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FATTY ACID PROFILE AND CHOLESTEROL CONTENT OF MEAT FROM PIGS FED DIFFERENT FATS

Piotr Hanczakowski, Beata Szymczyk, Ewa Hanczakowska

Department of Animal Nutrition and Feed Science, National Research Institute of Animal Production, 32-083 Balice n. Kraków, Poland

Abstract

Eighty fatteners with an initial weight of about 60 kg were fed a barley-wheat-soybean feed mixture containing 5% of one of the following fats: rapeseed oil (group I), low-linolenic linseed oil (group II), beef tallow (group III) and butter (group IV). Each group consisted of 10 gilts and 10 barrows. The animals were fed individually and received restricted amounts of feed according to their body weights. Water was supplied *ad libitum*. Pigs were slaughtered at about 110 kg of body weight and samples of *longissimus* muscle were taken for analysis. Fatty acid profile of meat fat and its cholesterol content were analysed. Dietary animal fats contained more fatty acids of shorter carbon chain (C<18) and twice as much of saturated fatty acids as fats of plant origin. Clear differences in the fatty acid profile of dietary fats were not reflected in the fatty acid profile of intramuscular fat. This particularly concerned palmitic and oleic acids. Also the cholesterol content of meat was relatively stable. Although in pigs fed linseed oil it was lower than in those receiving butter, the difference was not statistically significant.

Key words: pork, fat, fatty acids, cholesterol

Pork is a very popular meat in Polish cuisine. Modern consumers are interested in health products and in the case of meat its fat content and composition is the main problem. A high content of saturated fat is not recommended due to coronary heart disease risk (Xu et al., 2006) but a high content of unsaturated fat lowers the oxidative stability of meat (Tres et al., 2008). On the other hand, this stability can be improved by supplementation of pig feed rich in unsaturated fatty acids with vitamin E (Sandström et al., 2000). Low content of intramuscular fat also lowers meat palatability.

According to Straarup et al. (2006), the fatty acid profile of fat deposited in pig tissues is very similar to that given in feed mixture. On the other hand, however, Kloareg et al. (2005) found that amount of fatty acids deposited by pigs and the profile of *de novo* synthesized fatty acids can change as a result of their elongation and desaturation.

In our earlier experiment on rats (Hanczakowski and Szymczyk, 2007) we have found that amount of fat deposited in the whole body of rats did not depend on the fatty acid profile of consumed fat. Also in an experiment on pigs we have found that differences in fatty acid profile of feed fats are larger than those in animals' blood (Hanczakowski et al., 2006).

It seemed interesting to find if significant differences in the fatty acid pattern of feed fat can result in similar differences in intramuscular fat. Thus the aim of this experiment was to evaluate the degree to which the fatty acid and cholesterol content of pork depends on the fatty acid profile of consumed fats.

Material and methods

The experiment was carried out on 80 Polish Landrace fatteners mated to a Pietrain × Duroc boar, weighing about 60 kg. The basal feed mixture composition is given in Table 1. Pigs were allocated to 4 experimental groups, with 10 gilts and 10 barrows per group. Each group received 5% of different fat sources. Group I was fed rapeseed oil, and groups II, III and IV were fed low-linolenic linseed oil, beef tallow or butter, respectively. The animals were kept and fed individually and received restricted amounts of feed according to their body weight. Water was supplied *ad libitum*.

Table 1. Composition of basal feed mixture (%)

Component	Amount
Ground barley	60.0
Ground wheat	21.0
Soybean meal	12.0
Limestone	0.8
Dicalcium phosphate	0.3
NaCl	0.2
Polfamix (Lutamix PT-2)	0.5
Lys	0.2
Fat*	5.0
1 kg of feed mixture contained:	
crude protein (g)	140.0
crude fat (g)	44.8
ME (MJ)	13.3
Lys (g)	8.0
Met + Cys (g)	4.8
Thr (g)	4.8
Ca (g)	5.6
P (g)	4.2

* Groups: I – rapeseed oil; II – linseed oil; III – beef tallow; IV – butter.

The pigs were slaughtered at about 110 kg of body weight and samples of *longissimus* muscle were taken from the area of the last thoracic and first lumbar vertebrae.

Chemical analysis

Fat content in meat was analysed according to AOAC methods (1995). The energy, amino acid and mineral content of the feed are given according to Polish standards (Normy Żywienia Świń, 1993).

The total tissue lipids (*longissimus* muscle) were extracted according to the method of Folch et al. (1957). They were saponified (10 min, 75°C) in 0.5M KOH/Me-OH and then methylated (10 min, 75°C) in 14% BF_3/Me-OH. Finally, fatty acid methyl esters were extracted with hexane and analysed on a Varian 3400 gas chromatograph, equipped with a BPX 70 fused silica capillary column (50 m × 0.22 mm i.d. × 0.25 mm film thickness) and a flame ionization detector. The operating conditions were as follows: injector temperature 210°C, detector temperature 240°C.

Cholesterol content was estimated using the colourimetric method of Rhee et al. (1982).

Statistical analysis

Statistical analysis of treatment effects was conducted by two-way analysis of variance (MANOVA) with comparison of means by Duncan's multiple range test at $P<0.05$ and $P<0.01$ levels of significance using the Statistica v 5.1 package.

Results

There were distinct differences in the fatty acid profile of fats of plant or animal origin (Table 2). Beef tallow and butter contained more fatty acids of shorter carbon chain, i.e. myristic (C 14) and palmitic (C 16) acids. They also contained twice as much of saturated fatty acids (SFA) as plant oils.

Table 2. Fatty acid composition (% of total fatty acids) of experimental feed mixtures

Fatty acid	Dietary fat			
	Rapeseed oil	Linseed oil	Beef tallow	Butter
C 10:0	0.00	0.00	0.00	1.43
C 12:0	0.00	0.00	0.00	1.91
C 14:0	0.22	0.38	2.20	6.16
C 16:0	12.13	15.12	23.26	24.06
C 16:1	0.20	0.25	2.12	0.88
C 18:0	2.25	4.07	8.83	6.56
C 18:1	36.92	15.95	22.38	15.75
C 18:2	41.05	61.74	38.37	39.75
C 18:3	3.16	1.31	2.17	2.63
C 20:0	0.41	0.15	0.10	0.13
C 22:0	0.29	0.17	0.00	0.00
C 22:1	0.73	0.05	0.03	0.04
SFA*	15.30	19.89	34.41	40.25
MUFA*	37.84	16.25	24.54	16.67
PUFA*	46.86	63.86	41.06	43.07

*SFA – saturated fatty acids; MUFA – monounsaturated fatty acids; PUFA – polyunsaturated fatty acids.

The fatty acid pattern of intramuscular fat (Table 3) was apparently uniform when compared to fatty acids present in dietary fat. This was especially evident in the case of palmitic (plant oil feed: 12–15%, corresponding muscle fat: 22–24%) and oleic acids. The meat of pigs receiving linseed oil contained a significantly higher amount of polyunsaturated fatty acids (PUFA).

Table 3. Fatty acid composition (% of total fatty acids) of *longissimus* muscle

Fatty acid	Main effects						SEM	Interaction
	fat				sex			
	rapeseed oil	linseed oil	beef tallow	butter	♀	♂		
C 12:0	0.059	0.062	0.054	0.055	0.050 A	0.064 B	0.002	NS
C 14:0	1.07	1.21	1.25	1.23	1.10 a	1.28 b	0.039	NS
C 16:0	22.21 Aa	23.99 Abb	24.48 Bb	23.97 Abb	22.87 A	24.44 B	0.267	NS
C 16:1	2.62 A	2.79 AB	3.13 B	3.04 AB	2.73 A	3.06 B	0.067	NS
C 18:0	10.36 ab	9.91 a	10.4 b	10.12 ab	9.93 A	10.47 B	0.087	NS
C 18:1 *n-9*	37.21 B	32.68 A	37.84 B	36.79 B	36.75	36.41	0.450	NS
C 18:2 *n-6*	22.12 Aba	26.01 Bb	19.09 Aa	20.79 B	23.36 b	20.64 a	0.663	NS
C 18:3 *n-3*	0.85 Cc	0.38 Aa	0.47 Abb	0.49 Bb	0.57	0.53	0.022	NS
C 20:0	0.10	0.09	0.09	0.09	0.09	0.10	0.004	NS
C 20:4 *n-6*	2.24	2.04	2.16	2.34	2.50 B	1.89 A	0.077	NS
C 20:5 *n-3*	0.20 C	0.04 A	0.10 B	0.12 B	0.13 B	0.10 A	0.008	*
C 22:6 *n-3*	0.05 Bc	0.01 Aa	0.02 Abab	0.04	0.05 B	0.01 A	0.004	NS
SFA*	33.81 A	35.28 AB	36.28 B	35.47 AB	34.05 A	36.37 B	0.334	NS
MUFA*	39.83 B	35.48 A	40.97 B	39.83 B	38.48	39.57	0.493	NS
PUFA*	26.36 Abab	29.24 Bb	22.74 Aa	24.70 Aba	27.46 B	24.05 A	0.718	NS
PUFA *n-6*	24.45 Aba	28.15 Bb	21.37 Aa	23.24 Aba	25.98 B	24.05 a	0.724	NS
PUFA *n-3*	0.99 C	0.34 A	0.47 B	0.54 B	0.63 B	0.54 A	0.031	*
PUFA *n-6/n-3*	24.55 A	84.46 C	46.60 B	41.78 B	49.32	50.82	0.920	NS
Cholesterol (mg/100g)	47.04	46.33	48.18	50.05	47.39	48.41	0.700	NS

*SFA – saturated fatty acids; MUFA – monounsaturated fatty acids; PUFA – polyunsaturated fatty acids.
a, b, c – values in rows with different letters differ significantly ($P<0.05$).
A, B, C – values in rows with different letters differ significantly ($P<0.01$).
NS ($P\geq0.05$).

Type of dietary fat had no distinct effect on cholesterol level in loin. Although its content in the muscle of pigs receiving linseed oil was lower than in those receiving butter, this difference was not statistically significant.

Discussion

It is known that animal fats contain more saturated fatty acids than plant oils (Glaser et al., 2002; Jung et al., 2003) and a similar relationship was found also in this experiment. Oil from the low-linolenic variety of flax was chosen for the experiment as a rich source of linoleic acid (C 18:2). High-linolenic linseed oil is not readily eaten by pigs.

According to many published results, fatty acid profiles of fat deposited by pigs reflected the fatty acid profile of dietary fat (Glaser et al., 2002; Straarup et al., 2006), but many of these results concern pig adipose tissue. Averette Gatlin et al. (2002) found that type of dietary fat has a greater effect on bacon than on the loin muscle and Camara et al. (1996) found increased lipogenic enzyme activities in backfat compared to the *longissimus* muscle. This suggests that the fatty acid profile of loin is relatively stable and depends to a lesser degree on dietary fat composition than that of adipose tissue.

In the experiment of Fontanillas et al. (1997), fatty acid composition of *longissimus* muscle of pigs did not exactly reflect fatty acid composition of diets: the muscle contained more palmitic (C 16:0) and stearic (C 18:0) acids than dietary fat. In the case of stearic acid, clear differences between diets were almost completely levelled out in loin. Similar changes were found in this experiment, although a significantly higher level of PUFA was ascertained in the meat of pigs fed linseed oil, which could be due to the extremely high content of linoleic acid in this fat. No differences in palmitic and oleic (C 18:1) acids content of dietary fats used (Table 2) were found in intramuscular fat (Table 3). These differences were probably due to elongation or desaturation of particular fatty acids. Similar changes were reported by Kloareg et al. (2005), who found the largest differences for palmitic and oleic acids.

Although feed type can affect cholesterol level in pig blood (Martins et al., 2005), cholesterol content in muscles seems to be relatively stable. Fontanillas et al. (1997) and Kreuzer et al. (2002) found no difference in cholesterol content of pig muscle regardless of dietary fat. Also Kouba et al. (2003) did not find regular changes in cholesterol content of loin depending on polyunsaturated fatty acid content of feed or pigs' age. Only small differences in cholesterol content of loin as a result of supplementing soybean oil and vitamin E were observed also by Grela and Kondek (2000). Similar results were obtained in the present experiment: differences in cholesterol content of meat from pigs receiving different fats were not significant. This is in accordance with the opinion of Rideout et al. (2008) that the liver plays an important role as a modulator of the cholesterol concentration in serum, and the cholesterol content of tissues, as a fundamental component of cell membranes, tends to remain constant.

Based on this experiment it is concluded that the fatty acid profile of pig muscle is relatively stable and depends to a relatively small extent on the fatty acid composition of feed fat. In this situation the type of fat supplement used in pig feed (if necessary) is not very important from the consumer point of view.

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PIOTR HANCZAKOWSKI, BEATA SZYMCZYK, EWA HANCZAKOWSKA

Zawartość kwasów tłuszczowych i cholesterolu w mięsie świń żywionych z dodatkiem różnych tłuszczów

STRESZCZENIE

Osiemdziesiąt tuczników o wadze początkowej około 60 kg otrzymywało dawkę jęczmienno-pszenno-sojową, z dodatkiem 5% jednego z następujących tłuszczów: oleju rzepakowego (grupa I), niskolinolenowego oleju lnianego (grupa II), łoju wołowego (grupa III) lub masła (grupa IV). W skład każdej grupy wchodziło 10 wieprzków i 10 loszek. Zwierzęta były utrzymywane i karmione indywidualnie. Stosowano żywienie dawkowane, uzależnione od masy ciała. Wodę dostarczano *ad libitum*. Świnie ubito przy masie ciała około 110 kg i pobrano próbki mięśnia najdłuższego do analiz chemicznych. Oznaczano profil kwasów tłuszczowych tłuszczu mięsa oraz zawartość cholesterolu.

Podawane tłuszcze zwierzęce zawierały więcej kwasów tłuszczowych o krótszym łańcuchu węglowym (C<18) i prawie dwa razy więcej nasyconych kwasów tłuszczowych niż tłuszcze roślinne. Wyraźne różnice w składzie podawanych tłuszczów nie znalazły odbicia w profilu kwasów tłuszczowych tłuszczu śródmięśniowego. Dotyczyło to zwłaszcza kwasów palmitynowego i oleinowego. Także zawartość cholesterolu w mięsie była stała. Jego zawartość u świń otrzymujących olej lniany była niższa niż u otrzymujących masło, ale różnica ta nie była istotna statystycznie.