Fatty Acids Profile from *Longissimus Dorsi* Muscle in Local Swine Breeds Bazna and Mangalitsa

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Abstract
The Bazna and red Mangalitsa native swine breeds are known for their resistance to extensive farming. Worldwide, there is a high interest in analysing swine meat regarding the fatty acids profile for obtaining healthier food. Healthier meat has a higher ratio of polyunsaturated fatty acids to saturated fatty acids and a favourable balance between n-6 and n-3 PUFA (polyunsaturated fatty acids). The objective of this study is to determine the meat quality, more precisely the fatty acids composition content in *longissimus dorsi* muscle from two indigenous swine breeds, Bazna and red Mangalitsa. The biological material subjected to qualitative determination was represented by *longissimus dorsi* muscle samples collected from two experimental groups where we had both males and females with a body weight of over 90 kg, the difference between the groups consisted in breeds, the feed mixtures being the same. The samples obtained were analysed by gas chromatography. The concentration of polyunsaturated fatty acids is higher in the case of the red Mangalitsa breed (4.56 %). A higher distribution of monounsaturated fatty acids in Bazna breed was revealed (51.56 %). The main fatty acids were palmitic and stearic from the saturated category, respectively oleic from the unsaturated category. Our results suggest that the breed has a positive influence on the level of intramuscular fatty acids.

Keywords: Bazna, fatty acids, *longissimus dorsi*, Mangalitsa, pork quality

1. Introduction

Worldwide, in order to be able to offer meat at a reasonable price and quality, intensive breeding system is needed [1]. For a long period of time, there has been a growing interest among producers and consumers in improving meat quality. Fatty acid composition has a significant impact on meat quality, not only in terms of flavour, but also in terms of nutritional value. Given the quality parameters of pork, the interest is constantly growing. Tasty and healthy products of local origin are in high demand by consumers [2]. The World Health Organization (WHO, 2003) provided new guidelines emphasizing the importance of eating a well-balanced diet in preventing diseases like obesity, cancer, type-2 diabetes, and cardiovascular disease. Local pig breeds are an extremely important resource for returning to ancestral forms, thus having diversity in this continuous ultra-specialization [3]. Several factors can change the composition of fat deposits, including muscle type and muscle location, breed, sex, and diet [4]. The performance of swine represented by the growth rate, the efficiency of feed conversion and the low-fat content of the carcasses have been improved in the native breeds by intensive selection [5]. However, intensive selection has led to various negative side effects, including lower resistance of the body to various swine diseases and poor meat quality, as the intramuscular fat content of pork must be greater

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than 2% [6]. On the European continent there are small populations belonging to the cross-border breed Mangalitsa (in Austria, Germany, Romania, Serbia and Hungary), or the local breeds Turopolje (in Croatia) and Bazna (in Romania) [7]. Red Mangalitsa is descended directly from wild boar and is a rustic breed of swine from Carpathian Basin (based in Hungary and Romania) [8]. Bazna is a breed native to Romania, formed in 1872 from a crossing between Mangalitsa sows with Berkshire boars [9]. Genetic factors such as breed, sex, and halothane genotype, as well as environmental factors such as diet, have a significant influence on the fatty acid profile of intramuscular fat (IMF) in swine [10]. In order to obtain premium quality pork and to satisfy the requirements of the consumers, the essential sensory quality on which you must pay special attention is the intramuscular fat or the marbling [11]. The amount of intramuscular fat (IMF) influences the profile of fatty acids [12]. For health and economic reasons, improving the quality of fatty acids is of major interest to nutrition, growth and genetics [11]. Because the quality of the meat has a multifactorial background, it can be associated with both monogenic and polygenic effects, the differences between breeds include various effects on it [13, 14]. Fats and more specifically fatty acids are important due to the fact that their effects work direct on human health [15]. Fatty acid metabolism, cell proliferation and differentiation are traits regulated by several genes that are directly or indirectly involved [12]. The composition of fatty acids and the total amount of saturated fatty acids (SFA) are a food risk factor, being related to coronary heart disease and increase cholesterol and triglyceride content in the blood [15]. In terms of human health, it is known that polyunsaturated fatty acids (PUFA) and monounsaturated fatty acids (MUFA), have a beneficial influence, lowering cholesterol levels and improving the immune system [16]. A high percentage of oleic acid (C18:1 n-9) from monounsaturated fatty acids (MUFA) is required, as they are less sensitive to oxidation and have a positive effect on the level of cholesterol in human blood [17].

2. Materials and methods

Animal management

The biological material subjected to qualitative determination was represented by *longissimus dorsi* muscle samples collected from two experimental batches consisting of six swine per group raised at Agricultural Research and Development Station Turda (ARDS Turda) where we had both males and females with a body weight of over 90 kg, the difference between the groups consisted in breeds: Bazna and red Mangalitsa, the feed mixtures being the same.

Samples obtained

The working method consisted of cutting 10 g of finely ground meat, grinding it with 25 ml of hexane, the meat mixture was placed in 50 ml bottles. The samples were stirred on the shaker for two hours at 25 ° C. The mixture was centrifuged at 7000 rpm for five minutes 0.3 ml extract + 0.8 ml derivatization mixture. It was heated at 80°C for one h. It was extracted twice with 0.5 ml of heptane. All tests were performed in triplicate.

Samples analysis

The obtained samples were analysed on a Shimadzu gas chromatograph (Shimadzu, Kyoto, Japan) with triple quadrupole coupled with mass spectrometer (TQ 8040). The DB-1 capillary column (30 m long; 0.25 mm i.d.; 0.25 μm) was used. The carrier gas used was helium at a flow rate of 0.93 l x min^{-1}. The temperature program started from 1500, for 2 min, followed by an increase of 100 / min to 2000 maintained for 2 min, followed by an increase of 30 / min to 2200, maintained for 3 min, followed by an increase with 30 / min up to 2400, maintained 5 min. The total program lasted 30-33 min.

Results analysis

Statistical analysis of the results was performed by the t test, using GraphPad Prism 9 software.

The obtained data for the chromatographic determinations allowed the calculation of the content of each fatty acid in the meat samples subjected to the analysis.

The fatty acids determined were:

C12:0 Lauric acid
C14:0 Myristic acid
C14:1 Myristoleic acid
C16:0 Palmitic acid
C16:1 n-9 Hexadecenoic palmitoleic acid
C16:1 n-7 Palmitoleic acid
C17:0 Heptadecanoic acid

C17:1 Heptadecenoic acid
C18:0 Stearic acid
C18:1 n-9 Oleic acid
C18:1 n-7 Vaccenic acid
C18:2 Linoleic acid
C20:0 Arachidic acid
C20:1 n-9 Gondonic acid
C20:3 n-3 Eicosatrienolic acid
C20:4 n-6 Arachidonic acid
C22:0 Behenic acid

3. Results and discussion

Interpretation of the results of chromatographic determinations (Figures 1 and 2) allowed the calculation of the fatty acid content of the meat samples subjected to analysis.

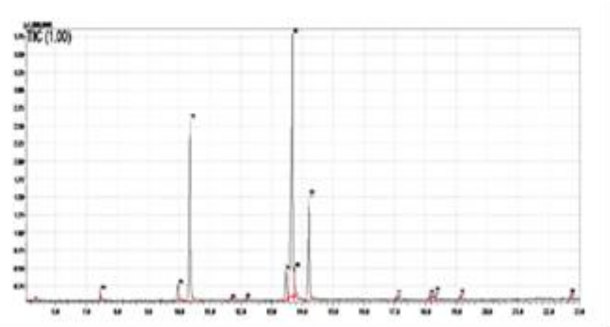

Figure 1. Chromatogram of the meat sample (*Longissimus dorsi*) at Bazna

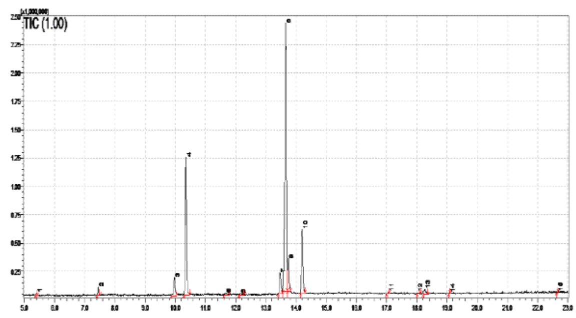

Figure 2. Chromatogram of the meat sample (*Longissimus dorsi*) at red Mangalitsa

The proportions of fatty acids determined from the samples taken from Bazna and red Mangalitsa are presented in table 1. We have noticed that the main fatty acids detected are palmitic and stearic in the category of saturated and oleic of unsaturated (Table 1). The distribution of linoleic acid is approximately similar in these two breeds with a small plus (+0.63%) for the red Mangalitsa compared to 3.37% at Bazna (Table 1). Lower amounts of saturated fatty acids (SFA) were observed in the case of C12:0 (0.14%), C12:0 (1.13%), C20:0 (0.27%) and C22:0 (0.07%) (Table 1). In the case of unsaturated fatty acids (UFA), small amounts of C14:1 (0.07 %), C16:1 n-7 (3.09%), C18:1 n-7 (4.00%), C18:2 (3.37%), C20:1 n-9 (0.71%), C20:3 n-3 (0.17%) and C20:4 n-6 (0.30%) have been observed (Table 1). The largest percentage of total lipids is C18:1 n-9 (41.85%) at Bazna and (35.21%) red Mangalitsa, followed by C16:0 (28.95%) at red Mangalitsa and (26.19%) Bazna (Table 1). Almost similar values were observed at C14:0, C17:1, C20:0, C20:3 n-3 and C22:0 (Table 1).

Table 1. The proportions of fatty acids obtained from *longissimus dorsi* at Bazna and red Mangalitsa (%)

Fatty acids	N	Bazna		Red Mangalitsa	
		$\overline{X}$	*SD*	$\overline{X}$	*SD*
C12:0	6	0.14	0.05	0.27	0.11
C14:0	6	1.13	0.13	1.23	0.13
C14:1	6	0.07	0.04	0.09	0.02
C16:0	6	26.19	0.39	28.95	0.88
C16:1 n-9	6	0.23	0.11	0.12	0.03
C16:1 n-7	6	3.49	0.53	3.09	0.61
C17:0	6	0.15	0.04	0.21	0.10
C17:1	6	0.19	0.04	0.22	0.10
C18:0	6	16.62	0.45	21.02	4.00
C18:1 n-9	6	41.85	1.59	35.21	4.61
C18:1 n-7	6	4.78	0.61	4.00	0.88
C18:2	6	3.37	0.92	4.00	1.07
C20:0	6	0.27	0.04	0.27	0.05
C20:1 n-9	6	1.01	0.12	0.71	0.14
C20:3 n-3	6	0.17	0.04	0.20	0.05
C20:4 n-6	6	0.30	0.03	0.36	0.07
C22:0	6	0.07	0.01	0.07	0.04

$\overline{X}$ means average value; SD means standard deviation

Regarding the distribution of saturated and unsaturated fatty acids, respectively the weights of monounsaturated and polyunsaturated fatty acids in these two breeds, the statistical values calculated are presented in Table 2.

The average value of saturated fatty acids was about 7.5% higher at the red Mangalitsa breed compared to the Bazna breed (Table 2). This difference is due to the much higher proportion of stearic fatty acid (21.02%) in the red Mangalitsa breed compared to the Bazna breed (16.62%). Palmitic fatty acid values are similar (28.95% at red Mangalitsa, 26.19% at Bazna) (Table 1).

Table 2. Total saturated, unsaturated, monounsaturated, polyunsaturated fatty acids (%) and fatty acid ratios in *longissimus dorsi* at Bazna and red Mangalitsa

	N	Bazna		Red Mangalitsa	
		$\overline{X}$	*SD*	$\overline{X}$	*SD*
SFA	6	44.55	0.82	52.01	4.99
UFA	6	55.45	0.82	47.99	4.99
MUFA	6	51.61	0.33	43.43	6.10
PUFA	6	3.84	0.97	4.56	1.15
P/S	6	0.09	2.07	0.09	0.52
n-6/n-3	6	1.72	0.69	1.84	1.37

$\overline{X}$ means average value; SD means standard deviation; SFA = sum of all identified saturated fatty acids; UFA = sum of all identified unsaturated fatty acids; MUFA = sum of all identified monounsaturated fatty acids; PUFA = sum of all identified polyunsaturated fatty acids; P/S = ratio of sum PUFA to sum SFA; n-6/n-3 = ratio of sum n-6 PUFA to sum n-3 PUFA

The average value of unsaturated fatty acids was about 7.5% higher in the Bazna breed (55.45%) compared to the red Mangalitsa breed (47.99%) (Table 2). This difference is due to the much higher distribution of oleic fatty acid (41.85% > 35.21%) in the Bazna breed (Table 1). Comparative values were reported by Hollo et al. [18] for blond Mangalitsa meat in *Longissimus dorsi* where the amount of UFA was 68.97%. The results obtained in our study are comparable to those reported for Serrano ham and Teruel ham from Spain (57.41 - 59.06%) [19]. Razmaite V. et al. [6] obtained a value of 61% at Lithuanian white pigs. In the Pulawaska pig breed was obtained the value of 60.39% [5].

Polyunsaturated fatty acids (PUFA) are essential dietary supplements components. From the analysis of the values presented in the Table 2 it is observed that the highest amount of polyunsaturated fatty acids (PUFA) is in the red Mangalitsa breeds (4.56%) (Table 2). Different values were obtained in similar studies [20] conducted on the Mangalitsa breed because in addition to the breed, a number of other factors influence the quality of the meat, such as diet, environmental conditions or the meat sample analysed [21].

In order to have a healthy diet, higher than 0.4% of the P/S ratio (PUFA / SFA) value is recommended [18]. The obtained percentage in this research was 0.09% in both breeds. Comparable values were obtained for the Pietrain breed 0.41% [15]. For the Celta pig breed, in the case of the three lines, the following values were obtained: Barcina (0.18%), Carballina (0.19%) and Santiaguesa (0.24%) [12].

The percentage of Omega fatty acids is another indicator of meat quality, and the most important is Omega 3 and 6. For the prevention of heart disease, good brain development and in the treatment of other autoimmune diseases the most important are the Omega 3 type [22]. There is no recommended daily dose of Omega 3, however the n-6 / n-3 ratio is an important indicator of food quality and more accurate meat quality. The values obtained in our experiment are 1.72% at Bazna breed and 1.84% at red Mangalitsa breed. Regarding the n-6 / n-3 ratio, it is much more influenced by diet than by genetics [23].

Table 3. Significance of differences between comparisons of mean fatty acids values (test t)

Bazna vs Red Mangalitsa	Averages difference	P-value	Significance threshold
SFA	-7.45 ± 2.07	0.0047	**
MUFA	8.18 ± 2.50	0.0083	**
PUFA	-0.71 ± 0.61	0.2712	ns

SFA = sum of all identified saturated fatty acids; MUFA = sum of all identified monounsaturated fatty acids; PUFA = sum of all identified polyunsaturated fatty acids; ** $P \le 0.01$; NS = no significant difference; ($P > 0.05$);

Regarding the statistical differences obtained, we have a significant difference (** $P \le 0.01$) in the percentage of saturated fatty acids between these two breeds, P-value = $0.0047 \le 0.01$ (Table 3). The statistical value of 0.0083 (** $P \le 0.01$) obtained in the case of monounsaturated acids indicates a significant difference between the two breeds Bazna and red Mangalitsa. The significant differences between the two types of fatty acids reveals, that the genotype can influence the proportion of saturated and monounsaturated fatty acids. However, in the case of polyunsaturated acids, there is no significant difference, P-value = 0.2712 > 0.05 (table 3).

4. Conclusions

Our results suggest that the breed has a positive influence on the level of intramuscular fatty acids.
This study provided results of inter-breed variability of the main meat quality traits based on data of two Romanian native pig breeds (Bazna and red Mangalitsa) raised under the same experimental conditions.
However, in order to determine intra-breed variability in terms of the influence of feed on the fatty acids profile of meat further studies are needed.

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