PAPER

Lipid composition of covering and intramuscular fat in pigs at different slaughter age

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Abstract

To study age-related variations in fatty acid composition of covering and intramuscular fat (IMF), 60 half siblings, Pic X Camborough, of the same age, 30 barrows and 30 gilts, chosen from 10 litters were used. Groups of 20 subjects each, 10 castrated males and 10 females, balanced for litter, were sacrificed at 6, 8.5 and 9.5 months of age, corresponding to the common slaughter age of the three Italian pig production types, at live weights averaging approximately 90, 145 and 160 kg, respectively. Samples of backfat and *longissimus thoracis* (LT) muscle, taken at the last rib, were analysed. On LT samples, moisture, fat content and drip loss were determined. Fatty acid composition was determined in lipids from subcutaneous adipose tissue and in lipid fractions from LT. Further, backfat lipids were submitted to iodine value (I.V.) determination. The data were evaluated by means of analysis of variance with age at slaughter and sex as the independent variables. As age increased (6, 8.5 and 9.5 months), higher contents of saturated fatty acids (SFA) (36.36, 39.08 and 39.19%, respectively; P<0.01) and monounsaturated fatty acids (MUFA) (41.78, 43.44 and 44.37%, respectively; P<0.01) were observed in backfat, whereas polyunsaturated fatty acids (PUFA) content, PUFA/SFA ratio and I.V. lowered (P<0.01). As total IMF is concerned, by increasing age, MUFA content increased (43.30; 46.76 and 47.28%, respectively; P<0.01), PUFA content decreased (18.63, 15.14 and 14.82%, respectively; P<0.01) and PUFA/SFA decreased as well (P<0.05); neutral lipids followed the same pattern, while an opposite trend was observed in polar lipids. IMF content (1.65%) was modified neither by sex nor age. The study shows that fatty acid composition of subcutaneous and intramuscular fats differs among the 3 slaughtering ages typical of the Italian pig industry. The variations observed, which could be ascribed to the increase of carcass fatness at increasing slaughter age, can affect both the nutritional and technological quality of pork.

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Introduction

Factors affecting quality traits of adipose tissue and lipids draw the ever-increasing attention of those involved at different levels in pork production, processing and consumption. In fact, animal fats are usually thought to be rich in saturated fatty acids (SFA) and therefore held responsible for health problems. It is for this reason that consumers may eventually develop an aversion to meat products (Woodward and Weelock, 1990). This attitude stems from the awareness that an excessive intake of SFA may favour coronary diseases associated with elevated cholesterol levels in blood and atherosclerosis (Rose, 1990; Ulbricht and Southgate, 1991; Azain, 2004).

Furthermore, the technological characteristics of lipids must also be taken into account, with main reference to the cuts of the Italian heavy pig, manufactured into cured and aged products. It is well known that processing parameters and the quality of the outcome are affected by fat amount and composition (Santoro, 1983; Santoro and Lo Fiego, 1985; Santoro *et al.,* 1985; Santoro, 1989; Santoro and Lo Fiego, 1992; Lo Fiego *et al.,* 2005b). The above mentioned literature reported as well that nutritional and technological qualities of pork fat composition have sometimes opposite requirements.

Moreover, a number of research studies showed that the accumulation of lipids and fatty acid (FA) composition are affected by environmental factors, mostly associated with different feeding strategies (Wood *et al.*, 1986; Cameron *et al*., 2000; Lo Fiego *et al*., 2005a), as well as by genetic factors related to the adipogenetic capacity of breeds (Wood, 1973; Cameron *et al.*, 2000; Piedrafita *et al.*, 2001). In addition, other factors, including age and live weight (LW) at slaughter, may influence these parameters (Lebret and Mourot, 1998; Lo Fiego *et al.,* 2005b).

The variation of FA composition in the pig carcass has been analysed mainly in growing animals and up to a LW of approximately 100 kg (Secondi *et al.,* 1994; Bragagnolo and Rodriguez-Amaya, 2002), while other studies investigated the subject at a higher weight range (Franci *et al.,* 1995; Geri *et al.,* 1988; Geri *et al.,* 1990; Virgili *et al.,* 2003).

The Italian pig industry relies on heavy pigs slaughtered aging 9 to 10 months and reaching an average LW of 160-170 kg. They are mostly processed into typical, high quality, dry cured products. Pork for fresh consumption is commonly provided by light pigs, slaughtered at about 6 months, weighing 95-100 kg. Mention must also be made of pigs of intermediate slaughter weight, averaging 140 kg at about 8 months of age. Their meat is destined for both fresh consumption and products like salami, sausages and cooked hams.

The aim of the present study was to investigate the fatty acid composition of lipid fractions in covering and intramuscular fat of pigs, sacrificed at the 3 slaughtering ages typical of the Italian pig industry: 6, 8.5 and 9.5 months.

Materials and methods

Animals and sampling procedure

This study involved initially 100 piglets produced by 13 Camborough sows, which had been fertilised with the semen of the same PIC breeding boar. At an average LW of 45 kg, 60 pigs were selected, three litters were left out and research was geared towards 6 pigs (3 castrated males and 3 females) from each of the

remaining 10 litters. Three groups of 20 pigs each (10 barrows and 10 gilts) of similar LW and age were housed in three adjoining pens and received the same diet until they reached their target age. A balanced commercial feed based on cereals, cereal by-products and soybean meal (15.5% crude protein and 4.0% ether extract) was given *ad libitum* up to 80 kg LW. Later, feed allowance was restricted at 9% of the metabolic weight (kg $LW^{0.75}$) starting from 2.4 kg and then increased fortnightly up to a maximum of 3.3 kg per pig per day.

A group of 20 pigs was slaughtered when reaching the age of 6 months and a LW of about 90 kg. The remaining groups were slaughtered at the age of 8.5 and 9.5 months, with a LW of about 145 and 160 kg, respectively. After slaughtering, the carcass was graded using Fat-o-Meater, as described in a previous paper (Lo Fiego *et al.,* 2005b). Samples of subcutaneous adipose backfat tissue and *longissimus thoracis* (LT) muscle were taken from the left half-carcass, in the region of the last rib. The samples were vacuum packed and deep frozen at -80°C, pending laboratory analysis.

Analysis

Each sample of LT muscle was analyzed in duplicate to determine water and ether extract contents; the former was determined by oven drying samples at 105°C for six hours, whereas the latter was determined using petroleum ether (Carlo Erba reagents, MI, Italy) and a Soxhlet apparatus (A.O.A.C., 1990). Results were expressed as percentage of wet matter.

The total lipids were extracted from both LT muscle and subcutaneous adipose tissue by chloroform:methanol mixture (2:1, v/v) according to the method of Folch *et al.* (1957). For lipid fractions separation, a 200-mg amount of total IMF was evaporated to dryness under nitrogen, then dissolved in 250 µL of chloroform and applied to a Vac-Elut apparatus (Varian, Harbor City, CA, USA), equipped with solid phase Bond-Elut Lc-NH2, columns (500 mg) (Supelco, Bellafonte, PA, USA), previously conditioned twice with hexane. The elution of neutral and polar fractions was carried out as described by Kaluzny *et al.* (1985).

Lipids from subcutaneous adipose tissue and lipid fractions from LT were submitted to methylation using a 12% boron trifluoride-methanol solution (w/w) (Sigma-Aldrich, MI, Italy), as reported by Joseph and Ackman (1992). The carrier gas was helium used at a flow rate of 2 mL/min. The column was operated at 140°C for 2 min, then the temperature was increased to 230°C at 4°C/min and held for 15 min. The injector and detector temperature was 260°C. Chromatograms were recorded and processed with a DP 700 Chromjet integrator (Fisons Instruments, Rodano, MI, Italy).

The fatty acid methyl esters (FAME) were identified by comparison of each retention time with the known retention times of the corresponding pure standards (Supelco 37 Component FAME mix and PUFA standard n. 2, animal source, Supelco, Bellafonte, PA, USA). For quantification purposes, the response factors were calculated and the method of the area normalization was used. The results were expressed as the percentage of each FAME in relation to total FAME. The FAME (0.5 µL) were analyzed using a Fisons Mega 2 HRGC gas-chromatograph (Fisons Instruments, Rodano, MI, Italy) equipped with a flame-ionization detector and a 30 m × 0.32 mm i.d. × 0.25 µm film thickness SupelcowaxTM 10 silica capillary column (Supelco, Bellafonte, PA, USA). Furthermore, subcutaneous lipids were submitted to iodine value (I.V.) determination according to Wijs as indicated by A.O.A.C. (1984).

Drip loss of LT muscle was measured after 48 h of storage at 2-4°C (Honikel, 1998). In particular, after a 12 h storage period of loin at 2-4°C, sample of approximately 100 g was cut from the loin, trimmed from visible fat and connective tissue, weighed and suspended in an inflated bag, ensuring that the bag did not touch the sample. After a storage period of 48 h at 2-4°C, sample was again weighed. Drip loss was expressed as a percentage of the initial weight.

Statistical analysis

Statistical analysis was performed by means of variance analysis using the GLM procedure of SAS (SAS Institute, 1996) with age at slaughter and sex as the independent variables. Further, reciprocal correlations between some of the main composition parameters of lipids in different lipid fractions were calculated.

Results and discussion

Table 1 shows data regarding carcass and LT muscle traits. Figures refer to different slaughter ages (6, 8.5 and 9.5 months) and sex. Data showed an increase in backfat thickness ($P<0.01$) as slaughter age increased. Youngest pigs showed higher lean meat and LT moisture contents ($P<0.01$), and a slight and not statistically significant increase in IMF. This is in agreement with other findings in younger pigs (Correa *et al.,* 2006), in pigs aged 8 to 10 months (Virgili *et al.,* 2003) and 8 to 15 months (Mayoral *et al.,* 1999). The IMF content (1.65%) is definitely low and favourable in terms of human nutrition. Actually, IMF has a direct impact on lipid intake associated with pork consumption. The IMF value found in this study is in agreement with the recommendations of lowering fat intake in human nutrition. In fact, though protein content was not determined, it can be assumed that lipid contribution to total energy is approximately 15%, i.e., the minimum threshold indicated by WHO/FAO (2003) for human diets. Sex did not noticeably affect the parameters observed thus far, though female carcass weight tended to be lower ($P=0.055$). Drip loss diminished as the slaughter age rose ($P<0.01$) and was higher in females ($P<0.05$). The impact of age on drip loss was in line with the findings of other authors (Virgili *et al.,* 2003), but as respects gender, Van Oeckel and Warnants (2003) did not find any difference between barrows and females slaughtered at 110 kg LW.

The FA composition of subcutaneous adipose tissue is shown in Table 2. The youngest pigs and females showed a significantly lower content of SFA and MUFA and a higher content of PUFA ($P<0.01$) resulting in higher ($P<0.01$) PUFA/SFA ratio and I.V. These results are gen-

Table 1. Effect of age and sex on carcass and *longissimus thoracis* (LT) muscle traits (least squares means and root-mean square error).

	Age at slaughter (months)			Sex		R-MSE
	6	8.5	9.5	Castrated males	Females	
Number of subjects	20	20	20	30	30	
Live weight (LW), kg	90.6^{C}	145.3^{B}	159.4^{A}	135.1	128.4°	12.98
Cold carcass weight, kg	70.4^{C}	115.5^{B}	129.1^{A}	107.7	102.3°	10.43
Backfat tickness, mm[#]	16.4^{C}	29.5^{B}	35.4^{A}	27.9	26.3	6.13
Lean meat content, %	54.8^{A}	49.1^{aB}	46.5^{Bb}	49.4	50.8	3.30
LT moisture content, %	74.43^{A}	73.86^{Bb}	73.41^{Ba}	73.78	74.03	0.54
LT fat content (IMF), %	1.57	1.66	1.71	1.80	1.49	0.70
LT drip loss, %	6.80^{A}	5.22^{B}	4.95^{B}	5.25	6.07*	1.29

IMF: intramuscular fat. [#]Average of two measurements carried out respectively between the 3/4 last lumbar vertebra and 3/4 last rib at 8 cm from the splitting line of the carcass. *, ^{a,b}: $P<0.05$; $^{A, B, C}$: $P< 0.01$; °: $P=0.055$.

erally in agreement with the findings of Lebret and Mourot (1998), as most differences were only present in subcutaneous fat of the youngest pigs. This group was characterized by less SFA than other groups, with the exception of myristic acid (C14:0) and margaric acid (C17:0).

Stearic acid (C18:0), which has been shown to have no impact on high cholesterol levels in blood (Bonamone and Grundy, 1988), was lower (P<0.01) in the youngest subjects. This fatty acid reached values reported as suitable for processing, as indicated by Girard *et al.* (1988). Among MUFA, a significant increase in oleic acid (C18:1) and eicosenoic acid (C20:1) was observed. This must be considered as a favourable factor, with special reference to oleic acid (C18:1), which is supposed to play a role in preventing cardiovascular disease (Kris-Etherton, 1999). Except for eicosadienoic acid (C20:2), all PUFA decreased with the increase in slaughter age (P<0.01 in the first age interval). High concentrations of linoleic acid (C18:2) should be avoided, being established a maximum threshold (15%) for processing fresh thigh into typical dry-cured hams (Consortium for Parma Ham, 1992). This value is to be kept under control in order to fulfil the specific needs of the processing industry and favour the aging of the product (Wood, 1984). Females showed a higher degree of unsaturation, due to a greater proportion of PUFA (P<0.01), and a higher PUFA/SFA ratio (P<0.01).

FA composition of total IMF is shown in Table 3. Age did not considerably affect the total content of SFA, except for margaric acid (C17:0) content, which decreased significantly (P<0.01) as age increased. As a whole, a significant rise (P<0.01) in total MUFA content was observed as age increased. The increment was mostly due to an increased content of oleic acid (C18:1) in the first stage, while a significant drop of heptadecenoic acid (C17:1) took place in the second age interval. On the contrary, PUFA decreased (P<0.01) as a result of a remarkable reduction of linoleic (C18:2), linolenic (C18:3) and eicosadienoic acid (C20:2) contents (P<0.01). As a consequence, PUFA/SFA ratio lowered from 0.49, at 6 months, to 0.40 in the next stages. This decreasing ratio as the age and carcass weight grew was also observed by other authors (De Smet *et al.*, 2004). The gradual drop in linoleic acid (C18:2) content should result in a higher oxidative-stability of lipids (Wood and Enser, 1982) which better suits processing needs. Sex of pigs affected only SFA, with lower values (P<0.05) detected in females due mainly to a lower content (P<0.01) of stearic acid (C18:0).

Table 2. Effect of age and sex on fatty acid composition (%)# of subcutaneous adipose tissue (least squares means and root-mean square error).

	Age at slaughter (months)			Sex		R-MSE
	6	8.5	9.5	Castrated males	Females	
Number of subjects	20	20	20	30	30	
C14:0	1.28	1.18	1.25	1.23	1.24	0.19
C16:0	22.41^{B}	23.34^{A}	23.56^{A}	23.55	22.66**	0.94
C17:0	0.33^{A}	0.28^{Ba}	0.24^{Bb}	0.28	0.28	0.05
C18:0	11.98^{B}	13.92^{A}	13.76^{A}	13.44	13.00	0.71
C20:0	0.21^{b}	0.24^{ab}	0.25^{a}	0.24	0.23	0.05
Saturated (SFA)	36.36^{B}	39.08^{A}	39.19^{A}	38.88	37.54**	1.57
C16:1	2.50^{A}	2.11^{B}	2.06^{B}	2.24	2.21	0.17
C17:1	0.26^{A}	0.23^{Ba}	0.20^{Bb}	0.23	0.23	0.03
C18:1	38.18^{B}	40.20^{Ab}	41.14^{Aa}	40.19	39.48*	1.33
C20:1	0.83^{Bb}	0.91^{a}	0.97^{A}	0.93	0.88	0.11
Monounsaturated (MUFA)	41.78^{B}	43.44^{A}	44.37^{A}	43.59	42.81*	1.44
C18:2	19.26^{A}	15.62^{B}	14.64^{B}	15.54	17.47**	1.96
C18:3	1.45^{A}	0.87^{B}	0.78^{B}	0.98	1.08*	0.14
C20:2	0.70	0.66	0.69	0.66	0.71*	0.09
C20:3	0.26^{A}	0.20^{B}	0.18^{B}	0.20	0.23*	0.06
C20:4	0.18^{A}	0.13^{B}	0.14^{B}	0.14	0.15	0.03
Polyunsaturated (PUFA)	21.85^{A}	17.47^{B}	16.43^{B}	17.51	19.65**	2.16
PUFA/SFA ratio	0.61^{A}	0.45^{B}	0.42^{B}	0.45	0.53**	0.08
Iodine value	74.67^{A}	69.24^{B}	67.02^{B}	68.43	72.19**	5.04

*, a, b: P <0.05; **, A, B: P< 0.01; #: other fatty acids detected: $C_{10:0}$, $C_{12:0}$.

Table 3. Effect of age and sex on fatty acid composition (%)# of total lipids of *longissimus thoracis* muscle (least squares means and root-mean square error).

	Age at slaughter (months)			Sex		R-MSE
	6	8.5	9.5	Castrated males	Females	
Number of subjects	20	20	20	30	30	
C14:0	1.23	1.13	1.23	1.23	1.17	0.19
C16:0	23.56	23.69	23.67	23.88	23.40	1.06
C17:0	0.22^{A}	0.17^{B}	0.13^{C}	0.17	0.18	0.03
C18:0	12.81	12.86	12.62	13.01	12.51**	0.61
Saturated (SFA)	38.07	38.10	37.91	38.54	37.51*	1.62
C16:1	3.53	3.71	3.65	3.59	3.66	0.38
C17:1	0.16^{a}	0.17^{A}	0.11^{Bb}	0.15	0.15	0.06
C18:1	39.00^{B}	42.23^{A}	42.81^{A}	41.69	41.00	2.78
C20:1	0.62	0.64	0.71	0.63	0.69	0.18
Monounsaturated (MUFA)	43.30^{B}	46.76^{A}	47.28^{A}	46.06	45.50	2.94
C18:2	14.31^{A}	11.24^{B}	10.93^{B}	11.66	12.67	2.69
C18:3	0.66^{A}	0.33^{B}	0.30^{B}	0.40	0.47	0.12
C20:2	0.40^{A}	0.30^{B}	0.17^{C}	0.28	0.30	0.10
C20:3	0.43	0.39	0.38	0.39	0.41	0.12
C20:4	2.83	2.87	3.03	2.68	3.15	1.07
Polyunsaturated (PUFA)	18.63^{A}	15.14^{B}	14.82^{B}	15.40	16.99	3.84
PUFA/SFA ratio	0.49^{a}	0.40^{b}	0.40^{b}	0.40	0.46	0.11

*, a, b: P<0.05; **, A, B, C: P< 0.01; #: other fatty acids detected: $C_{10:0}$, $C_{12:0}$, $C_{20:0}$.

Females also showed slightly lower concentrations of MUFA, higher concentrations of PUFA and a higher PUFA/SFA ratio. These results, though the differences were not statistically significant, confirmed the findings in subcutaneous adipose tissue.

FA composition of neutral fraction of IMF is reported in Table 4. The overall values of SFA did not significantly change in relation to slaughter age. The only difference (P<0.01) concerned margaric acid (C17:0) content, which was lower in heavier pigs. Females

showed a lower content (P<0.05) of palmitic acid (C16:0) and a reduction in the total SFA concentration. Significant variations could be observed in the proportion of MUFA in the neutral fraction, where oleic (C18:1) and palmitoleic acids (C16:1) considerably rose (P<0.01) with age. Sex did not affect significantly the concentration of any of these MUFA found in the neutral fraction. As age and carcass fatness increased, PUFA noticeably decreased (P<0.01): this may be due to a synthesis *de novo* of SFA and MUFA and, consequently, to a dilution effect (De Smet *et al.,* 2004). In detail, linoleic (C18:2), linolenic (C18:3) and eicosadienoic (C20:2) acids decreased, whereas eicosatrienoic (C20:3) and arachidonic acid (C20:4) initially rose and then decreased in the oldest pigs. Females showed a higher content of PUFA (P<0.05), especially linoleic acid (P<0.01). In agreement with the findings of Warnants *et al.* (1996), this result confirms that the lipids of females have a better nutritional quality than those of barrows.

PUFA/SFA ratio of neutral lipids dropped (P<0.01) from 0.29 to 0.18 with increasing age, and was significantly higher in females (P<0.01). Therefore, previous observations are confirmed as a whole.

Table 5 shows fatty acid composition of the polar lipid fraction. SFA decreased from 6 to 8.5 months of age, while main single FA, palmitic (C16:0) and stearic (C18:0) showed a different pattern variation. Sex-related differences were not significant. As a whole, MUFA were lower in the oldest pigs. No main differences were recorded between the first and second age group under investigation. Age did not affect the value of C17:1, while C20:1 was highest at 9.5 months of age. Contents of MUFA were similar between genders. PUFA gradually increased with slaughter age (P<0.01), mainly on account of their major components, namely linoleic (C18:2) and arachidonic (C20:4) acids. Linolenic acid (C18:3) decreased with increasing age (P<0.01), while eicosadienoic (C20:2) and eicosatrienoic (C20:3) decreased at first and then rose. Between 8.5 and 9.5 months, variations were not statistically significant. As a whole, these differences brought about a gradual increase in PUFA/SFA ratio (P<0.01) of the polar fraction with increasing slaughter age. It can also be assumed that polar lipids may vary considerably with age, despite their commonly acknowledged quite stable composition, due to their role in cellular membranes (De Smet *et al.,* 2004).

The concentration of linoleic acid (C18:2) only, which was higher in barrows (P<0.05), varied significantly depending on sex. PUFA content in polar fraction was similar in both male and female pigs, as also observed by Warnants *et al.* (1996).

Table 6 shows reciprocal correlations between some of the main composition parameters of lipids in different lipid fractions. If fatty acid composition of subcutaneous fat changed, so did the composition of IMF and its neutral fraction. Actually, all parameters observed, except for palmitoleic acid (C16:1), showed a positive reciprocal correlation (P<0.01, C18:0 P≤0.09). In the polar fraction,

Table 4. Effect of age and sex on fatty acid composition (%)# of neutral lipids of *longissimus thoracis* muscle (least squares means and root-mean square error).

	Age at slaughter (months)			Sex		R-MSE
	6	8.5	9.5	Castrated males	Females	
Number of subjects	20	20	20	30	30	
C14:0	1.45	1.36	1.43	1.43	1.40	0.14
C16:0	23.69	23.39	23.95	24.13	23.23*	1.36
C17:0	0.15^{A}	0.14^{a}	0.11^{Bb}	0.14	0.13	0.03
C18:0	12.16	12.61	12.60	12.60	12.32	1.24
C20:0	0.10	0.11	0.10	0.10	0.10	0.03
Saturated (SFA)	37.81	37.82	38.40	38.61	37.41*	2.05
C16:1	3.91^{B}	4.10^{b}	4.54^{Aa}	4.12	4.24	0.60
C17:1	0.17^{A}	0.13^{B}	0.13^{B}	0.14	0.15	0.03
C18:1	46.34^{Bb}	48.14^{a}	49.42^{A}	48.52	47.41	2.57
C20:1	0.78	0.78	0.80	0.81	0.77	0.09
Monounsaturated (MUFA)	51.19^{Bb}	53.15^{a}	54.89^{A}	53.59	52.57	2.76
C18:2	9.45^{A}	6.97^{B}	5.69^{B}	6.58	8.16**	2.16
C18:3	0.70^{A}	0.34^{B}	0.28^{B}	0.41	0.46	0.17
C20:2	0.40^{A}	0.28^{aB}	0.20^{Bb}	0.29	0.30	0.09
C20:3	0.11^{b}	0.19^{a}	0.10^{b}	0.11	0.16	0.10
C20:4	0.33^{b}	1.27^{a}	0.45^{b}	0.42	0.95	1.07
Polyunsaturated (PUFA)	11.00^{A}	9.03^{a}	6.71^{Bb}	7.81	10.02*	3.23
PUFA/SFA ratio	0.29^{A}	0.24^{AB}	0.18^{B}	0.20	0.27**	0.10

*, ^{a,b}: P<0.05 ; **, ^{A,B}: P< 0.01; #: other fatty acids detected: $C_{10:0}$, $C_{12:0}$.

Table 5. Effect of age and sex on fatty acid composition (%)# of polar lipids of *longissimus* thoracis muscle (least squares means and root-mean square error).

	Age at slaughter (months)			Sex		R-MSE
	6	8.5	9.5	Castrated males	Females	
Number of subjects	20	20	20	30	30	
C14:0	1.73^{a}	1.58^{ab}	1.33^{b}	1.59	1.50	0.58
C16:0	22.89^{a}	23.19^{a}	21.67^{b}	22.21	22.96	1.81
C17:0	0.35^{Aa}	0.27^{b}	0.23^{B}	0.30	0.27	0.11
C18:0	8.16^{A}	6.32^{C}	7.23^{B}	7.30	7.18	0.95
Saturated (SFA)	33.29^{A}	31.43^{B}	30.66^{B}	31.49	32.09	1.56
C16:1	2.71^{A}	2.33^{a}	1.76^{Bb}	2.32	2.22	0.70
C17:1	0.15	0.16	0.14	0.14	0.16	0.10
C18:1	14.93^{a}	15.44^{A}	13.82^{Bb}	14.70	14.76	1.45
C20:1	0.18^{b}	0.15^{Bb}	0.24^{Aa}	0.20	0.18	0.08
Monounsaturated (MUFA)	17.97^{A}	18.07^{A}	15.96^{B}	17.35	17.32	1.78
C18:2	34.90^{B}	36.87^{A}	37.31^{A}	36.87	35.85*	1.85
C18:3	0.56^{Aa}	0.51^{Ab}	0.42^{B}	0.51	0.49	0.07
C20:2	0.53^{a}	0.45^{b}	0.52^{ab}	0.51	0.49	0.10
C20:3	1.52	1.42	1.51	1.47	1.49	0.26
C20:4	11.23^{B}	11.26^{B}	13.62^{A}	11.81	12.27	1.42
Polyunsaturated (PUFA)	48.74^{C}	50.50^{B}	53.38^{A}	51.16	50.59	1.76
PUFA/SFA ratio	1.48^{C}	1.61^{B}	1.76^{A}	1.64	1.59	0.11

*, ^{a,b}: P<0.05 ; ^{A,B,C}: P< 0.01; #: other fatty acids detected: $C_{10:0}$,. $C_{12:0}$, $C_{20:0}$.

on the contrary, only palmitoleic acid (C16:1) showed a significant positive correlation with subcutaneous fat (P<0.05), while other components, namely stearic acid (C18:0), linoleic acid (C18:2), and the total PUFA, showed a negative one (P<0.01). With reference to IMF, its composition proved to be mostly influenced by the composition of the neutral fraction, with the correlations coefficients between these two components ranging from 0.49 to 0.79 (P<0.01). Polar fraction exerted a slight influence on fatty acid composition of total IMF, as correlations coefficients were smaller and statistically less significant (P≤0.09).

Correlation coefficients between neutral and polar fractions showed a negative value for PUFA (P<0.05), palmitic acid (P<0.05) and stearic acid (P<0.01).

Table 6. Pearson's single correlation coefficients (r) between the main lipid composition parameters of different lipid fractions.

	Intramuscular lipids		
	Polar	Neutral	Total
Subcutaneous adipose tissue			
C16:0	+ 0.106	+ 0.514**	+ 0.610**
C16:1	+ 0.320*	- 0.040	+ 0.139
C18:0	- 0.576**	+ 0.388**	+ 0.240#
C18:1	+ 0.037	+ 0.538**	+ 0.598**
C18:2	- 0.425**	+ 0.644**	+ 0.638**
Saturated (SFA)	- 0.158	+ 0.451**	+ 0.467**
Monounsaturated (MUFA)	+ 0.002	+ 0.500**	+ 0.559**
Polyunsaturated (PUFA)	- 0.470**	+ 0.545**	+ 0.589**
Total intramuscular lipids			
C16:0	+ 0.031	+ 0.698**	
C16:1	- 0.081	+ 0.658**	
C18:0	- 0.011	+ 0.631**	
C18:1	+ 0.234#	+ 0.487**	
C18:2	- 0.226#	+ 0.729**	
Saturated (SFA)	- 0.041	+ 0.785**	
Monounsaturated (MUFA)	+ 0.137	+ 0.511**	
Polyunsaturated (PUFA)	- 0.235#	+ 0.614**	
Neutral intramuscular lipids			
C16:0	- 0.276*		
C16:1	- 0.327*		
C18:0	- 0.407**		
C18:1	+ 0.191		
C18:2	- 0.217		
Saturated (SFA)	- 0.194		
Monounsaturated (MUFA)	+ 0.092		
Polyunsaturated (PUFA)	- 0.377*		

*: P<0.05 ; **: P< 0.01; #: P≤0.09.

Conclusions

The present study shows that fatty acids composition of subcutaneous and intramuscular fats differs among the 3 slaughtering ages typical of the Italian pig industry. These changes, which could be ascribed to the increase of carcass fatness at increasing slaughter age, can affect both the nutritional and the technological quality of pork. As slaughter age rises, the total content of MUFA increases in subcutaneous adipose tissue, as well as in the IMF and its neutral fraction, while PUFA decrease. Saturated fatty acids content (SFA) varies only in subcutaneous adipose tissue. The most significant changes occur in the first age interval (6 to 8.5 months). Polar lipids of IMF follow an opposite pattern and a considerable increase in PUFA is recorded as age advances. The meat of females is characterised by a lower concentration of SFA and higher concentration of unsaturated FA and therefore it better suits consumers' needs. Special attention must be paid to linoleic acid (C18:2) as its concentration remains, in this pig genotype, relatively high in relation to processing and curing requirements, even though a gradual decrease is observed as age increases. This is a favourable result from a human nutritional point of view. On the other hand, the decrease of the unsaturation degree as the slaughter age rises confirms that the meat of older pigs is more suitable for processing. The twofold goal of maintaining the desirable dietetic properties of pork while optimising industrial processing may actually be reached through appropriate control measures and continuous monitoring.

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