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FATTY ACIDS IN WILD BOAR MEAT

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Abstract

In the context of the increased interest in the nutritional quality of meat, this study aimed to evaluate the physicochemical composition and fatty acid profile of wild boar meat (Sus scrofa, Linnaeus, 1758) from three representative counties of the Transylvania region (Cluj, Sălaj and Bistrița-Năsăud, Romania). A total of 24 Longissimus dorsi muscle samples (including the control group) were collected from wild boars during hunting parties and analyzed from a compositional point of view. Physicochemical parameters were determined by FT-NIR spectroscopy, while lipid extraction and fatty acid profile were performed by solvent extraction, followed by chromatographic analysis. The results showed a protein content between 26.4–29.4%, a fat content of 1.1–1.2% and pH values between 6.2 and 6.6, with significant differences observed in Sălaj and Bistrița-Năsăud ($p < 0.05$). The total PUFA content ranged between 20.36% and 23.77%, the SFA content between 35.35% and 38.37%, and the MUFA content between 40.72% and 44.51%. The PUFA/SFA ratio ranged between 0.57 and 0.63, indicating a favorable lipid profile. Therefore, this study confirms that wild boar meat from Transylvania presents a lean composition and a favorable nutritional profile of fatty acids, with moderate regional variations, probably influenced by habitat and diet.

Key words: *fatty acids, meat, Transylvania, wild boar.*

INTRODUCTION

The wild boar (*Sus scrofa*, Linnaeus, 1758) is an omnivorous species with a high capacity for ecological adaptation, widely distributed across Europe, Asia and parts of North Africa, playing an important role in forest and agricultural ecosystems. Due to its behavioral flexibility and feeding adaptability, the species occupies a wide range of habitats, including deciduous and coniferous forests, wetlands, agricultural areas, semi-arid regions, and mountain ecosystems (Viganò et al., 2019; Kamieniarz et al., 2020; Dannenberger et al., 2013).

Therefore, this adaptability can determine significant variations in the composition and quality of the meat, especially in terms of lipid profile. Game meat, including wild boar meat, is considered a valuable source of protein with high biological value, characterized by a low lipid content and a superior mineral profile compared to meat from intensive farming systems (Sales & Kotrba, 2013; Niewiadomska et al., 2021). An additional advantage of wild boar meat is the increased nutritional interest of consumers, due to its high iron, zinc and phosphorus content and low sodium content compared to domestic pork (Sales & Kotrba, 2013).

Regarding meat quality, it can be influenced by biological and environmental factors, including sex, age, physical activity and type of habitat, these factors determining significant variations in chemical and lipid composition (Tesarova et al 2018; Morán et al., 2019; Hoffman et al., 2021; Quaresma et al., 2011).

It is worth noting that intramuscular fat influences the sensory properties of meat, including texture and flavor, being strongly dependent on the lipid metabolism of the animal. From a nutritional point of view, game meat is considered, according to the literature, a healthier alternative due to its favorable lipid profile, characterized by an optimal ratio between saturated and unsaturated fatty acids and an increased content of polyunsaturated fatty acids (Kelava Ugarković et al., 2021; Raba et al., 2016). Another important aspect is that the consumption of game meat is associated with

dietary diversification and the intake of essential nutrients and is recommended as part of a balanced diet (Raba et al., 2016).

According to the literature, the superiority of wild boar meat quality is primarily determined by living conditions in the natural environment, characterized by varied food resources and an unpolluted environment. These conditions can influence the chemical composition of the meat, including the content of macro- and microelements, the optimal ratio between polyunsaturated and saturated fatty acids, as well as the organoleptic characteristics of wild boar meat (Szmańko et al., 2007).

Regarding the fatty acid profile, it can be significantly influenced by diet, habitat, season and level of physical activity, with the predominance of palmitic (C16:0), stearic (C18:0), oleic (C18:1 n-9) and linoleic (C18:2 n-6) acids being reported in wild boar meat (Razmaite et al 2009; Raba et al., 2016; Niewiadomska et al., 2020). In this context, consumers show an increased interest in natural products with reduced fat content and, and game meat in cholesterol is an important alternative in this regard (Szmańko et al., 2007).

Compared to systems from intensive farming, wild boar meat has a lower lipid content, especially in the psoas major muscle, due to the high level of physical activity and species-specific metabolism (Viganò et al., 2019; Niewiadomska et al., 2020).

In the literature, the distribution of fatty acids is influenced by biological and ecological factors such as sex, age, season and food availability, which determines important variations between populations (Quaresma et al., 2011). These variations are nutritionally and technologically relevant, influencing both the oxidative stability and the sensory quality of the meat (Raba et al., 2016; Niewiadomska et al., 2021).

Recent studies confirm that not all types of game meat present an optimal lipid profile from a nutritional point of view, the differences being influenced by factors such as geographical area, diet, age and sex of the animal (Lešić et al., 2025). In addition, significant differences have been reported between game species and domestic pork, especially in terms of omega-3 fatty acid content (Sampels et al., 2023).

In a balanced diet, wild boar meat consumption is considered moderate, representing approximately 20% of the total food intake, and in terms of meat proteins, they have a high biological value due to the content of essential amino acids (Strazdiņa et al., 2013; Honikel, 2009). Therefore, meat represents an important source of essential amino acids such as lysine, leucine and isoleucine, which cannot be synthesized by the human body and must be provided through food (Strazdiņa et al., 2013). It is worth mentioning that in recent decades, game meat has become an important component of the diet, due to the increased interest in products from animals raised in natural conditions, being appreciated both for its sensory properties and for its high nutritional value (Soriano et al., 2006). However, the literature shows that the fatty acid profile can vary significantly depending on ecological and biological conditions, which requires detailed regional studies (Lešić et al., 2025). It is also worth noting that the composition of meat can be influenced by post-mortem and technological factors, including the handling and processing method, as well as by the enzymatic activity specific to the muscle tissue of wild animals, which influences meat maturation and protein degradation (Cioata et al., 2025).

MATERIALS AND METHODS

In this study, a total of 24 samples of wild boar meat (*Sus scrofa*, Linnaeus, 1758) were analyzed, divided into four experimental groups, with n = 6 samples each, and a reference group. The samples were collected following hunting parties in the Transylvania region (Cluj County, Sălaj County and Bistrița-Năsăud County).

All sampled specimens were classified as subadult animals aged 1-2 years, including both males and females.

The hunting was carried out authorized in accordance with the Hunting and Protection of Game Reserves Law no. 407/2006 from the Official Gazette, Part I no. 944 of 22 November 2006.

The samples in this study were taken from the *Longissimus dorsi* muscle considered a representative muscle for the analysis of the chemical and lipid composition of the meat**.**

The samples, after collection, were transported to the INCDO-INOE 2000 laboratory, Branch of the Research Institute for Analytical Instrumentation (ICIA), Cluj-Napoca, Romania, under refrigerated conditions (4 ± 1°C). The

samples were homogenized in the laboratory to obtain a uniform and representative sample before their analysis.

Wild boar samples were analyzed for dry matter, total lipid, NaCl content, protein and pH using a Bruker FT-NIR spectrometer in diffuse reflectance mode. The calibration used was internal, previously validated in the laboratory by reference methods, which include ash by calcination, lipid by solvent extraction, protein by Kjeldahl method, salt by titration or gravimetry, and pH by potentiometry.

Each wild boar meat sample was subjected to homogenization by comminution to uniform the particles and reduce the variation due to scattering effects. Spectra were collected in the range 12,000-4,000 cm^{-1} with a resolution of 8 cm^{-1} and 64 scans per analysis.

For the determination of lipids, we took a quantity of 0.5 g of the muscle tissue sample taken from the wild boar and mixed it with 20 ml of chloroform-methanol mixture (2:1) (v/v). For extraction, the mixture of biomass and solvents were extracted in an ultrasonic bath (Sonorex RK 512H), for 60 min.

After the extraction step, the mixture was filtered to separate the organic phase. The organic phase was treated with 10 ml of KCl (0.74%) for extraction and purification.

The chloroform phase was separated from the aqueous phase and filtered and dried using Na_2SO_4. As for the solvent, it was evaporated to dryness using a rotary evaporator, and the obtained oil was dried at 60°C, after which it was weighed. Regarding the analysis of the fatty acid profile of wild boar muscle tissue there may be changes, which may be associated with the type and quality of dietary lipids.

RESULTS AND DISCUSSIONS

The physicochemical composition of wild boar meat (*Sus scrofa*, Linnaeus, 1758) from Cluj, Sălaj and Bistrița-Năsăud counties is presented in Table 1. The results in the table indicate a relatively homogeneous profile between the studied batches. The sex of wild boar specimens was not included as a factor in the analysis due to the homogeneous age structure and limited batch size.

Regarding the protein content, it varied between 26.4% and 29.4%, slightly lower values being observed in Sălaj, while the highest values were recorded in Bistrița-Năsăud. The fat content was reduced (1.1-1.2%), confirming the lean meat character specific to game (Table 1).

Table 1. Physico-chemical composition of wild boar meat by area

Parameter	Wild boar reference group	Wild boar Cluj	Wild boar Sălaj	Wild boar Bistrița-Năsăud
Ash (%)	2.8±0.1	2.6±0.1^{ns}	2.9±0.1^{ns}	2.5±0.1^{ns}
Protein (%)	28.1±0.5	28.7±0.4^{ns}	26.4±0.6^{ns}	29.4±0.5^{ns}
Fat (%)	1.1±0.05	1.2±0.05^{ns}	1.1±0.05^{ns}	1.1±0.05^{ns}
Collagen (%)	2.2±0.1	2.4±0.1^{ns}	2.1±0.1^{ns}	2.4±0.1^{ns}
Water (%)	70.9±0.3	71.4±0.4^{ns}	70.6±0.3^{ns}	71.5±0.4^{ns}
pH	6.6±0.1	6.4±0.1^{ns}	6.3±0.1*	6.2±0.1*

(P-value; ns- insignificant; p >0.05 -ns; p < 0.05∗)

According to published studies, the results are in agreement with the data reported by Sales & Kotrba (2013), which highlighted that wild boar meat has a lower lipid content and a higher protein content compared to domestic pigs. Also, Honikel (2009) reported results regarding meat protein values between 13-23%, which confirms the high protein character of the analyzed samples. Regarding the significant differences in pH between some counties, they may be associated with post-mortem factors, such as harvesting stress, handling or cooling conditions of the meat.

For fatty acids, the results (Table 2) indicate higher levels of saturated fatty acids (SFA) in wild boar meat samples from Bistrița-Năsăud and Sălaj, compared to the control group. This increase is mainly associated with higher values of C14:0, C17:0 and C20:0. In contrast, total polyunsaturated fatty acids (PUFA) were higher in all investigated regions, compared to the control group, with the highest values observed in Sălaj and Bistrița-Năsăud, reaching the highest levels of significance. This pattern is largely related to the increased content of linoleic acid (C18:2 n-6) in these samples (Table 2). PUFAs showed higher values in all experimental groups compared to the control, with maximums in Sălaj (23.77%) and Bistrița-Năsăud (23.27%) (Table 2). The PUFA/SFA ratio ranged from 0.57 (control group) to 0.63 (experimental groups), with values ranging from 0.61 to 0.63 in wild boar meat from the studied regions. These values are considered nutritionally favorable, as a PUFA/SFA ratio

greater than 0.4 is generally associated with a lipid profile beneficial to human health. The results are similar to those reported by Quaresma et al. (2011), who demonstrated the influence of diet and habitat on the lipid profile in wild boar. Sampels et al. (2023) highlighted a higher content of polyunsaturated fatty acids in game meat compared to meat from intensive systems.

Table 2. SFA, MUFA and PUFA fatty acids in wild boar meat depending on the area

Fatty acids	Wild boar reference group	Wild boar Cluj vs reference group	Wild boar Sălaj vs reference group	Wild boar Bistrița-Năsăud vs reference group
∑ SFA	35.51	35.35 (ns)	37.50 (*)	38.37 (**)
∑ MUFA	41.01	42.20 (ns)	40.72 (ns)	44.51 (**)
∑ PUFA	20.36	21.79 (*)	23.77 (***)	23.27 (***)
PUFA/SFA	0.57	0.62 (*)	0.63 (*)	0.61 (*)
n-6/n-3	13.86	13.09 (ns)	16.68 (**)	15.14 (*)

ns (insignificant); * significant ($p < 0.05$); ** distinct significant ($p < 0.01$); *** high significant ($p < 0.001$)

The high protein values and favorable fatty acid profile observed in the present study support the claims of Soriano et al. (2006), according to which game meat represents a valuable and healthy food alternative due to its nutritional and sensory properties. The low fat content (1.1-1.2%) and high levels of polyunsaturated fatty acids identified in the analyzed samples contribute to the high biological value of wild boar meat.

Oleic acid (C18:1 n-9) was one of the main fatty acids identified in our study, with values between 37.25% and 40.28%, confirming its dominant role in the lipid structure of wild boar meat. Palmitic acid (C16:0) showed minimal variations between groups (20.9-21.9%), indicating a relative metabolic stability. Linoleic acid (C18:2 n-6) was significantly higher in Sălaj and Bistrița-Năsăud compared to the values in Cluj, suggesting the influence of habitat factors and available food resources, (Table 3). These results are in agreement with Quaresma et al. (2011), who concluded that the natural diet significantly influences the fatty acid composition of wild boar. Authors Razmaite et al. (2009) and Quaresma et al. (2011), who identified palmitic acid and stearic acid as the main saturated fatty acids in wild boar meat. Also, Sales & Kotrba (2013) highlighted the favorable lipid profile of wild boar meat compared to domestic pork.

Table 3. Average values for wild boar meat by area

Fatty Acids (%)	reference group	Wild boar Cluj	Wild boar Sălaj	Wild boar Bistrița-Năsăud	p-value	Semni-fication
C14:0	1.2	1.4	1.5	1.9	0.008	**
C15:0	0.4	0.9	0.4	0.7	0.042	*
C16:0	21	20.9	21.7	21.9	0.115	Ns
C16:1	2	2.2	2.3	2.6	0.004	**
C17:0	0.6	0.9	1.6	1.3	< 0.001	***
C17:1	0.45	0.52	0.61	0.93	< 0.001	***
C18:0	11.51	11.22	11.82	11.91	0.241	Ns
C18:1 n-9 (Oleic)	38.08	39.01	37.25	40.28	0.012	*
C18:2 n-6 (Linoleic)	16.02	17.13	19.22	18.42	< 0.001	***
C18:3 n-6	0.45	0.37	0.42	0.55	0.031	*
C18:3 n-3	0.88	0.99	0.91	1.02	0.045	*
C20:0	0.3	0.31	0.38	0.45	0.006	**
C20:1	0.37	0.33	0.4	0.51	0.018	*
C20:2 n-6	0.21	0.27	0.3	0.29	0.058	Ns
C20:4 n-6	2.34	2.49	2.51	2.54	0.382	Ns
C22:0	0.28	0.32	0.29	0.22	0.092	Ns
C22:1 n-9	0.11	0.13	0.16	0.19	0.009	**
C22:5 n-3	0.46	0.53	0.41	0.45	0.154	Ns
Others (C23:0, C24:0)	3.92	3.66	3.91	2.77	0.003	**

The differences observed between the counties analyzed by us can be explained by the particularities of the habitat, the diversity of natural food sources and the degree of physical activity of the wild boar. Cioată et al. (2025) highlighted the fact that the diet and living conditions of the wild boar directly influence the chemical composition and lipid profile of the meat. Also, the study conducted by Lešić et al. (2025) emphasized that not all wild boar populations present the same fatty acid profile, the differences being determined by factors such as season, sex, age and habitat conditions.

The high protein values and favorable fatty acid profile observed in the present study support the claims of Soriano et al. (2006), according to which game meat represents a valuable and healthy food alternative due to its nutritional and sensory properties. The low fat content (1.1-1.2%) and high levels of polyunsaturated fatty acids identified in the analyzed samples contribute to the high biological value of wild boar meat. According to the study conducted by Strazdiņa et al. (2013), among the Latvian population, special attention was paid to maintaining health by adopting a balanced diet. The authors mention that, in the food pyramid, meat is considered a product to be consumed in

moderation, representing approximately 20% of the total food.

Regarding the results obtained in this study, they are consistent with data reported in the specialized literature for wild boar meat from other regions, confirming the predominance of oleic, palmitic, stearic and linoleic acids in its lipid fraction (Skobrák et al., 2011; Quaresma et al., 2011; Tomljanović et al., 2014; Tesarova et al 2018; Blaška et al., 2023; Lešić et al. 2025).

CONCLUSIONS

This study highlighted that there may be some differences in the chemical composition and fatty acid profile of wild boar meat (*Sus scrofa* L., 1758) from different counties of the Transylvania region (Cluj, Sălaj and Bistrița-Năsăud). The results show, that from a physico-chemical point of view, most of the analyzed parameters (protein, fat, collagen, water and ash) did not present significant differences between the studied batches. The pH values were significantly different for the samples from Sălaj and Bistrița-Năsăud counties compared to the control batch ($p < 0.05$).

Regarding the lipid profile, the highest values of saturated fatty acids (SFA) were identified in the samples from Bistrița-Năsăud county (38.37%), followed by those from Sălaj county (37.50%). The total content of polyunsaturated fatty acids (PUFA) was higher in the samples from Sălaj County (23.77%), followed by those from Bistrița-Năsăud County (23.27%). Also, the highest content of oleic acid (C18:1 n-9) was recorded in Bistrița-Năsăud County (40.28%), and the highest content of linoleic acid (C18:2 n-6) in Sălaj County (19.22%).

The PUFA/SFA ratio ranged between 0.57 and 0.63, all values exceeding the threshold of 0.40 recommended for a balanced diet, which confirms the high nutritional value of the analyzed wild boar meat.

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