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CARCASS, MEAT, AND SUBCUTANEOUS FAT PROPERTIES OF OUTDOORS-REARED MANGALIŢA PIGS

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Abstract

Mangaliţa pig meat is renowned for its high quality; however, there is limited information regarding the characteristics of this breed when raised for heavy pig production. The study aimed to assess the effects of sex on the carcass, loin, and lard characteristics (inner and outer layers) of Blonde Mangaliţa pigs. On average, the Mangaliţa pigs exhibited a fat thickness of 69 mm and a loin cholesterol content of 0.683 mg/g. The loin contained 40.0% saturated fatty acids (SFA), 51.3% monounsaturated fatty acids (MUFA), and 7.9% polyunsaturated fatty acids (PUFA). Significant differences were observed between the two lard layers, with the inner layer being brighter and having a higher dry matter content than the outer layer. Regarding fatty acid composition, the inner layer had a lower PUFA content, but a higher SFA content compared to the outer layer. The sex of the pigs did not affect the carcass, meat, or lard characteristics. The findings contribute to the characterization of meat and lard quality in outdoor-reared heavy Mangaliţa pigs, addressing gaps in current knowledge.

Key words*: acids, lard, fatty, Mangaliţa, meat.*

INTRODUCTION

At present, the selection of meat products is influenced not merely by perceived quality and convenience and by nutritional value, the welfare of animals and the environmental effects of production methods (Appleby et al., 2004). This has contributed to a growing interest in foods sourced from organic or environmentally responsible production practices in recent years. In light of this, numerous traditional breeds have been reintroduced within European pig agriculture, which aimed at preserving and advancing agrobiodiversity, enhances less productive lands while guaranteeing the creation of premium meat. Furthermore, the adaptability of native or traditional breeds to this specific environment, along with their resilience to illness and harsh weather is viewed favourably. A case in point of specialized breeding is the Mangaliţa breed, a traditional variety originating from Hungary. The renewed interest in native breeds and the focus on a "low input" breeding strategy have facilitated the growth of this breed throughout Europe and helped maintain its conservation status (Egerszegi et al., 2003). The Mangaliţa variety is noted for its delayed maturity, reduced fertility, a gradual growth rate, and a greater fat content compared to other swine varieties with lard comprising around 65-70% of the average carcass weight achieved until 1950 (Egerszegi et al., 2003). Following this time, the population of this breed saw a sharp decline due to the emergence of other breeds and hybrids that exhibited significantly enhanced productive capabilities, the establishment of modern pig farming practices and shifts in consumer dietary preferences (Hoha et al., 2018). Conversely, the meat from this variety is acclaimed for its exceptional quality.

While numerous studies have investigated the meat qualities of these pigs, the researchers indicated a necessity for further details regarding the fatty acid (FA) profile (Petroman et al., 2021).

Recently, the researchers conducted have been focused on the growth performance and carcass features or meat quality of Mangaliţa pigs raised indoors (Roberts et al., 2023).

The objective of the research was to investigate the characteristics of carcasses as well as the quality of meat and lard from heavily raised Mangaliţa pigs outdoors, taking into account the impact of sex and the fatty acid composition of lard across various layers.

MATERIALS AND METHODS

To proceed with the research, a total of 10 Mangaliţa pigs, comprising 5 females and 5 castrated males, were evaluated. These pigs were kept together in an outdoor paddock measuring one hectare on a farm and were processed at an average age of 23 months, which was consistent across genders. Within the paddock, there were wooden structures providing shelter for the animals, along with covered feeding stations and water troughs. Their diet consisted of a concentrated pellet feed that included maize, wheat bran, a mixed based on hulled soybean meal, wheat flour, barley, calcium carbonate, sodium chloride, dicalcium phosphate, and various vegetable oils and fat, such as palm oil. The composition of this concentrate included: dry matter (DM) at 89%, ash at 7.1% DM, neutral-detergent fibres (NDF) at 14.9% DM, ether extract at 5.21% DM and raw protein at 15.94% DM. Pigs were given unrestricted access to both feed and water.

Following a fasting period of 12 hours, the animals were processed at the slaughterhouse, adhering to national laws and under the supervision of a veterinarian. Electrical stunning has been utilised for the slaughtering process and the carcasses were stored at a temperature of 4°C; 45 minutes post slaughter, pH measurements of the gluteus medius muscle (GMM) and semimembranosus muscle (SM) have been taken.

The weight of the hot carcasses was recorded with the head included but the offal excluded. The GMM thickness was determined from the muscle's cranial tip to the vertebral canal, while the thickness of fat that was in contact with the muscle was noted at its least covered point.

Portions of the *Longissimus lumborum* muscle, known as the loin, together with its associated subcutaneous fat, identified as lard were gathered and stored at a temperature of 4°C.

One day after the animal's death, the muscle and fat tissues have been segregated and cleaned. The lard was separated into two sections: the outer lard which was denser and stuck to the skin, and the inner lard, which was softer and adhered closer to the muscle. Three samples from each pig were analysed, including the loin, and both inner and outer layers of lard. After allowing a blooming period of 30 minutes, colour metrics were taken from both the loin and the inner and outer fat with a Spectrophotometer Konica Minolta CM 2600. Samples were gathered from each animal and each type of tissue for chemical composition profiling and gas chromatography assessments, stored at -20°C. Additional samples of the loin of each animal were acquired to evaluate drip loss and cooking loss.

Specifically, drip loss was measured using the modified EZ- Drip loss technique (Rasmussen & Andersson, 1996). The analyses for cooking loss were conducted according to the method outlined by Ncogo Nchama et al. in 2022.

The strategies of Affiliation of Official Explanatory Chemists (2016) were taken after. Around 100 grams of loin were ground, freeze-dried and subjected to the assurance of dampness, fiery remains, unrefined protein and other extricate (lipids) substance. For the fat (inward and external), dampness, fiery debris and lipid substance were decided. The overall muscle hydroxyproline substance (HPro) was decided utilizing the commercial hydroxyproline test unit (Cat. N. MAK008, Sigma-Aldrich, St. Louis, Mo., USA) and add up to collagen was gotten by increasing the HPro substance by 7.25 (Goll et al., 1963). Insoluble collagen was extricated from lyophilized muscle taking after the strategy of Palka (1999). At that point, the HPro substance in this division was decided utilizing the already cited commercial kit. Hence, the insoluble collagen substance within the new meat was calculated based on the water substance misplaced from the test through freeze-drying. The soluble collagen substance was gotten by subtracting the insoluble collagen from the overall collagen.

Lipid extraction from meat and fat was performed, as detailed in Pianezze et al. (2021). The greasy corrosive methyl esters (FAMEs) were gotten taking after the strategy portrayed by Sukhija & Palmquist (1988) and as detailed in Ncogo Nchama et al. (2022). Gas chromatography-mass spectrometry (GC/MS) investigations were carried out as detailed in Pianezze et al. (2021) with a few alterations. In specific, 1 μL was infused in part mode (1:100), and the GC broiler program was 1 min at 50°C. At that point, the temperature administration was expanded by 8°C/min to 160°C (hold time 3 min), 5°C/min to 200°C (hold 1 min) and 15°C/min to 240°C (hold time 5 min). Each run kept going 40 min. The National Established of Benchmarks and Advances Mass Ghostly Library (NIST, 2014) was utilized to recognize the diverse compounds. C21:0 was the inside standard and FAME was communicated as a rate of the whole FA distinguished.

Cholesterol assurance was performed based on coordinate saponification in KOH taking after the method of Naeemi et al. (1995). Within the extraction step, 5α-cholestane was utilized as inner standard. FA was measured based on chromatographic runs performed utilizing the GC/MS 5977E, but with a nonpolar stationary stage (5%-phenyl) methyl polysiloxane and HP-5ms column with measurements of 30 m x 0.25 mm x 0.25 μm (Agilent Technologies, Santa Clara, CA, USA). The run kept going 19 min, with a beginning temperature of 200°C and an increment of 10°C/min to 280°C, kept up for 10 min. the particle source and quadrupole temperatures wee set so also to those utilized for FA location.

Information examinations were performed utilizing the SPSS program (version 17, SPSS Inc., Chicago, IL, USA) and the R computer program bundle, adaptation 4.1.2 (R Core Team, 2021). Information related to the carcass and meat composition and quality were analysed agreeing to a one-way investigation of function assessing the impact of sex (female versus castrated). The information relating to the composition of the grease were prepared concurring to a show for rehashed measures, where the layer (internal versus external) and the sex (female versus castrated) were considered as inside and between components, separately. Moreover, interaction of interaction layer x sex was considered. A comparative show but considering muscle sort (gluteus medius muscle versus semimembranosus muscle) rather than layer (as inside calculate), was considered for the pH. The FAs of the loin and the inward and external layers of subcutaneous fat were prepared based on bi-plot investigation utilizing the factoextra bundle (Kassambara & Mundt, 2020). The test level for importance was set at p <0.05.

RESULTS AND DISCUSSIONS

Adult pigs are typically processed for meat at a required age range of 9 to 10 months when their carcass weight is roughly between 130 to 140 kilograms which provides the best qualities of meat (Bava et al., 2017).

In this particular study, Mangaliţa pigs were processed at 23 months old and displayed a hot carcass weight of 141 kilograms. The increased age at which these pigs attained the desired carcass weight may be attributed to greater energy consumption due to outdoor living conditions and the slower growth rates of Mangaliţa pigs (Roberts et al., 2023).

No notable differences related to gender were observed regarding carcass features. The estimated average lean meat was significantly less than what is found in commercial crossbreeds, falling short by approximately 50% (Pesenti Rossi et al., 2022), thereby reinforcing the notion that the Mangaliţa breed is characterized by substantial fat deposition.

The pH level at 45 minutes of the GMM was significantly elevated compared to that of the SM, with no significant variation attributed to gender, which might be explained by the different muscle fibre types present (Table 1).

Table 1. Effect of gender and muscle on carcass and subcutaneous fat characteristics of Mangaliţa pigs

Item	Unit of measurement	Gender		Calculated average values	MSE (mean standard error)	Significance
		Female	Castrated male			Gender
Hot carcass weight	kg	135	145	140	5.72	0.462
Subcutaneous fat thickness	mm	70	68	69	2.00	0.545
Muscle thickness	mm	60	57	58.5	1.43	0.328
pH 45' for GMM	%	6.33	6.23	6.28	1.012	0.628
pH 45' for SM	%	6.16	6.04	6.1	0.035	0.178

Fast-twitch glycolytic fibres facilitate glycolysis, leading to a quick reduction in pH (Choe et al., 2008); in contrast, oxidative fibres lessen the decrease in pH levels.

No meaningful distinctions were found in the traits of the *Longissimus lumborum* muscle (loin) when comparing females and castrated males (Table 2). The pH last readings for loin fell within the acceptable limits (5.3-5.8), as indicated by Stanišić et al. (2016). Gender did not have a notable impact on the colour of the loin, levels of drip loss or cooking loss. Consistent with findings of this study, Peinado et al. (2012) did not observe variation in colour attributes, drip loss or cooking loss in their exploration of castrated males and female's pigs weighing approximately 102 kilograms in carcass.

Table 2. Effect of gender and on loin (*Longissimus lumborum* muscle) characteristics of Mangaliţa pigs

Item	Gender		Calculated average values	MSE (mean standard error)	Significance
	Female	Castrated male			Gender
Last pH	5.38	5.48	5.43	0.070	0.464
Lightness	39.23	38.82	39.03	1.013	0.757
Redness	7.02	7.13	7.08	0.506	0.878
Drip loss, %	3.65	3.84	3.75	0.413	0.800
Cooking loss, %	25.7	25.8	25.75	1.17	0.970

The current findings revealed a lower average lightness in the loin and a greater redness compared to those recorded in commercial larger pig breeds, which typically fall between 48-50 for lightness and 2-4 for redness (Latorre et al., 2003, Virgili et al., 2003).

The enhanced firmness of meat from Mangaliţa pigs can be attributed to their outdoor upbringing and continuous physical activity, which alters muscle structure at the myofibril and collagen protein levels thus impacting tenderness. The pH and colour of lard were not notably influenced by the sex of the pigs, therefore the difference between characteristics values is insignificant (Table 3). In actuality, a higher melting point can produce fat that appears whiter (Wood et al., 2004).

Table 3. Effect of gender on lard (subcutaneous fat) characteristics of Mangaliţa pigs

Item	Gender		Calculated average values	MSE (mean standard error)	Significance
	Female	Castrated male			Gender
Last pH	6.73	6.75	6.74	0.045	0.823
Lightness	72.73	72.13	72.43	0.247	0.996
Redness	-0.69	-0.7	-0.7	0.092	0.260

Male castration did not have a notable impact on the meat and subcutaneous fat's chemical composition, as shown in Table 4. The researchers, in their work with free-range Mangaliţa pigs, found that the *Longissimus dorsi* muscle from castrated males exhibited a chemical composition analogous to that of females, except for moisture levels being lower and total fat being higher in castrated males; nonetheless, these pigs had a considerably reduced carcass weight of 76 kg compared to what is analysed in this study (Vranic et al., 2015). On the other hand, other scientists did not find any influence of sex on the meat's chemical composition (Peinado et al., 2012).

Table 4. Effect of sex on chemical composition of meat and subcutaneous fat from Mangaliţa pigs (10 samples - 5 females and 5 castrated males)

Item	Unit of measurement	Gender		Calculated average values	MSE (mean standard error)	*p*-Value
		Female	Castrated male			Gender
Loin (*Longissimus lumborum* muscle) % fresh meat						
Water	%	69	68.3	68.65	0.548	0.560
Ash	%	1.13	1.11	1.12	0.011	0.287
Crude protein	%	22.6	22.3	22.45	0.187	0.490
Total collagen	mg/g	2.93	3.01	2.97	0.082	0.624
Soluble collagen	% total	34.5	37.1	35.8	2.649	0.664
Total fat	%	7.02	8.11	7.57	0.676	0.428
Cholesterol	mg/g	0.632	0.651	0.642	0.02	0.710
Lard, lumbar region (subcutaneous fat) % fresh meat						
Dry matter	%	95.5	95.3	95.4	0.136	0.425
Ash	%	0.052	0.042	0.047	0.0038	0.248
Total fat	%	84.3	84.4	84.35	0.618	0.903
Cholesterol	mg/g	0.902	0.914	0.908	0.0180	0.765

In this investigation, the average of fat percentage in the meat fell within the Mangaliţa breed's typical range of about 6-17% which is considerably elevated in relation to the desired fat range for consumers of approximately 2.5-3.5% (Despotović et al., 2018), and is also significantly higher than the observed level for heavy genetically improved pig breeds, which average roughly 2-4% (Parunović et al., 2013).

The chemical makeup of the inner fat layer did not show significant differences from that of the outer layer, with the sole exception being that dry matter was considerably higher in the inner layer.

The gender had no significant impact on the fatty acid composition of subcutaneous fat, as shown in Table 5, which is consistent with Peinado et al. (2012). Contrarily, Grela et al. (2013) indicated that females displayed greater levels of C18:2n-6 and C20:2n-6 while having lower levels of C18:0 than castrated males. The lard layer played a role in shaping the fatty acid composition (Table 5). Specifically, the inner layer contained significantly elevated levels of C16:0 and C20:0, but showed significantly reduced amounts of C15:1, C17:0, C18:2n-6, C18:3n-3, C20:2, C20:3n-3 and C20:4n-6 compared to the outer layer.

When examining the fatty acid categories, the inner layer had a notably higher proportion of saturated fatty acids - SFA, while having markedly lower amounts of polyunsaturated fatty acids - PUFA, both in total n-3 and n-6 measurements, than the outer layer.

The growth of subcutaneous fat layers does not align with fluctuations in overall body weight. At the time of birth, the external layer is predominant followed by a subsequent increase in the thickness of the inner layer. Moreover, the inner fat layer appears to be more active in its processes compared to the outer layer (McEvoy et al., 2007).

Supporting the current research, Ayuso et al. (2020) suggested that the inner layer exhibited a greater capability for fatty acid synthesis than the outer layer. In fact, levels of C16:0 and saturated fatty acids, both of which can be synthetized within the organism were more pronounced in the inner layer (Domaradzki et al., 2022). The heightened fatty acid synthesis may have diluted the levels of C18:2n-6 and C18:3n-3, which are derived solely from diet, thus resulting in diminished percentage concentrations.

Table 5. Effect of sex on fatty acid composition of subcutaneous fat of Mangaliţa pigs (% of total lipids)

Fatty acid	Gender		MSE (mean standard error)
	Female	Castrated male	
C10:0	0.05	0.05	0.003
C12:0	0.07	0.07	0.003
C14:0	1.62	1.67	0.035
C15:1	0.042	0.044	0.002
C16:0	22.46	22.44	0.207
C16:1n-7	0.45	0.46	0.02
C16:1n-9	2.21	2.19	0.078
C17:0	0.32	0.33	0.008
C17:1	0.24	0.29	0.012
C18:0	14.61	15.79	0.265
C18:1n-9	37.62	36.95	0.512
C18:1n-7	2.34	2.32	0.08
C18:2n-6	12.39	13.02	0.267
C20:0	0.34	0.32	0.008
C18:3n-3	0.85	0.9	0.041
C20:1n-9	2.17	2.17	0.11
C20:2	1.21	1.28	0.055
C20:3n-6	0.16	0.12	0.01
C20:3n-3	0.31	0.27	0.012
C20:4n-6	0.35	0.24	0.03
C22:4n-6	0.18	0.1	0.022
Σ SFA	39.44	39.61	0.465
Σ MUFA	46.14	45.51	0.713
Σ PUFA n-6	15.2	15.83	0.342
Σ PUFA n-3	1.1	1.12	0.025
Σ PUFA	15.3	15.79	0.276

The heightened fatty acid synthesis may have diluted the levels of C18:2n-6 and C18:3n-3, which are derived solely from diet, thus resulting in diminished percentage concentrations. While this results in the outer layer being nutritionally favourable, it presents technological challenges since it is softer and more susceptible to oxidation and rancidity. The distinct fatty acid profiles contribute to varying fluidity in the fat layers, which may be interpreted as an evolutionary adaptation of pigs to temperature conditions (Monziols et al., 2007). In terms of thermal regulation and energy processing, the outer layer contributes to heat retention, while the inner layer, as previously noted, appears to be more involved in the accumulation and release of energy supplies. Concerning the fatty acid makeup of lard from Mangaliţa pigs in this research, it was noted that monounsaturated fatty acids were the predominant type, comprising an average of 45.83% of total fatty acids, trailed by saturated fatty acids at an average of 39.53% and polyunsaturated fatty acids, at an average of 15.55%. Similar to subcutaneous fat, the fatty acid profile of the loin did not show significant variation based on sex. Studies have shown that no significant distinctions even in comparisons between females and males, indicating that hormonal influence on the fatty acid composition appeared minimal.

In the Figure 1 has been shown a comprehensive overview over the fatty acid compositions for each type of acid and the minimal difference demonstrated for females and castrated males. Comparing the average values obtained for fatty acid compositions, it can be observed that the higher difference has been registered for monounsaturated fatty acids on females, with 0.63 more, than was registered for castrated males.

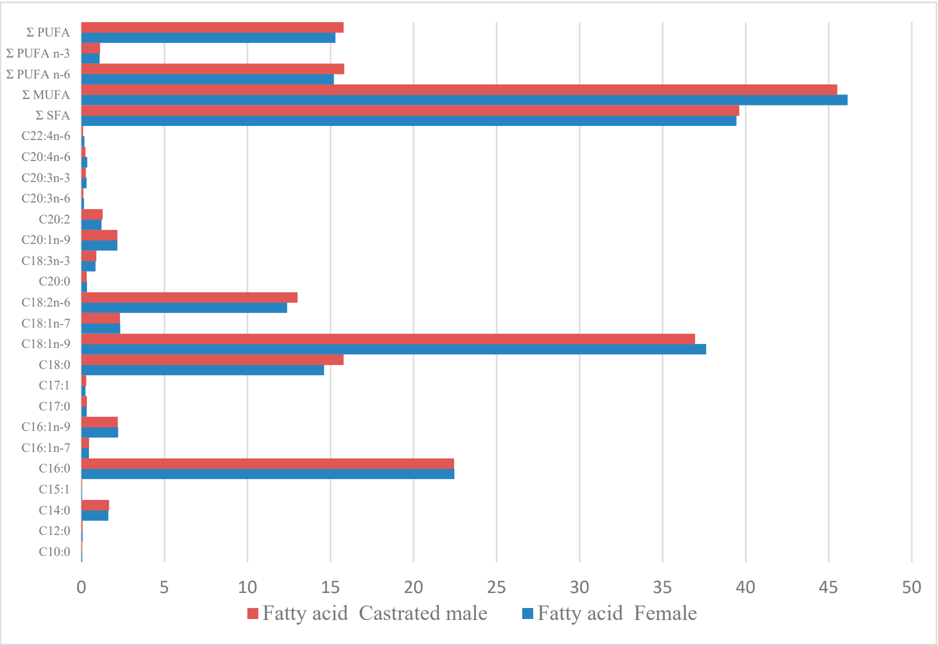

Figure 1. Fatty acid composition of subcutaneous fat from castrated male and female from Mangaliţa pigs

CONCLUSIONS

The features of the carcass, loin or lard were unaffected by the gender of the Mangaliţa breed, but the diet's composition can affect the fatty acid profile of meat and fat. Depending on the particular fatty acids, dietary fats can convert to carcass fat at a high rate between 35-40%, but this is to be determined in the future studies.

According to this research, the layers of subcutaneous fat from females were brighter than the ones from males, even though the pH is slightly lower on those. The values recorded for pH 45 minutes after slaughtering, were close for both 2 types of muscles, 6.27% for GMM (for female) and 6.13 for SM (for castrated male). Also, regarding the chemical composition of meat and fat from Mangaliţa, there were determined insignificant differences on females and males, around 0.10%.

The current study's findings showed that an outdoor breeding system may successfully raise the Mangaliţa breed for heavy pig production.

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