Study of Fatty Acids Composition of Muscle and Adipose Tissues from Mangalitsa Breed

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Abstract

In the past, consumers preferred well marbled meat, very rich in intramuscular fat, which was very important in preparation of grilled meat from the Anglo-Saxon areas.

The lower content of saturated fatty acids and the higher proportion of unsaturated fatty acids are advantageous especially for human nutrition. Due to the ratio between linoleic and linolenic acids, the oxidation capacity is lower, which reduces the risk of rancidity.

Slaughtering the pigs at a lower weight (90-115 kg) is reducing the fat content of the meat and it's having a significant impact on the protein content from gammon and ham, as well as on the fatty acids composition.

Comparing the composition in fatty acids from back and belly fat, back fat contained more saturated fatty acids and les monounsaturated fatty acids. Stearic acid content which determines fat hardness was higher in back fat.

Keywords: acid, content, fat, meat

1. Introduction

Historically, consumers have exhibited a preference for meat with a high intramuscular fat content [1, 2], which was of particular importance in the preparation of steak among those of Anglo-Saxon descent. The effects of intramuscular fat on meat quality can be summarized as follows: it reduces dripping and cooking losses, improves doneness and juiciness [3]. The targeted breeding of pigs, which commenced in the 1960s, has yielded remarkable outcomes in the enhancement of their lean meat content. This has resulted in the eradication of pig breeds with diminished reproductive capacity, slower growth rates, and inferior feed conversion efficiency [4].

However, the selection for increased amounts of colored meat has been associated with alterations in muscle fiber types in pigs, including an increase in the proportion of glycolytic muscle fibers and in the average muscle fiber diameter, which contributes to the development of the PSE trait. Conversely, the reduction in intramuscular fat content has had a detrimental impact on the organoleptic properties and sensory value of the meat [5].

Presently, research in numerous countries is concentrated on augmenting the intramuscular fat content and producing premium-quality bacon. To achieve this objective, the utilization of "traditional" breeds, including Duroc, Tamworth, Berkshire, Large Black, and Meishan, in crossbreeding procedures is proposed.

Additionally, recent years have seen the emergence of new insights into the quality of Hungarian Mangalitsa pork, particularly regarding its fat. These findings suggest that Mangalitsa meat is well-suited to produce dried products and for use in barbecue.

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Consequently, the Mangalitsa has gained popularity not only in Hungary but also in Spain (where it is known as the Serano pig), Switzerland, Austria, and Germany. Furthermore, there is a growing interest in traditional, indigenous animal species that highlight local specialties in product manufacturing. These species utilize region-specific raw materials and possess unique properties that are integral to the product's identity [6] posits that this presents a significant opportunity for the future of the Mangalitsa breed in Hungary. There is a strong possibility that it could serve as a foundation for the globalization of agriculture in the country.

2. Materials and methods

In this study, 10 Mangalitsa pigs were slaughtered at the abattoir. The animals, which were fed with a mixed grain-based feed (maize, wheat, barley) supplemented with potatoes (winter) and green fodder (summer) depending on the season., were divided into two groups according to the warm carcass weight (group I 91 kg, group II 114 kg). The time interval between slaughter and sample collection was one hour. The post-mortem time point at which measurements were taken was 24 hours.

The pigs were graded after slaughter using a probe meter (FAT-O-MEATER).

During slaughter, pH and meat color were measured in the dorsal long muscle. The pH has been measured direct by inserting a sensor into the meat for obtaining accuracy of the results. This is based on a polymer reference system which helps having the correct results.

The color measurements were carried out with a Minolta CR 200.

During the dissection of the pig half-carcasses, samples were taken from the left half-carcass between ribs 11 and 12 (dorsal vertebrae), from the loin (L.L.D.) and from the ham (musculus semimembranosus, abbreviated as M.SM.) and from the back fat, and from the ventral fat of the heavier animals in group II. Laboratory analysis (chemical composition) and determination of fatty acid composition of muscle and fat samples were carried out in the analytical laboratory of the Institute of Macromolecular Chemistry, Petru Poni, from Iaşi. The fatty acid composition was determined in the laboratory. The results for unknown samples were expressed as relative weight percentage of fatty acid methyl esters.

Intramuscular fat content was determined using Soxhlet method, while fatty acid composition was assessed through gas chromatography (GC) following chloroform/methanol extraction, saponification, and methylation. Results were expressed as relative percentages of methyl esters. Statistical analysis was carried out using SPSS 10.0, employing one-way ANOVA and Student's t-test, with significance set at $p<0.05$.

3. Results and discussion

In the present study, as shown in Table 1, instead of the recommended slaughter weight of 130-150 kg for Mangalitsa, the animals were slaughtered at a lower live weight of 90 kg (group I) and 110 kg (group II), respectively. The percentage of lean meat estimated by routine grading (FAT-O-MEATER) was about 38% for both groups, typical for the breed. However, there was a significant difference in mean bacon thickness and hip diameter (m. l. d.). Mean bacon thickness was 4.8 cm in pigs slaughtered at a lower live weight and 7.0 cm in pigs slaughtered at a higher live weight. Smaller, but significant, differences were also found in the diameter m.l.d. (group I: 4.8 cm, group II: 5.4 cm).

The data in Table 1 show that, with increasing slaughter weight, protein and fat content decreased and increased for both muscles tested. However, the differences are not significant for protein content in M.SM. However, it is noteworthy that, in comparison with literature data, the fat content of meat from other breeds with long tradition, e.g. Iberian is lower (2.5-4%) than that of Mangalitsa in both muscles (m. l. d., m.sm.).

The chemical composition of the two indicator muscles, which are leg and ham, also differ. The water and ash content of the leg muscle is lower, while the fat content is significantly higher than that of the ham muscle. However, there is no significant difference in protein content between the two muscles and no statistically proven difference when comparing the two groups. An important physio-chemical property from the point of view of the processing industry is the water-to-protein ratio, which, according to [7], is lower in both muscles than in currently widely bred pig breeds and hybrids. Table 2 shows the fatty acid

composition of m. longissimus dorsi and Table 3 shows the fatty acid composition of m. semimembranosus.
The results obtained show that there was a significant difference between the two groups in the proportion of 8 fatty acids in the m. longissimus dorsi (m. l. d.), whereas in the m. semi membranous, representing the ham, there was a difference of only 5 fatty acids significantly. Both muscles showed significant differences in the proportion of myristic acid (C 14:0) and linolenic acid (C 18:3 n-3). However, according to the literature, the predominant proportion of fatty acids in both meat samples was palmitic acid (C 16:0), stearic acid (C 18:0) and oleic acid (C 18:1 n-cis-9). When analyzed for total saturated (SAFA) and unsaturated (UFA) fatty acids, the long backbone contained more saturated and monosaturated fatty acids (MUFA) and less polyunsaturated fatty acids (PUFA).

Table 1. Chemical composition of muscle samples from Mangalitsa pigs slaughtered at different live weights

Parameter	Mangalitsa		
	Group 1 (n=5)	Group 2 (n=5)	Total (n=10)
Longissimus dorsi muscle M.L.D.			
Slaughter weight, kg	91.64	114.14	102.39
Dry matter, %	31.04	31.20	31.12
Moisture, %	68.96	68.80	68.88
Crude protein, %	22.04	21.24	21.64
Crude fat, %	7.72	9.04	8.38
Crude ash, %	1.03	1.00	1.02
Semimembranosus muscle M.SM.			
Dry matter, %	26.80	26.06	26.43
Moisture, %	73.20	73.94	73.57
Crude protein, %	22.88	22.16	22.52
Crude fat, %	2.68	2.78	2.73
Crude ash, %	1.08	1.11	1.09

Table 2. Fatty acid composition of *Longissimus dorsi* muscle (%)

Parameter	Mangalitsa		
	Group 1 (n=5)	Group 2 (n=5)	Total (n=10)
Capric acid C 10:0	0.07	0.10	0.09
Lauric acid C 12:0	0.06	0.08	0.07
Myristic acid C 14:0	1.26	1.42	1.34
Myristoleic acid C 14:1	0.02	0.03	0.03
Pentadecanoic acid C 15:0	0.03	0.02	0.03
Heptadecenoic acid C 17:1	23.85	25.30	24.58
Stearic acid C 18:0	4.03	4.93	4.48
Oleic acid C 18:1 cis-9	0.31	0.26	0.29
Octadecanoid acid C 18:1 cis-11	0.21	0.19	0.20
Octadecanoid acid C 18:1 trans-11	10.16	10.22	10.19
Linoleic acid C 18:2 n-6 cis	51.32	50.61	50.96
Eladic acid C 18:1 trans-9	0.34	0.23	0.28
Arahic acid C 20:0	6.52	5.52	6.02
Eicosaneoic acid C 20:1 n-6	0.31	0.14	0.22
Eicosenoic acid C 20:1 n-6	0.10	0.11	0.10
Eicosadienoic acid C 20:2 n-6	0.30	0.27	0.29
Eicosatrienoic acid+Erucic acid C 20:3 n-6+C 22:1 n-9	0.14	0.14	0.14
Eicosatrienoic acid C 20:3 n-3	0.02	-	0.02
Arachidonic acid C 20:4 n-6	0.87	0.45	0.66
Docosadienoic acid C 22:2 n-6	0.03	-	0.03
Eicosapentaenoic acid C 20:5 n-3	0.05	-	0.05
Saturated fatty acids SAFA	35.75	37.40	36.58
Monosaturated fatty acid MUFA	56.02	56.09	56.05
Polyunsaturated fatty acid PUFA	8.24	6.51	7.37

Table 3. Fatty acid composition of semimembranosus muscle (%)

Parameter	Mangalitsa		
	Group 1 (n=5)	Group 2 (n=5)	Total (n=10)
Capric acid C 10:0	0.05	0.06	0.06
Lauric acid C 12:0	0.04	0.06	0.05
Myristic acid C 14:0	0.95	1.05	1.00
Myristoleic acid C 14:1	0.02	0.02	0.02
Pentadecanoic acid C 15:0	0.04	0.03	0.04
Heptadecenoic acid C 17:1	21.36	21.78	21.57
Stearic acid C 18:0	3.54	4.17	3.86
Oleic acid C 18:1 cis-9	0.65	0.41	0.53
Octadecanoid acid C 18:1 cis-11	0.26	0.21	0.23
Octadecanoid acid C 18:1 trans-11	9.44	8.91	9.17
Linoleic acid C 18:2 n-6 cis	0.46	0.28	0.37
Eladic acid C 18:1 trans-9	47.85	48.24	48.05
Arahic acid C 20:0	11.03	11.49	11.26
Eicosaneoic acid C 20:1 n-6	0.37	0.25	0.31
Eicosenoic acid C 20:1 n-6	0.10	0.12	0.11
Eicosadienoic acid C 20:2 n-6	0.43	0.51	0.47
Eicosatrienoic acid+Erucic acid C 20:3 n-6+C 22:1 n-9	0.33	0.32	0.33
Eicosatrienoic acid C 20:3 n-3	0.05	-	0.05
Arachidonic acid C 20:4 n-6	2.77	1.91	2.34
Docosadienoic acid C 22:2 n-6	0.10	0.07	0.09
Eicosapentaenoic acid C 20:5 n-3	0.14	0.10	0.12
Saturated fatty acids SAFA	32.55	32.31	32.43
Monosaturated fatty acid MUFA	53.24	53.04	52.64
Polyunsaturated fatty acid PUFA	15.22	14.66	14.94

One of the potential products of Mangalitsa as a fatty pork on the market is good quality bacon. In his study, [8] describes good quality bacon as having a firm texture and a white color, while poor quality bacon is described as having a soft, watery, wilted texture and a gray color.

The quality, processing value and firmness of bacon are largely dependent on the fatty acid composition. Table 4 shows the fatty acid composition of back and belly fat. The data show that back fats of pigs slaughtered at higher weights contained significantly less margaric acid (C 17:0), significantly less arachidonic acid (C 20:4 n-6) and significantly more linoleic acid (C 18:2 n-6) and eicosatrienoic acid (C 20:2 n-6). This resulted in a significant difference in the ratio of monosaturated fatty acids (MUFA) to polyunsaturated fatty acids (PUFA).

According to [9], the ratio of stearic acid (C 18:0) to linoleic acid (C 18:2 n-6) is a measure of the firmness of the fat. The results obtained show that this ratio is more favorable in back fat 1.06; while in belly fat it is 0.6, which explains the hardness of back fat.

In a different approach, [10] reported that good quality bacon has a stearic acid (C 18:0) content of less than 12%. In this regard, however, our data show that belly bacon has a more favorable value, but the stearic acid content of back bacon does not significantly exceed the desirable value - only 1%. For animals in experimental group II both back and belly fatty acid composition values were available. Back fat contains more saturated fatty acids (SAFA) and less monosaturated fatty acids (MUFA) than the belly fat. There were no significant differences in the amount of polyunsaturated fatty acids (PUFA). In both back and belly bacon, the proportion was about 15%, considered by [11] to be desirable in good quality back bacon.

The results obtained confirm the characteristics of the Mangalitsa breed, known for its ability to accumulate fat both subcutaneously and intramuscularly. However, the nutritional implications could be further nuanced: higher PUFA levels imply a healthier profile but also an increased risk of oxidation, which requires certain measures during processing.

Table 4. Fatty acid composition of back fat and abdominal fat (%)

Parameter	Mangalitsa			
	Back fat			Bacon
	Group 1 (n=5)	Group 2 (n=5)	Total (n=10)	Group 2 (n=5)
Capric acid C 10:0	0.05	0.05	0.05	0.07
Lauric acid C 12:0	0.11	0.10	0.10	0.09
Myristic acid C 14:0	1.39	1.46	1.43	1.45
Pentadecanoic acid C 15:0	0.05	0.04	0.05	0.04
Heptadecenoic acid C 16:0	24.58	26.33	25.46	25.11
Stearic acid C 16:1	2.26	2.21	2.23	3.12
Oleic acid C 17:0	0.39	0.29	0.34	0.30
Octadecanoid acid C 17:1	0.30	0.20	0.25	0.26
Octadecanoid acid C 18:0	12.92	13.05	12.98	9.71
Palmitic acid C 18:1 cis-9	44.87	40.69	42.78	44.03
Eladic acid C 18:1 trans-9	0.60	0.27	0.43	0.29
Linoleic acid C 18:2 n-6 cis	11.08	13.86	12.47	14.05
Stearic acid C 18;3 n-3	0.60	0.50	0.55	0.52
Eicosadienoic acid C 20:2 n-6	0.54	0.72	0.63	0.67
Eicosatrienoic acid C 20:3 n-6	0.09	0.10	0.10	0.12
Arachidonic acid C 20:4 n-6	0.18	0.13	0.16	0.19
Saturated fatty acids SAFA	39.49	41.33	40.41	36.75
Monosaturated fatty acid MUFA	48.03	43.37	45.70	47.71
Polyunsaturated fatty acid PUFA	12.49	15.31	13.90	15.54

4. Conclusions

The findings of this study corroborate the conclusions drawn in previous literature that the quality of Mangalitsa pig meat exhibits notable differences from that of commonly utilized breeds and hybrids. These discrepancies pertain to various attributes, including intramuscular fat content, meat color, fat thickness, and fat color. The high intramuscular fat content (7.5-9.04) and its fine and even distribution in the meat have a positive effect on palatability, tenderness, and taste, particularly in the production of roasts and special products (ham, salami).

Mangalitsa pork ham is characterized by a high degree of hardness (stearic acid content: 9.71-13.05%) and a favorable fatty acid composition (PUFA: 12.49-15.54%), rendering it an optimal choice to produce premium-quality, high-value ham.

In general, the results of our study indicate that Mangalitsa pigs are well-suited to produce traditional products with high added value and specific qualities. The future of the breed is contingent upon the ability to secure a long-term market for these products.

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