levels between breeds existed as presented in table 4.

Differences were observed in fatty acid composition of all major fatty acids (C14 through C 18=3) due to diet (table 5). Backfat from pigs that received whole roasted soybeans in their diet contained more unsaturated and less saturated fatty acids than backfat from pigs that received soybean meal as supplemental protein. The increase in level of unsaturated fatty acids, linoleic and linolenic, corresponded to the increase in level of whole roasted soybeans in the diet. These observations confirm data reported by Wahlstrom <u>et</u> <u>al</u>. (1971). The greatest increase in the unsaturated fatty acids due to whole roasted soybeans in the diet was for linoleic acid. The apparent preferential deposition of linoleic acid in the backfat is in agreement with a report of Brooks (1971) in which he showed that soybean oil in the diet of the pig raised the linoleic acid level in all depot fats.

The mean fatty acid methyl ester levels for each layer of backfat and perirenal fat are presented in table 6. The first layer of backfat (outermost layer) contained more ($P<.05$) total unsaturated fatty acids and less saturated fatty acids than the second and third layers. Similarly, the second layer contained more total unsaturated and less saturated fatty acids than the third layer, and the third layer more unsaturated and less saturated fatty acids than the perirenal fat. Diet exhibited a greater influence on the levels of saturated and unsaturated fatty acids in the first layer of backfat compared to the second and third layers. However, in all instances, pigs that received whole roasted soybeans (Group 1) in the diet had less saturated and more unsaturated fatty acids in all three layers of backfat and perirenal fat than pigs that received soybean meal in their diet. The preferential deposition of more unsaturated fatty acids in the first layer of backfat compared to the inner layers is in agreement with the reports of Sink *et al*., (1964) and Koch *et al*., (1968). The main difference in the degree of unsaturation between the perirenal fat and the back fat depot fats was due to a higher ($P<.05$) content of stearic acid in the perirenal fat.

Data presented in table 7 show that the fat from Hampshire pigs had greater ($P<.05$) iodine values than fat from the other three breeds. In general, fat from the outer layer (1st) of backfat had the greater iodine value, fat from the inner layer (3rd) the lowest value and fat from the middle (2nd) layer had intermediate values.

Summary

Two feeding trials involving 64 pigs from four breeds (Duroc, Hampshire, Yorkshire and Crossbred (D x H x Y) were conducted to compare the adipose tissue characteristics as influenced by breed and diets containing whole roasted soybeans versus extracted soybean meal. The initial weight of the pigs at the beginning of the experiments was approximately 31 kilograms. All pigs were slaughtered at a live weight of approximately 102 kilograms.

Adipose tissue samples were excised from the 10th - 12th rib area over the *longissimus* muscle (backfat) and from the perirenal deposit of the carcass. From these samples the contents of myristic, palmitic, palmitoleic, stearic, oleic, linoleic and linolenic acids were determined by gas liquid chromatography. Iodine vlaues were also determined.

Backfat and perirenal fat from Hampshire pigs contained more

unsaturated fatty acids and less saturated fatty acids than Duroc pigs. The levels of total unsaturated fatty acids for Yorkshire and Crossbred pigs were intermediate between those of Hampshire and Duroc pigs.

Adipose tissue from pigs that received whole roasted soybeans in their diet contained more unsaturated fatty acids than adipose tissue from pigs that received soybean meal in their diet. The total unsaturated fatty acid content was greater in the outer layer of backfat than in the inner two layers. There was a preferential deposition of more unsaturated fatty acids in the outer layer of backfat compared to the inner two layers, and linoleic acid was the most responsive to diet. The fatty acid composition of perirenal fat was affected less than backfat by diet.

TABLE 1. PERCENTAGE COMPOSITION OF DIETS

Ingredient	Trial I						Trial II			
	Diet from 31 to 45 kg live weight			Diet from 46 to 102 kg live weight			Diet from 31 to 54 kg live weight		Diet from 55 to 102 kg live weight	
	1	2	3	4	5	6	1	3	4	6
Yellow corn	75.0	72.6	70.2	80.7	78.65	76.65	74.9	70.0	80.6	77.1
Soybean meal (44% protein)	21.2	11.8	-	16.0	9.0	-	21.2	-	16.0	-
Whole roasted soybeans	-	11.8	26.0	-	9.0	20.0	-	26.1	-	19.5
Dicalcium phosphate	1.4	1.4	1.4	1.0	1.0	1.0	1.4	1.4	1.1	1.1
Calcium carbonate	1.0	1.0	1.0	0.95	1.0	1.0	1.0	1.0	0.9	0.9
Trace mineral salt[a]	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Vitamin supplement[b]	0.7	0.7	0.7	0.7	0.7	0.7	0.8	0.8	0.8	0.8
Tylan 10[c]	0.2	0.2	0.2	0.15	0.15	0.15	0.2	0.2	0.1	0.1
Chemical analyses										
Crude protein	14.8	14.7	15.2	14.2	14.2	14.2	14.8	14.7	14.2	14.2
Ether extract	3.6	5.6	8.2	3.4	4.9	6.9	3.6	5.6	3.4	6.9
Moisture	11.7	11.4	10.5	11.6	11.4	10.6	11.7	11.4	11.6	10.6
Fiber	3.6	3.4	3.2	3.3	5.2	3.3	3.6	3.4	3.3	3.3
Ash	4.8	4.5	4.5	3.8	3.8	4.0	4.8	4.5	3.8	4.0

[a]Contained the following trace minerals: zinc 1.8%, manganese 0.8%, iron 0.5%, sulfur 0.24%, copper 0.1%, iodine 0.01% and cobalt 0.01%.

[b]Each kilogram contained 309,900 IU Vitamin A, 55,100 IU Vitamin D_3, 1.32 g riboflavin, 2.31 g pantothenic acid, 5.94 g niacin, 6.6 g choline and 3.3 mg Vitamin B_{12}.

[c]Contained 22 mg/g tylosin.

TABLE 2. EXPERIMENTAL DESIGN

Group	No. pigs	Diet[a] pigs received during period of live weight gain, kg					
		31-45	46-102	46-79	80-102	31-54	55-102
				Trial I			
1	8	1	4	-	-		
2	8	2	5	-	-		
3	8	3	-	6	4		
4	8	3	5	-	-		
				Trial II			
1	16					1	4
2	16					3	6

[a]Description of diets is presented in table 1.

TABLE 3. PERFORMANCE AND CARCASS CHARACTERISTICS OF PIGS

Live animal and carcass characteristic	Trial I		Trial II			
	Hampshire	Duroc	Yorkshire	Crossbred	Hampshire	Duroc
Average daily gain, Kg	0.79[b]	0.91[a]	0.92[b]	0.91[b]	0.75[a]	0.76[a]
Backfat thickness, Cm	2.96	3.14	3.34[b]	3.32[b]	2.83[a]	3.01[ab]
Fat trim, %	15.85	17.97	15.52[ab]	16.12[a]	13.08[c]	15.01[ab]
Four lean cuts, %	54.73	51.86	50.72[a]	51.45[ab]	56.30[c]	53.78[b]

[a,b,c]Means on the same line within trial bearing different superscripts are significantly different (P<.05).

TABLE 4. MEAN FATTY ACID METHYL ESTERS OF BACKFAT FROM FOUR BREEDS OF SWINE

	Grams of fatty acid ester per 100 grams lipid					
	Trial I		Trial II			
Fatty acid ester	Hampshire	Duroc	Yorkshire	Crossbred	Hampshire	Duroc
Myristic (C14)	1.28[b]	1.49[a]	1.39[b]	1.32[b]	1.30[b]	1.51[a]
Palmitic (C16)	20.21[b]	22.52[a]	24.87[bc]	24.26[b]	21.46[a]	25.62[c]
Palmitoleic (C16=1)	2.66[b]	2.08[a]	2.02[a]	2.52[b]	3.12[c]	2.41[b]
Stearic (C18)	10.63[b]	13.11[a]	13.78[a]	13.24[a]	10.78[b]	12.74[a]
Oleic (C18=1)	43.73[b]	40.81[a]	39.34[a]	40.24[ab]	41.57[b]	38.78[a]
Linoleic (C18=2)	17.06[a]	15.39[a]	14.35[a]	14.76[a]	18.35[b]	14.94[a]
Linolenic (C18=3)	1.53[b]	1.40[a]	1.35[a]	1.44[ab]	1.02[b]	1.25[a]
Total saturated	32.12[b]	37.12[a]	40.04[a]	39.87[a]	33.54[b]	38.82[a]
Total unsaturated	64.98[b]	59.68[a]	57.06[a]	57.38[a]	64.06[b]	58.96[a]
Ratio unsaturated/ saturated	2.02	1.60	1.42	1.51	1.92	1.43

[a,b,c] Means within the same trial and on the same line bearing different superscripts are significantly different. (P<.05).

TABLE 5. MEAN FATTY ACID METHYL ESTERS OF BACKFAT FROM FOUR BREEDS OF PIGS FED WHOLE ROASTED SOYBEANS AND THOSE FED SOYBEAN MEAL (TRIAL II)

Fatty acid ester	Grams of fatty acid ester per 100 grams lipid							
	Yorkshire		Crossbred		Hampshire		Duroc	
	1[a]	2[a]	1	2	1	2	1	2
Myristic (C14)	1.33[c]	1.46[c]	1.32[c]	1.32[c]	1.16[d]	1.44[c]	1.38[c]	1.63[b]
Palmitic (C16)	24.11[cd]	25.64[d]	24.17[cd]	24.35[c]	21.08[b]	21.84[b]	23.71[c]	27.54[e]
Palmitoleic (C16=1)	1.74[b]	2.30[c]	2.04[bc]	3.01[d]	2.36[c]	3.88[e]	1.88[bc]	2.95[d]
Stearic (C18)	13.67[c]	13.89[c]	12.24[bc]	14.25[d]	10.85[b]	10.71[b]	12.50[c]	12.98[c]
Oleic (C18=1)	36.26[b]	42.41[e]	38.23[bc]	42.24[de]	38.40[bc]	44.75[e]	37.73[bc]	39.84[cd]
Linoleic (C18=2)	17.99[d]	10.71[b]	18.24[d]	11.28[b]	22.95[e]	13.76[c]	18.46[d]	11.42[b]
Linolenic (C18=3)	2.03[d]	0.66[b]	2.05[d]	0.83[b]	2.42[e]	0.82[b]	1.69[c]	0.80[b]
Total saturated	39.12[c]	40.99[c]	37.74[c]	39.93[c]	33.10[b]	34.00[b]	37.59[c]	42.16[c]
Total unsaturated	58.43[cd]	56.10[bc]	60.57[e]	57.38[bcd]	66.14[f]	63.22[e]	59.78[d]	55.02[b]
Ratio unsaturated/ saturated	1.48	1.36	1.60	1.43	1.99	1.85	1.59	1.30

[a]Group 1 received diets 3 and 6, and group 2 received diets 1 and 4 presented in table 1.

[b,c,d,e,f]Means within the same line bearing different superscripts are significantly different ($P<.05$).

TABLE 6. MEAN FATTY ACID METHYL ESTERS OF THREE LAYERS OF BACKFAT AND PERIRENAL FAT FROM PIGS FED WHOLE ROASTED SOYBEANS AND THOSE FED SOYBEAN MEAL (TRIAL II)

Fatty acid ester	Grams of fatty acid ester per 100 grams lipid							
	1st layer		2nd layer		3rd layer		Perirenal	
	1[a]	2[a]	1	2	1	2	1	2
Myristic (C14)	1.37^{c}	1.47^{c}	1.24^{c}	1.34^{c}	1.28^{c}	1.39^{c}	1.32^{c}	1.65^{b}
Palmitic (C16)	22.39^{c}	23.71^{d}	22.41^{c}	23.98^{d}	23.30^{d}	24.56^{d}	24.98^{d}	27.11^{b}
Palmitoleic (C16=1)	2.42^{d}	2.58^{f}	1.81^{bc}	2.99^{e}	2.19^{cd}	3.31^{ef}	1.60^{b}	2.26^{d}
Stearic (C18)	9.75^{b}	11.30^{c}	11.87^{c}	11.94^{c}	11.60^{c}	12.22^{c}	16.04^{d}	16.37^{d}
Oleic (C18=1)	39.84^{c}	43.54^{cde}	38.19^{c}	44.17^{e}	39.46^{c}	43.59^{de}	33.14^{b}	37.93^{bc}
Linoleic (C18=2)	21.10^{e}	12.86^{b}	19.97^{de}	11.82^{b}	17.90^{c}	11.26^{b}	18.67^{cd}	11.22^{b}
Linolenic (C18=3)	2.16^{c}	0.82^{b}	2.14^{c}	0.80^{b}	1.92^{c}	0.72^{b}	1.99^{c}	0.78^{b}
Total saturated	33.52^{b}	36.49^{c}	35.52^{b}	37.26^{c}	36.18^{c}	38.18^{c}	42.34^{d}	45.14^{e}
Total unsaturated	65.53^{f}	60.83^{de}	62.12^{e}	59.80^{de}	61.47^{de}	58.89^{cd}	55.41^{bc}	52.20^{b}
Ratio unsaturated/ saturated	1.95	1.66	1.74	1.60	1.69	1.54	1.30	1.15

[a]Group 1 received diets 3 and 6, and group 2 received diets 1 and 4 presented in table 1.

[b,c,d,e,f]Means within the same line bearing different superscripts are significantly different ($P<.05$).

TABLE 7. MEAN IODINE NUMBERS OF BACKFAT AND PERIRENAL FAT FROM FOUR BREEDS OF PIGS

Fat depot	Breed			
	Yorkshire	Crossbred	Hampshire	Duroc
		Trial I		
Backfat, composite 3 layers	------	------	73.02[a]	65.88[b]
		Trial II		
Backfat				
1st layer	73.50[a]	75.22[a]	79.88[b]	75.57[a]
2nd layer	68.55[a]	72.07[b]	78.35[c]	70.31[ab]
3rd layer	67.71[a]	70.58[a]	78.11[b]	71.45[a]
Perirenal	60.93[a]	63.39[a]	73.05[b]	63.89[a]

[a,b,c]Means on the same line bearing different superscripts are significantly different ($P<.05$).

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