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Fatty acid profile of pork from a local and a commercial breed

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Abstract. This study investigated the effects of breed on the fatty acid compositions of the *Longissimus thoracis et lumborum* (LTL) of gilts and barrows. Although only one muscle was analyzed, the results gave a good indication of the effect that breed and sex may have on the fatty acid compositions of the meat. Breed exhibited a significant effect on the fatty acid composition of pigs, whereas the effects of sex were found to be minor. Higher contents of intramuscular fat (IMF), C16 : 1, C18 : 1 and monounsaturated fatty acids (MUFAs); darker color of meat; and lower cholesterol content, drip loss, C18 : 0, C18 : 2, polyunsaturated fatty acids (PUFAs), n-6 and n-6 : n-3 ratios were found in the LTL muscle of Pulawska pigs compared with Polish Landrace pigs. Meat of Pulawska pigs is especially suitable for the production of good-quality, cured and smoked loin for longer storage. Fat content was higher in barrows than in gilts, and as a consequence the IMF from barrows had higher saturated fatty acid proportions and hypercholesterolemic acids (OFAs) as well as lower C18 : 1 than that from gilts.

1 Introduction

Recent guidelines from the World Health Organization (WHO, 2003) and the Food and Agriculture Organization have emphasized the importance of maintaining a balanced diet to reduce the incidence of various diseases such as obesity, type-2 diabetes, cancer and cardiovascular pathologies. It is thus recommended that total fat should contribute to less than 15–30 % of total energy intake, including precise recommendations concerning saturated fatty acids (SFA), n-6 polyunsaturated fatty acids (PUFAs), n-3 PUFAs, trans fatty acids and cholesterol (Hocquette et al., 2010). Scollan et al. (2006) recommended that the n-6 : n-3 PUFA ratio be limited to 4 : 1. Ulbricht and Southgate (1991) suggested that the ratio of PUFAs to SFAs (P : S) should be at least 0.4 and the atherogenic index lower than 0.5. Consumers are becoming increasingly interested in safe, tasty, healthy and regional-origin meat products produced under eco-friendly, animal-friendly and sustainable (resource-conserving) conditions (Nuernberg et al., 2015).

The fatty acid composition of pig muscle and adipose tissue is affected by several factors, including fatness, body weight (Fischer et al., 2006), age, energy intake and dietary fatty acid composition (Panella-Riera and Neil, 2007; Vaclavkova and Bečkova, 2007; Wasilewski et al., 2011, 2012; Cechova et al., 2012; Mukumbo et al., 2014; Nuernberg et al., 2015). There are also factors connected to gender (Biedermann et al., 2000), de novo synthesis of fatty acids (Leibetseder, 1996) and genetic background (Wood et al., 2004b; Glodek et al., 2004; Kasprzyk, 2007). Deposition and composition of fat are highly heritable and vary among and within breeds (Kasprzyk, 2007). Reducing carcass fatness was one of the major breeding goals in pigs for many years (Furman et al., 2010). Some research has focused on reducing the cholesterol content in meat by dietary modifications; curiously, reducing the fat content of meat can actually in-

crease the cholesterol levels in lean meat (Mandigo, 1991; Parra et al., 2010). Studies on the genetic variability of fatty acid profiles in tissues of livestock, including the pig, are quite limited. In this paper, emphasis was placed on muscle fatty acid composition, because intramuscular fat cannot be removed before consumption and thus inevitably has an impact on human health.

The aim of this study was to determine the fatty acid profile of intramuscular fat for genetically diverse pig breeds.

2 Material and methods

The study was conducted on local Pulawska (an autochthonous Polish breed) and commercial Polish Landrace (PL) breeds kept on farms in the Lublin region. All pigs were maintained at the same environmental and feeding conditions. The fattening was divided into two periods. The composition and nutritive value of mixtures in first period were wheat 42 %, barley 43 %, concentrate 15 %, EM 13 MJ, and crude protein 170 g; in the second period of fattening they were barley 88.5 %, concentrate 11.5 %, EM 12.5 MJ, and crude protein 150 g. The diets were formulated according to the Nutrient Requirements of Swine (Polish Norm of Pig Nutrition, 1993). A total of 40 animals (20 barrows and 20 gilts of each breed) were evaluated for this study. Males were castrated at 5 ± 2 days of age. The fatteners were slaughtered after reaching a live weight of 103–105 kg in 185 days. From the right halves of the carcasses, samples of the *Longissimus thoracis et lumborum* (LTL) between the 5th thoracic vertebra and the 10th lumbar vertebra were used in the analysis. Muscle pH was measured using a portable pH meter equipped with a glass electrode (CPU Star) at 45 min and 24 h post-mortem in fresh samples. Each value was the mean of four random measurements at different points in the loin before slicing. A reflectance spectrophotometer (Minolta CR-310) was used to measure color at the surface of a 2 cm thick steak of LTL muscle (at 24 h post-mortem) exposed to air for 2 h. A 2 cm thick steak was cut from LTL and immediately weighed. The samples were placed on a supporting mesh in a sealed plastic container (with no contact between sample and container). After a storage period of 24 h at chill temperatures (1–4 °C), the samples were taken out of the container, dabbed lightly on filter paper and weighed again. Drip loss was expressed as a percentage of the initial weight, based on Honikel (1998). Meat chemical composition was analyzed according to the procedures of AOAC (2000). Fatty acid composition total lipids of samples were extracted by using chloroform : methanol (2 : 1, v/v) according to the procedure of Folch et al. (1957). The fatty acid composition of intramuscular fat (IMF) was determined using the method described in ISO (2011). The fatty acid methyl esters were analyzed by a gas chromatograph (Varian 450-GC) coupled with a fused silica capillary column (30 m × 0.32 mm, 0.25 µm film thickness). Oven temperature was at 200 °C and carrier gas velocity was 2.5 mL min^{-1}. The injection port was at 250 °C and the detector was maintained at 300 °C. Results were expressed as percentages of the total fatty acid detected based on the total peak area. Cholesterol concentration was determined according to the procedure described by Rhee et al. (1982). The atherogenic index (AI) was calculated as (C12 : 0 + 4 × C14 : 0 + C16 : 0)/(MUFA + PUFA), and the thrombogenicity index (TI) as (C14 : 0 + C16 : 0 + C18 : 0)/(0.5 × MUFA + 0.5 × n-6PUFA + 3 × n-3PUFA + (n-3 PUFA/n-6 PUFA) according to Ulbricht and Southgate (1991).

Analysis of variance was performed using Statistica version 5.0 software. The statistical model used for the calculations was as follows:

$$Y_{ijk} = \mu + B_i + S_j + (B \times S)_{ij} + E_{ijk},$$

in which Y_{ijk} is the target value, μ the mean, B_i the fixed effect of the breed ($i = 1,\ 2$), S_j the fixed effect of the sex ($j = 1,\ 2$), $(B \times S)_{ij}$ the interactions between breed and sex, and E_{ijk} the random error. Data are reported as means ± SD. Differences between the means were tested at 5 and 1 % levels using Duncan's multiple range test.

3 Results

The chemical composition of muscle tissue is shown in Table 1. The Pulawska breed presented higher ($p < 0.01$) pH_1, pH_{24} and total fat content than the PL breed but lower cholesterol content and drip loss. No significant breed or sex differences were found in protein content. Barrows presented higher total fat content ($p < 0.05$) than gilts. A significant ($p < 0.05$) interaction between breed and sex was observed in total fat content. In this work, significant ($p < 0.05$) differences were found in the color of meat between breed. The commercial breed had a higher value L^* than the Pulawska breed. Pork from the PL breed had the highest content of cholesterol. Caloric value and drip loss were significantly different in two groups of fatteners.

Among saturated fatty acids, a higher content of C18 : 0 ($p < 0.01$) was recorded in meat of PL fatteners (Table 2). Within this acid group, among saturated fatty acids the highest values of palmitic acid (25 and 24 %) were observed in Pulawska and PL, respectively. Breed had a significant effect on C16 : 1 ($p < 0.05$), C18 : 1 and C18 : 2 ($p < 0.01$). With respect to sex differences, gilts showed a lower ($p < 0.01$) percentage of C20 : 0 and higher ($p < 0.05$) percentage of C16 : 1 fatty acids. An interaction between breed and sex was observed for C20 : 0 ($p < 0.01$). Unsaturated fatty acids (UFAs) were most common in both sexes, followed by monounsaturated fatty acids (MUFAs) and then SFAs; PUFAs presented the lowest concentration in Pulawska and PL pork (Table 3). In both studied breeds the predominant monounsaturated acid was oleic acid, which amounted to 92 % of all MUFAs. MUFAs was noted significantly higher ($p < 0.01$)

Table 1. The chemical composition of muscle tissue of the Pulawska and PL breeds.

Specification	Pulawska			PL			Effects		
	gilts $\overline{X} \pm$ SD	barrows $\overline{X} \pm$ SD	$\overline{X} \pm$ SD	gilts $\overline{X} \pm$ SD	barrows $\overline{X} \pm$ SD	$\overline{X} \pm$ SD	breed	sex	interaction $B \times S$
pH_1	6.17 ± 0.21	6.12 ± 0.19	6.15 ± 0.20	5.90 ± 0.23	5.85 ± 0.20	5.87 ± 0.21	$^{p} < 0.01$	ns	ns
pH_{24}	5.62 ± 0.05	5.56 ± 0.10	5.59 ± 0.08	5.47 ± 0.10	5.43 ± 0.06	5.45 ± 0.08	$p < 0.01$	ns	ns
Protein (%)	22.58 ± 0.35	22.51 ± 0.30	22.54 ± 0.32	22.59 ± 0.36	22.55 ± 0.33	22.57 ± 0.33	ns	ns	ns
IMF (%)	2.48 ± 0.30	2.68 ± 0.33	2.58 ± 0.32	1.48 ± 0.30	1.71 ± 0.40	1.60 ± 0.36	$p < 0.01$	$p < 0.05$	ns
Cholesterol (mg 100 g^{-1})	56.51 ± 3.75	57.29 ± 4.19	56.90 ± 3.88	58.52 ± 2.58	60.68 ± 3.05	59.60 ± 2.97	$^{p} < 0.05$	ns	ns
Caloric value (kcal 100 g^{-1})	151.02 ± 1.77	152.55 ± 4.73	151.79 ± 3.57	141.63 ± 1.98	143.63 ± 4.41	142.63 ± 3.48	$p < 0.01$	ns	ns
Drip loss (%)	3.64 ± 1.27	3.78 ± 1.26	3.71 ± 1.23	4.94 ± 1.44	4.77 ± 1.63	4.85 ± 1.50	$p < 0.05$	ns	ns
L^*	52.37 ± 1.41	52.53 ± 1.34	52.45 ± 1.34	53.23 ± 1.64	53.62 ± 1.56	53.42 ± 1.57	$p < 0.05$	ns	$p < 0.01$
a^*	3.41 ± 0.58	2.98 ± 0.50	3.19 ± 0.54	4.77 ± 0.61	4.14 ± 0.53	4.46 ± 0.58	$p < 0.01$	$p < 0.05$	ns
b^*	9.64 ± 0.43	9.67 ± 0.35	9.65 ± 0.38	10.42 ± 0.48	10.68 ± 0.39	10.55 ± 0.44	$p < 0.05$	ns	ns

ns: not significant ($p > 0.05$).

Table 2. Fatty acid composition (% of total fatty acids) of muscle tissue of the Pulawska and PL breeds.

Specification	Pulawska			PL			Effects		
	gilts $\overline{X} \pm$ SD	barrows $\overline{X} \pm$ SD	$\overline{X} \pm$ SD	gilts $\overline{X} \pm$ SD	barrows $\overline{X} \pm$ SD	$\overline{X} \pm$ SD	breed	sex	interaction $B \times S$
C10 : 0	0.10 ± 0.01	0.10 ± 0.02	0.10 ± 0.02	0.10 ± 0.01	0.10 ± 0.02	0.10 ± 0.02	ns	ns	ns
C12 : 0	0.18 ± 0.02	0.18 ± 0.02	0.18 ± 0.02	0.19 ± 0.01	0.19 ± 0.01	0.19 ± 0.01	ns	ns	ns
C14 : 0	1.11 ± 0.06	1.16 ± 0.14	1.14 ± 0.11	1.14 ± 0.06	1.10 ± 0.12	1.12 ± 0.10	ns	ns	ns
C16 : 0	23.56 ± 0.38	23.86 ± 0.40	23.71 ± 0.41	23.60 ± 0.44	23.79 ± 0.30	23.69 ± 0.38	ns	ns	ns
C16 : 1	2.99 ± 0.43	2.51 ± 0.41	2.75 ± 0.42	2.51 ± 0.45	2.47 ± 0.40	2.49 ± 0.42	$p < 0.05$	$p < 0.05$	ns
C17 : 0	0.32 ± 0.11	0.31 ± 0.16	0.32 ± 0.13	0.28 ± 0.20	0.37 ± 0.21	0.33 ± 0.20	ns	ns	ns
C17 : 1	0.32 ± 0.02	0.35 ± 0.07	0.34 ± 0.05	0.31 ± 0.07	0.27 ± 0.12	0.29 ± 0.10	ns	ns	ns
C18 : 0	11.94 ± 0.60	11.96 ± 0.46	11.95 ± 0.52	12.25 ± 0.53	12.50 ± 0.33	12.38 ± 0.45	$p < 0.01$	ns	ns
C18 : 1	47.62 ± 0.86	47.37 ± 0.88	47.50 ± 0.86	46.75 ± 0.93	46.39 ± 1.38	46.57 ± 1.16	$p < 0.01$	ns	ns
C18 : 2	8.60 ± 0.37	8.83 ± 0.51	8.72 ± 0.45	9.69 ± 0.67	9.86 ± 0.81	9.77 ± 0.73	$p < 0.01$	ns	ns
C18 : 3 n-6	0.08 ± 0.06	0.06 ± 0.02	0.07 ± 0.04	0.06 ± 0.02	0.05 ± 0.03	0.05 ± 0.02	ns	ns	ns
C18 : 3 n-3	0.77 ± 0.16	0.80 ± 0.16	0.78 ± 0.15	0.69 ± 0.15	0.72 ± 0.13	0.70 ± 0.14	ns	ns	ns
C20 : 0	0.10 ± 0.01	0.15 ± 0.02	0.13 ± 0.02	0.12 ± 0.02	0.12 ± 0.02	0.12 ± 0.02	ns	$p < 0.01$	$p < 0.01$
C20 : 1	0.77 ± 0.07	0.78 ± 0.08	0.77 ± 0.07	0.75 ± 0.03	0.75 ± 0.08	0.75 ± 0.06	ns	ns	ns
C20 : 2	0.55 ± 0.05	0.52 ± 0.03	0.53 ± 0.04	0.53 ± 0.04	0.53 ± 0.05	0.53 ± 0.05	ns	ns	ns
C20 : 4	0.72 ± 0.29	0.60 ± 0.22	0.66 ± 0.26	0.65 ± 0.31	0.59 ± 0.29	0.62 ± 0.29	ns	ns	ns
C21 : 0	0.21 ± 0.11	0.33 ± 0.31	0.27 ± 0.24	0.17 ± 0.23	0.23 ± 0.24	0.20 ± 0.24	ns	ns	ns
C22 : 1	0.10 ± 0.02	0.09 ± 0.02	0.10 ± 0.02	0.09 ± 0.02	0.10 ± 0.02	0.10 ± 0.02	ns	ns	ns

ns: not significant ($p > 0.05$).

in intramuscular fat of the Pulawska breed. PL fatteners had the highest ($p < 0.01$) PUFA and n-6 fatty acid content. SFAs and OFAs as well as UFA : SFA, MUFA : SFA and DFA : OFA ratios significantly differed by sex. The value of n-6 : n-3 ratio was significantly lower in Pulawska pigs than it was in PL. Meat of both breeds was characterized by a relatively favorable atherogenic index. The average indices of atherogenicity and thrombogenicity of LTL muscle samples did not differ significantly ($p < 0.05$).

4 Discussion

The tested genotypes differed in pH_1, pH_{24}, content of intramuscular fat and caloric value due to large differences between native and more improved breeds. High variability among breeds has been demonstrated for pH_1 by our study, although Franci et al. (2005) found no differences between Cinta Senese and Large White pigs. PL fattening pigs showed a lower pH_1 and pH_{24}. These values could suggest that these pigs experienced great pre-slaughter stress. The pH_{24} value of the PL breed was consistent with the results reported by Yu et al. (2013) in Landrace pigs. The parameter pH_{24} was higher in Pulawska than in PL pigs. Several authors (Franci et al., 2005; Teixeira and Rodrigues, 2013; Yu et al., 2013) have observed pH_{24} values higher in local breeds than in selected genetic types, suggesting that local breeds could have slower rates of post-mortem pH decline. Results for pH_{24} obtained in the present study for Pulawska pigs are in agree-

Table 3. Fatty acid groups (% of total fatty acids) of muscle tissue of the Pulawska and PL breeds.

Specification	Pulawska			PL			Effects		
	gilts $\overline{X} \pm$ SD	barrows $\overline{X} \pm$ SD	$\overline{X} \pm$ SD	gilts $\overline{X} \pm$ SD	barrows $\overline{X} \pm$ SD	$\overline{X} \pm$ SD	breed	sex	interaction $B \times S$
SFA	37.53 ± 0.69	38.05 ± 0.63	37.79 ± 0.69	37.85 ± 0.64	38.40 ± 0.85	38.13 ± 0.78	ns	$p < 0.05$	ns
UFA	62.53 ± 0.89	61.91 ± 0.75	62.22 ± 0.86	62.02 ± 0.81	61.72 ± 0.94	61.87 ± 0.87	ns	ns	ns
MUFA	51.80 ± 0.77	51.10 ± 0.87	51.45 ± 0.88	50.41 ± 0.84	49.98 ± 1.10	50.19 ± 0.98	$p < 0.01$	ns	ns
PUFA	10.72 ± 0.61	10.81 ± 0.45	10.77 ± 0.52	11.61 ± 0.70	11.74 ± 0.79	11.68 ± 0.73	$p < 0.01$	ns	ns
DFA	74.46 ± 0.53	73.88 ± 0.60	74.17 ± 0.63	74.27 ± 0.82	74.22 ± 0.74	74.25 ± 0.76	ns	ns	ns
OFA	25.60 ± 0.39	26.09 ± 0.61	25.84 ± 0.56	25.60 ± 0.69	25.90 ± 0.58	25.75 ± 0.64	ns	$p < 0.05$	ns
UFA : SFA	1.67 ± 0.05	1.63 ± 0.05	1.65 ± 0.05	1.64 ± 0.05	1.61 ± 0.06	1.62 ± 0.05	ns	$p < 0.05$	ns
MUFA : SFA	1.38 ± 0.04	1.34 ± 0.04	1.36 ± 0.04	1.33 ± 0.04	1.30 ± 0.05	1.32 ± 0.05	$p < 0.01$	$p < 0.05$	ns
PUFA : MUFA	0.21 ± 0.01	0.21 ± 0.01	0.21 ± 0.01	0.23 ± 0.01	0.24 ± 0.02	0.24 ± 0.02	$p < 0.01$	ns	ns
DFA : OFA	2.91 ± 0.06	2.83 ± 0.09	2.87 ± 0.08	2.90 ± 0.10	2.87 ± 0.08	2.89 ± 0.09	ns	$p < 0.05$	ns
n-6	9.41 ± 0.56	9.49 ± 0.47	9.45 ± 0.51	10.40 ± 0.72	10.49 ± 0.82	10.45 ± 0.75	$p < 0.01$	ns	ns
n-6 : n-3	12.75 ± 3.19	12.61 ± 3.81	12.68 ± 3.42	15.96 ± 4.27	15.26 ± 3.83	15.61 ± 3.96	$p < 0.05$	ns	ns
TI	1.11 ± 0.03	1.13 ± 0.03	1.12 ± 0.03	1.14 ± 0.03	1.15 ± 0.03	1.14 ± 0.03	ns	ns	ns
AI	0.46 ± 0.01	0.47 ± 0.02	0.46 ± 0.02	0.46 ± 0.01	0.46 ± 0.02	0.46 ± 0.02	ns	ns	ns

ns: not significant ($p > 0.05$); SFA: saturated fatty acids' sum; UFA: unsaturated fatty acids' sum; MUFA: monounsaturated fatty acids' sum; PUFA: polyunsaturated fatty acids' sum; DFA: hypocholesterolemic acids; OFA: hypercholesterolemic acids; TI: thrombogenicity index; AI: atherogenic index.

ment with investigations performed on autochthonous pigs by Poto et al. (2007). Also, results for pH_{24} obtained in the present study for the PL breed are in agreement with the findings of Yu et al. (2013) in Landrace pigs.

The IMF levels found in the Pulawska breed can be considered appropriate for the sale of fresh meat. The ideal concentration of IMF has been estimated to be between 2 and 3 %. Fernandez et al. (1999) indicated that levels over 3.5 % are associated with a significant risk of meat being rejected by consumers (referring to fresh meat). Results for IMF obtained in the present study for Pulawska pigs are in agreement with investigations performed on autochthonous pigs by Galián et al. (2008) and Yu et al. (2013). In the study of Poto et al. (2007), purebred Chato Murciano (CH) pigs and Chato Murciano crossed with Iberian (IN) pigs (CH × IN) reared outdoors showed the content of IMF at levels of 10.47 and 8.97 % for CH and CH × IN, respectively. Results of fat content of loin of PL pigs, i.e., 1.60 %, are compatible with the results shown by Tyra and Żak (2010), who reported that the mean fat content in loin of Polish Landrace pigs was 1.76 %. This parameter was below the level acceptable for good-quality meat.

Some research has focused on reducing the cholesterol content in meat through dietary modifications. Consumers are becoming increasingly critical about the food they eat. Nowadays consumers choose low-fat and low-cholesterol products. There is a strong belief in society that cholesterol is responsible for many diseases in humans. Cholesterol content was higher ($p < 0.05$) in the meat of PL than Pulawska pigs.

The rate of post-mortem pH fall is an important determinant of water-holding capacity and color. An abnormally rapid rate of post-mortem glycolysis (initial pH ≤ 6.0) in the muscles produces poor-quality pork (pale, soft and exudative meat) (Galián et al., 2008). In our study the percent drip loss of pork decreases along with increasing pH. Higher pH is associated with better water-holding capacity and darker color (Tomović et al., 2014). The level of drip loss was higher in PL fatteners. Low pH_{24} values probably influenced these losses. Some authors (Franci et al., 2005; Galián et al., 2008; Franco et al., 2014) have reported that traditional breeds are characterized by lower drip loss during the storage than modern breeds. Yu et al. (2013) measured drip loss in *Longissimus dorsi* muscle of Landrace and Lantang pigs and found that there was no significant difference between the two breeds. The high ultimate pH alters the light absorption characteristics of the myoglobin, with the meat surfaces becoming a darker red (Winkler, 1939). Such meat will also appear dark because its surface does not scatter light to the same extent as the more open surface of meat with lower pH_u (Tomović et al., 2014). The commercial breed had a higher value L^* than the Pulawska breed ($p < 0.05$). Meat of Pulawska pigs was more intensely colored than PL meat because of the greater red contribution, in agreement with the results of Franci et al. (2005), where meat of Italian local breeds was more red than that of Large White pigs. According to Yu et al. (2013), the L^* values were higher in Lantang LD muscle (48.94 vs. 45.79 in Landrace; $p < 0.01$). Tomović et al. (2014) found lower values for L^* in the local breed Swallow-belly Mangulica pigs.

Apart from nutritional aspects, IMF influences meat tenderness and flavor, while the profile of fatty acids influences the color and firmness of fat (Maw et al., 2003). Fatty acid composition is an important factor in the nutritional quality of meat and adipose tissue and as such has long been a subject of study in meat science receiving considerable attention due to its important role in human health (Furman et al., 2010). For these reasons, the proper composition of fatty

acids in meat and fat has become an important issue from the standpoint of consumers, nutritionists, and food technologists (Nuernberg et al., 2015). Fatty acid composition is influenced by genetic factors, including breed differences. The most significant differences ($p < 0.01$) were observed in the percentage of C18 : 0, C18 : 1, C18 : 2 and C16 : 1 ($p < 0.05$). Gilts showed a higher ($p < 0.05$) percentage of C16 : 1 and a lower ($p < 0.01$) percentage of C20 : 0 fatty acids. Teixeira et al. (2013), examining sex differences, found that the females showed a higher ($p < 0.05$) percentage of C16 : 0 and C18 : 1 fatty acids than males. Statistically, the SFAs of the LTL muscle did not differ between the two groups, but PL pork had a higher SFA content. Significant differences were observed between examined breeds in regard to stearic acid (C18 : 0) content. In barrows the level of SFA was significantly higher ($p < 0.05$) than in gilts. A higher concentration of SFA in loin fat of barrows in comparison to gilts was also found by Tuz et al. (2004); however, the results of research carried out by Teixeira et al. (2013) indicate that the SFA level in the loin of gilts was higher than the SFA level in boars. Although stearic acid is considered a neutral fatty acid, excessive intake of SFAs has been considered as the one out of many other factors for cancer and coronary heart disease (Webb and O'Neill, 2008). Regarding the SFA series, even if saturated fatty acids sensu lato are involved in atherogenic and thrombogenic processes, not all of them express the same behavior as regards the increase in serum cholesterol. Among the SFAs, lauric (C12 : 0), myristic (C14 : 0) and palmitic (C16 : 0) acids increased plasma cholesterol concentration (Ulbricht and Southgate, 1991). Furthermore, C14 : 0 was considered to have the most harmful cardiovascular effect on humans, the effect being almost 4 times the effect of C12 : 0 and C16 : 0 (Hegsted et al., 1959). Palmitic and stearic acids predominant in the saturated fatty acids group in animal fat. A large share of animal fat in the human diet is considered to be one of the factors causing cardiovascular diseases (Lin et al., 2004). We do not support this opinion, because intramuscular fat is very important for the consumer, as it contains a significant quantity of phospholipids (Demirel et al., 2004) that are rich in polyunsaturated fatty acids and for which bioactive properties are well recognized (Wood et al., 2008). Phospholipids are essential components of cell membranes, and their amount remains fairly constant (Wood et al., 2008). It was reported that intramuscular fat of Duroc pigs had higher concentrations of SFAs and MUFAs and lower concentrations of PUFAs than Landrace (Cameron and Enser, 1991). The levels of fatty acids found in the Pulawska breed correspond to those from traditional breeds noted by Galián et al. (2008), with low PUFA and high MUFA levels. According to Wood et al. (2004a), the proportion of linoleic acid is higher in lean than in fatter pigs, which explains the highest concentration of C18 : 2 n-6 in LTL of PL pigs noted by us. However, Yu et al. (2013) found a significantly lower MUFA percentage in Lantang than in Landrace pigs. In animals with less fat, a higher level of PUFAs (among which C18 : 2 n-6 dominates, and which is contained in phospholipids) and MUFAs is observed (Wood et al., 2008). In animals with less fat due to the ratio of phospholipids to neutral lipids, the proportion of oleic acid in IMF should be smaller, and a greater quantity of acid occurs in the phospholipids (Wood et al., 2008). Similar relations were noticed in our study. PL pigs had the highest concentration of total PUFAs, mainly due to a high content of linoleic acid (10 %). Galián et al. (2008) pointed out that the PUFA levels should not be higher than 12–14 % in meat destined to become processed products. The PUFA levels found, below the 15 % level established by Warnants et al. (1996), are advisable for minimizing undesirable effects of oxidation and rancidity (Wood et al., 2004b; Zhang et al., 2009). The polyunsaturated fatty acids and monounsaturated fatty acids play a role in decreasing the blood LDL-cholesterol concentration by increasing hepatic LDL receptor activity (Rudel et al., 1995). Cameron et al. (2000) showed that C18 : 2, C20 : 4 and C22 : 6 polyunsaturated fatty acids had a positive correlation with flavor of meat.

It is recommended that the PUFA : SFA ratio be above 0.4. In both of the analyzed breeds (Pulawska and PL), however, this ratio in intramuscular and visceral fat was below 0.4, averaging 0.28 and 0.31, respectively. The n-6 : n-3 fatty acid ratio is important due to its influence on human health. The recommended n-6 : n-3 ratio should be less than 4 (Wood et al., 2004b). This study showed that the Pulawska breed had lower n-6 : n-3 ratios of PUFAs in LTL by 1.23 % ($P < 0.05$) than the PL breed.

Lipid quality indicators that depend on the relative content of particular groups of fatty acids are the atherogenic index and thrombogenicity index. These indices indicate the global dietetic quality of lipids and their potential effects on the development of coronary disease (Jankowska et al., 2010). TI ranged from 1.12 to 1.14, while the mean value of AI was 0.46. The values in our study were consistent with the results reported by Franci et al. (2005) for Cinta Senese, Large White and Large White × Cinta Senese pigs. Higher values were noted for TI and AI in the study of Mukumbo et al. (2014) of Large White × Landrace gilts, but Matassino et al. (2008) found lower values in the Casertana breed.

In conclusion, breed exhibited a significant effect on the fatty acid profile of the LTL of pigs. Higher contents of IMF, C16 : 1, C18 : 1 and MUFAs; darker color of meat; and lower cholesterol content and drip loss were found in the LTL muscle of Pulawska pigs compared with Polish Landrace pigs. Meat of Pulawska pigs is especially suitable for the production of good-quality, cured and smoked loin for longer storage. Meat of both breeds was characterized by a relatively favorable atherogenic index.

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