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### COMPARATIVE ANALYSIS OF QUALITY PARAMETERS FOR RAW-STIRRED SALAMI MADE OF WILD BOAR AND DEER MEAT

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#### Abstract:

The present paper explores the technological process of obtaining a salami from game meat (own production) and evaluates the physico-chemical quality indicators that define the nutritional value and stability of this artisanal product. The manufacturing technology followed the specific stages of raw-dried and matured products, emphasizing the selection of the hunting raw material (characterized by a high myoglobin content and low lipid profile) and its mixing with pig fat fractions to ensure juiciness and optimal maturation and fermentation texture was monitored to ensure the controlled reduction of water activity and the achievement of a stable sensory and microbiological balance. The results of the physico-chemical analyses for game salami (own production) reveal a product with an exceptional nutritional density. The total protein content of 27.086% is characteristic of game meat, exceeding the values found in most poultry or pork products. The humidity level of 28.036% confirms an advanced and correctly executed drying process, which, together with the salt content of 4.7%, ensures the long-term preservation of the product by inhibiting the development of alternative microorganisms. From the point of view of freshness, the slightly hydrolyzable nitrogen value of 11.4 mg NH<sub>3</sub>/100g indicates a raw material of remarkable quality and rigorous hygiene in the technological flow, being well below the alert thresholds for matured products. The pH of 5.8 and the total ash content of 9.24% reflect rich mineralization and optimal acidification during fermentation. With an energy intake of 401 kcal/100g and a fat content of 30.076%, the analyzed product is a food with a high biological value, representative of the category of superior processed hunting products.

**Keywords:** game meat, matured salami, technological process, physicochemical indicators, food safety, total protein.

#### Introduction

Game meat — particularly wild boar (*Sus scrofa*), roe deer (*Capreolus capreolus*) and red deer (*Cervus elaphus*) — represents a valuable source of high biological value protein, characterized by low fat content, a favorable fatty acid profile and a high concentration of micronutrients such as iron, zinc and vitamin B12. Compared to conventional meat, it is obtained from animals raised in natural conditions without growth promoters or antibiotics, contributing to its superior nutritional image and increasing consumer appeal [1], [5]. The growing demand for premium and artisanal products has led to increased interest in fermented sausages based on game meat, combining its distinct sensory profile with the preservation advantages of dry-cured salami technology [2].

The production of raw-dried game salami involves key technological stages — raw material selection, formulation, fermentation, drying and maturation — all requiring strict control to ensure quality and safety. Due to the lean nature and high myoglobin content of game meat, pork fat is commonly added to improve texture, juiciness and binding capacity. Product stability is achieved through reduced water activity and pH, resulting from salting, drying and lactic acid fermentation, which inhibit microbial growth [1], [3].

Physicochemical characterization is essential for evaluating product quality and compliance. Parameters such as moisture, protein, fat, salt, pH and ammonia nitrogen reflect maturation degree, nutritional value and product safety. This study aimed to analyze the processing technology and physicochemical characteristics of a game salami (own production), comparing it with similar products based on wild boar, roe deer and red deer meat, as well as a pork control variant, to assess the influence of meat type and formulation [1]–[4].

Wild boar meat is darker and more flavorful than pork, with 20–22% protein and a higher proportion of polyunsaturated fatty acids. Roe deer and red deer meat are even leaner (below 3–5% fat) and rich in protein and iron, making them suitable for high-protein, reduced-fat products [2], [3]. Fermentation is driven by lactic acid bacteria, lowering pH to 5.3–5.8, while drying and maturation develop flavor, texture and aroma through biochemical processes [1], [4].

Consumer interest in game products is increasing due to their perception as natural, sustainable and premium foods. EU Regulation (EC) No. 853/2004 establishes hygiene requirements for their production and commercialization. A key factor in formulation is the balance between game meat and pork, with optimal ratios (40–60%) ensuring both sensory quality and technological performance. Higher game content intensifies flavor but may reduce juiciness, while more pork improves texture but dilutes the characteristic taste [1]–[4].

#### Material and method

The raw materials used for the own production game salami comprised: wild boar meat (*Sus scrofa*) obtained from controlled hunting operations, roe deer meat (*Capreolus capreolus*) and red deer meat (*Cervus elaphus*), sourced from licensed game processing facilities and subjected to full veterinary inspection in compliance with Regulation (EC) No. 853/2004. Pork backfat was used as the lipid fraction to ensure adequate fat content, juiciness and appropriate technological functionality during the emulsification and maturation stages. Auxiliary materials included: nitrite curing salt (NaCl + NaNO<sub>2</sub>), black pepper, garlic powder, paprika, marjoram and dextrose (as fermentation substrate for lactic acid bacteria), used according to the standardized own production recipe. Natural pork casings with a diameter of 50–60 mm, obtained from authorized suppliers, were used for stuffing. All raw and auxiliary materials were stored under controlled refrigeration conditions (0–4°C) prior to processing and met the microbiological and physicochemical requirements established by current European food safety legislation.

The manufacturing process of the game salami followed the standard technology for raw-dried, matured fermented sausages, comprising the following critical stages: trimming and preparation of game meat (removal of sinews, cartilage and fascia) followed by grinding through a 6 mm plate on the meat mincer; preparation of the pork backfat by dicing into 5–8 mm cubes and chilling to -2°C to maintain defined particle size during mixing; preparation of the curing and spice mixture and its homogeneous incorporation into the minced meat and fat; mixing in a vacuum tumbler at 4°C for 15 minutes until a cohesive, sticky batter was obtained; stuffing into natural casings using a vacuum stuffer at 0°C, followed by tying and hanging on smoking sticks; cold smoking at 18–22°C for 6–8 hours using beech wood chips, to achieve surface dehydration and the development of characteristic color and aroma; fermentation in a controlled climate chamber at 22–24°C and 90–95% relative humidity for 48–72 hours, until a pH of 5.2–5.4 was reached in the core of the product; drying and maturation at 12–14°C and 75–85% relative humidity for 21–28 days, with gradual reduction of moisture to the target level; final quality inspection, packaging under vacuum and refrigerated storage at 0–4°C until analysis [1], [2].

The game salami samples were subjected to the following physicochemical analyses, performed in triplicate: determination of moisture content by drying at 103 ± 2°C to constant mass, according to SR ISO 1442:2008 [11]; determination of total fat content by Soxhlet extraction with petroleum ether, according to SR ISO 1443:2008 [12]; determination of total protein content by the Kjeldahl method (nitrogen conversion factor N × 6.25), according to SR ISO 937:2008 [13]; determination of salt content (NaCl) by Mohr titrimetry, according to SR ISO 1841-2:2002 [14]; pH measurement with a calibrated pH-meter (pH 4 and pH 7 buffers) on a homogenate prepared in distilled water at a ratio of 1:10 (w/v), according to SR ISO 2917:2001 [15]; determination of slightly hydrolyzable / ammonia nitrogen by the Conway diffusion method in a closed chamber, according to SR ISO 2918:2001 [16]; determination of total ash content by incineration at 550°C in a muffle furnace to white ash, according to SR ISO 936:2001 [17]. The energy value was calculated using the Atwater conversion factors: proteins 4 kcal/g, fats 9 kcal/g, carbohydrates 4 kcal/g. Results are expressed as the mean ± standard deviation of three independent determinations performed on each sample.

#### Results and discussions

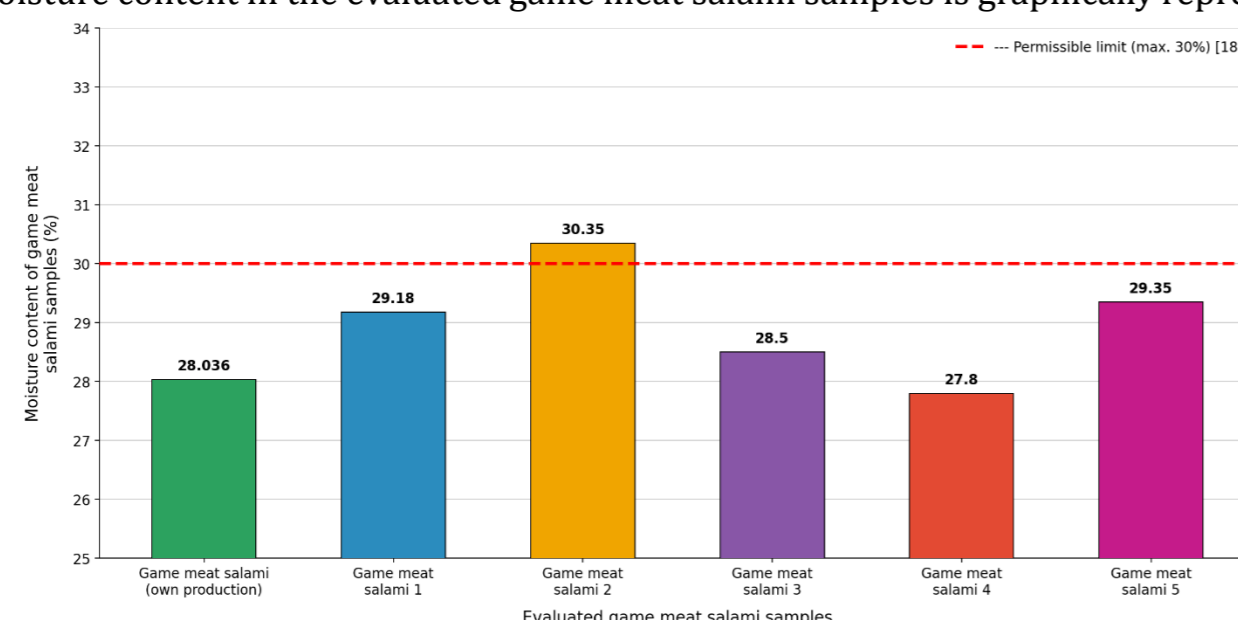
Table 1 shows the results of the physicochemical analyses for the sample of game meat salami of our own production, as well as the results of some samples of game meat salami taken from the specialized literature.

**Table 1. Results of physicochemical analyses for the game salami sample as well as the results of game meat salami samples taken from the specialized literature**

Crt No.	Game salami samples evaluated	Humidity (%)	Fat content (%)	Total protein (%)	Salt (NaCl, %)	pH	Easily hydrolyzable / ammonia nitrogen (mg NH <sub>3</sub> /100g)	Total ash (%)	Energy value (kcal/100 g)
1	Salami from game meat of our own production	28.036	30.076	27.086	4.7	5.8	11.4	9.24	401
2	Game Meat Salami 1 (Boar - 50% Wild Boar + 50% Pork) [1]	29.18	32.01	28.11	4.66	5.8	12.5	10.61	385.2
3	Game Meat Salami 2 (Wild Boar - 40% Wild Boar + 60% Pork) [1]	30.35	33.28	27.26	4.63	5.9	11.8	9.11	392.4
4	Game Meat Salami 3 (Deer - 50% Deer + 50% Pork) [2]	28.5	28.5	28.5	4.5	6.0	13.2	9.5	364.5
5	Game Salami 4 (Deer - 60% deer + 40% pork) [3, 4]	27.8	26.8	29.2	4.4	5.7	10.5	8.8	351.6
6	Game salami 5 [4]	29.35	34.79	27.36	4.59	5.6	14.0	8.50	401.3
7	Standard limits	max. 30%	max. 46%	min. 20%	max. 6%	5.3 – 6.0	max. 130 mg NH <sub>3</sub> /100g	max. 12%	—

#### Comparative evaluation of moisture content (%) in the evaluated game salami samples.

In the following figure, the variation of moisture content in the evaluated game meat salami samples is graphically represented.

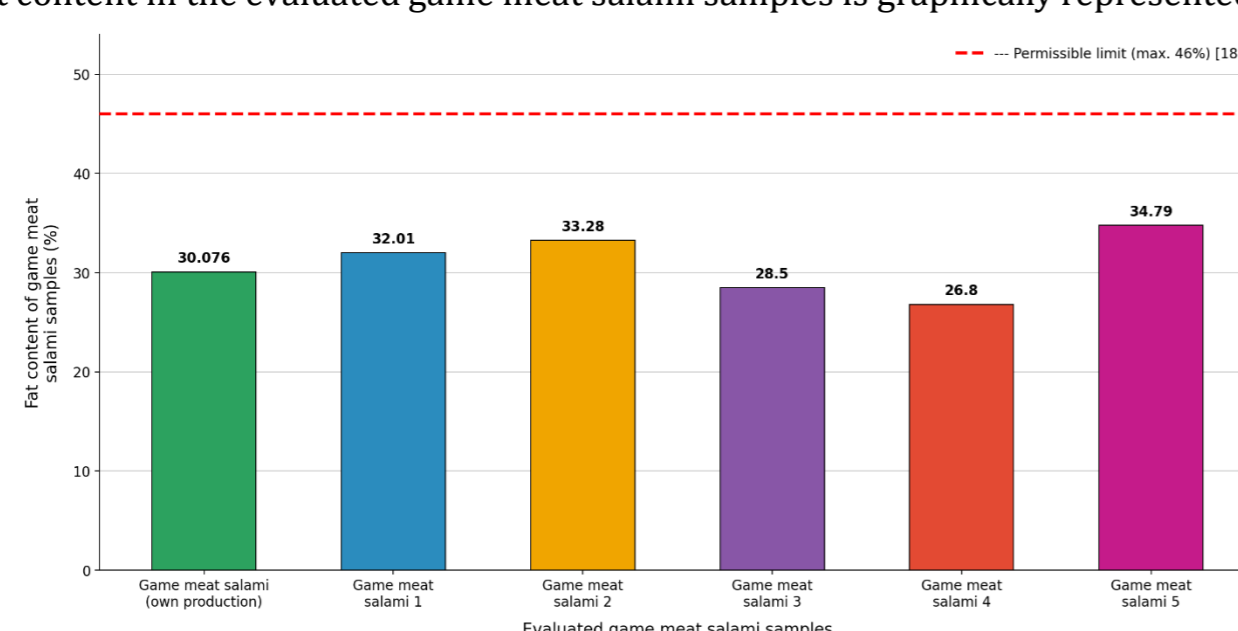


**Figure 1. Variation of moisture content in the evaluated game meat salami samples**

The moisture content of the evaluated game meat salami samples ranged from 27.8% (Game meat salami 4) to 30.35% (Game meat salami 2), all values falling below the maximum permissible limit of 30.0% established by the current standards for raw-dried matured salami [18], with the exception of Game meat salami 2 (30.35%), which marginally exceeded this threshold. The own production sample (28.036%) confirms an advanced and correctly executed drying process. Game meat salami 4 (27.8%) and Game meat salami 3 (28.5%) present the lowest moisture values, indicating a more pronounced dehydration consistent with a higher proportion of lean venison in the formulation. Game meat salami 2 (30.35%) and Game meat salami 5 (29.35%) record the highest moisture levels, associated with their higher pork content. The narrow range of moisture values across all samples (2.55 percentage points) confirms the application of similar technological drying and maturation parameters in all evaluated variants [1], [2].

#### Comparative evaluation of fat content (%) in the evaluated game salami samples.

In the following figure, the variation of fat content in the evaluated game meat salami samples is graphically represented.

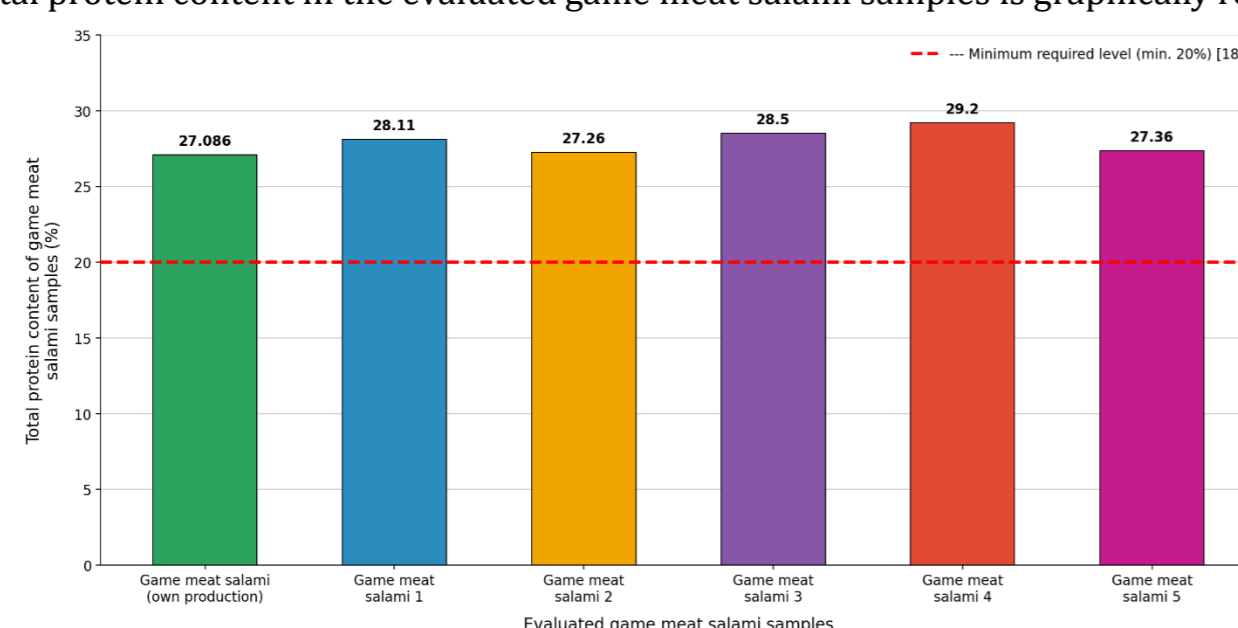


**Figure 2. Variation of fat content in the evaluated game meat salami samples**

The fat content of the analyzed samples varied between 26.8% (Game meat salami 4) and 34.79% (Game meat salami 5), all values being well within the maximum permissible limit of 46.0% [18]. The own production sample (30.076%) presents an intermediate lipid content, higher than Game meat salami 4 (26.8%) and Game meat salami 3 (28.5%), but lower than Game meat salami 5 (34.79%), Game meat salami 2 (33.28%) and Game meat salami 1 (32.01%). The higher fat values of Game meat salami 5 (100% pork — control) and Game meat salami 2 (40% wild boar + 60% pork) are explained by the greater proportion of pork meat and backfat in their composition, which has a higher intrinsic lipid content than game meat. The lower fat contents of Game meat salami 4 and Game meat salami 3 reflect the higher proportion of roe deer and roe deer meat, respectively, species characterized by an exceptionally lean lipid profile [2], [3].

#### Comparative evaluation of total protein content (%) in the evaluated game salami samples.

In the following figure, the variation of total protein content in the evaluated game meat salami samples is graphically represented.

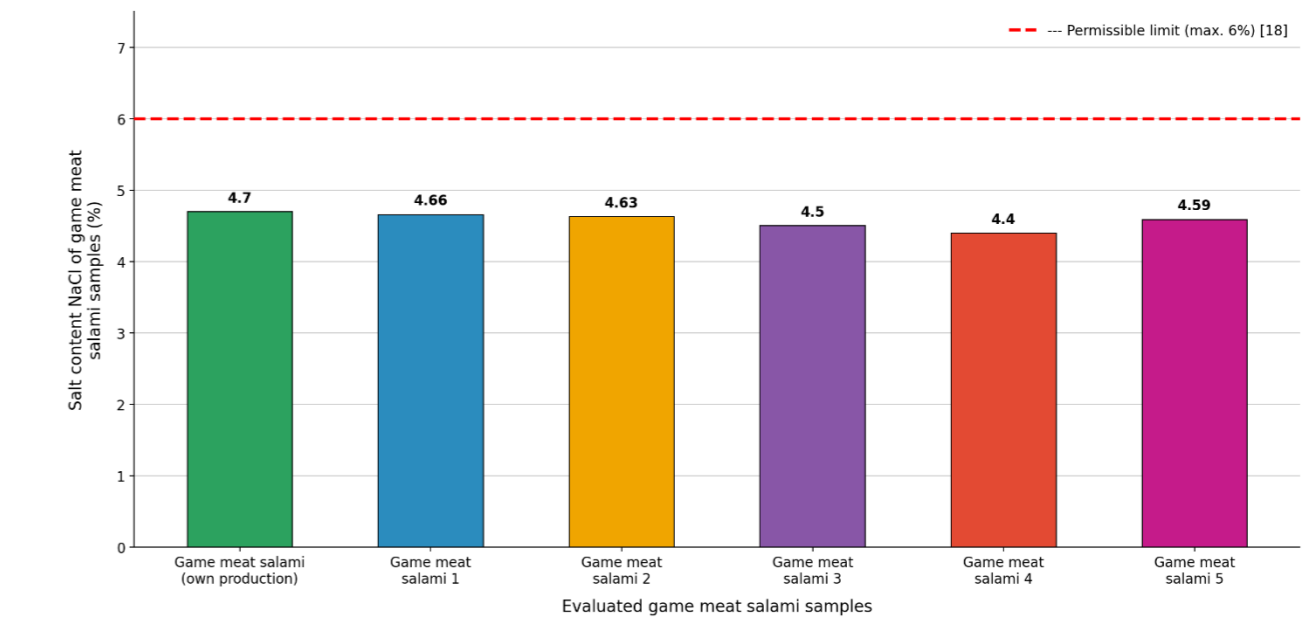


**Figure 3. Variation of total protein content in the evaluated game meat salami samples**

The total protein content of all samples exceeded the minimum required level of 20.0% established by the applicable standards [18], with values ranging from 27.086% (own production) to 29.2% (Game meat salami 4). Game meat salami 4 (29.2%) recorded the highest protein content, explained by the high proportion of lean roe deer meat (60%) used in the formulation. Game meat salami 3 (28.5%) and Game meat salami 1 (28.1%) follow with superior values, reflecting the protein contribution of roe deer and wild boar meat at 50%, respectively. The own production sample (27.086%), Game meat salami 2 (27.26%) and Game meat salami 5 (27.36%) present comparable values, all far exceeding the minimum level of 20% and confirming the superior nutritional quality of all game meat salami variants compared to conventional products [1], [4].

#### Comparative evaluation of salt content (NaCl, %) in the evaluated game salami samples.

In the following figure, the variation of salt (NaCl) content in the evaluated game meat salami samples is graphically represented.

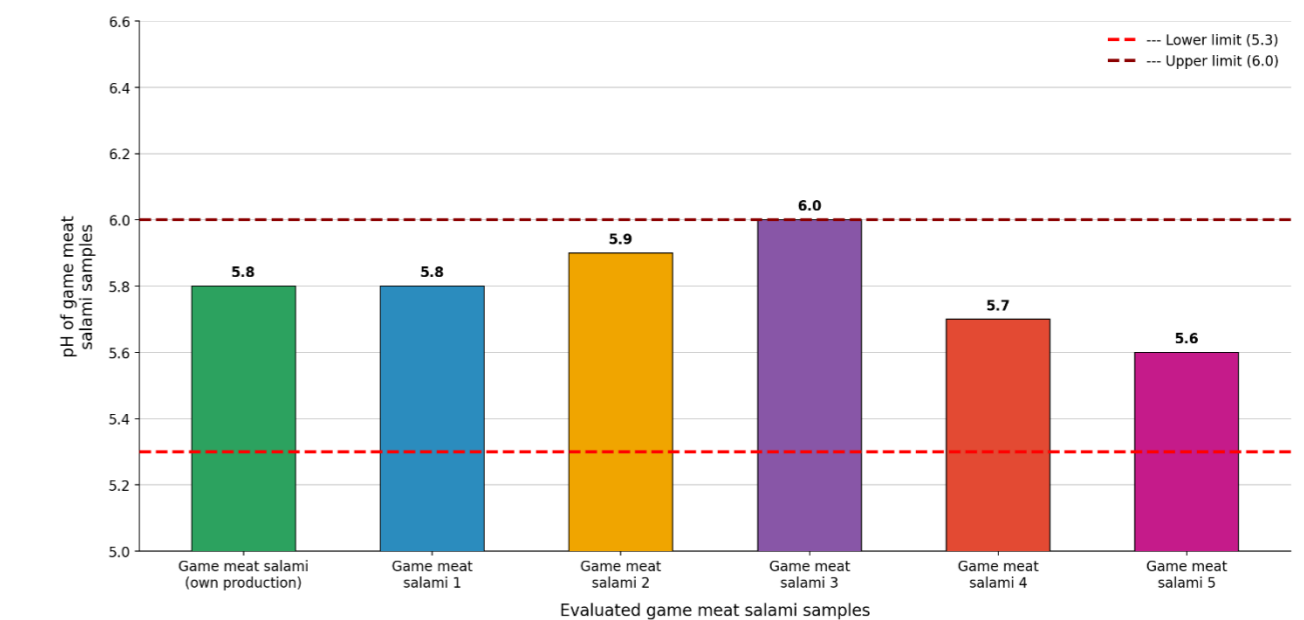


**Figure 4. Variation of salt (NaCl) content in the evaluated game meat salami samples**

The NaCl content of the analyzed samples ranged from 4.4% (Game meat salami 4) to 4.7% (own production), all values substantially below the maximum permissible limit of 6.0% [18]. The own production sample (4.7%) recorded the highest salt content, followed by Game meat salami 1 (4.66%), Game meat salami 2 (4.63%) and Game meat salami 5 (4.59%), values typical for raw-dried matured salami in which salt plays a critical role in reducing water activity and controlling microbiological stability. Game meat salami 3 (4.5%) and Game meat salami 4 (4.4%) present the lowest NaCl concentrations. The narrow variability of salt content among samples (0.3 percentage points) indicates the use of standardized recipes, with minor adjustments reflecting differences in the game species and pork ratios used [1], [2].

#### Comparative evaluation of pH in the evaluated game salami samples.

In the following figure, the variation of pH in the evaluated game meat salami samples is graphically represented.

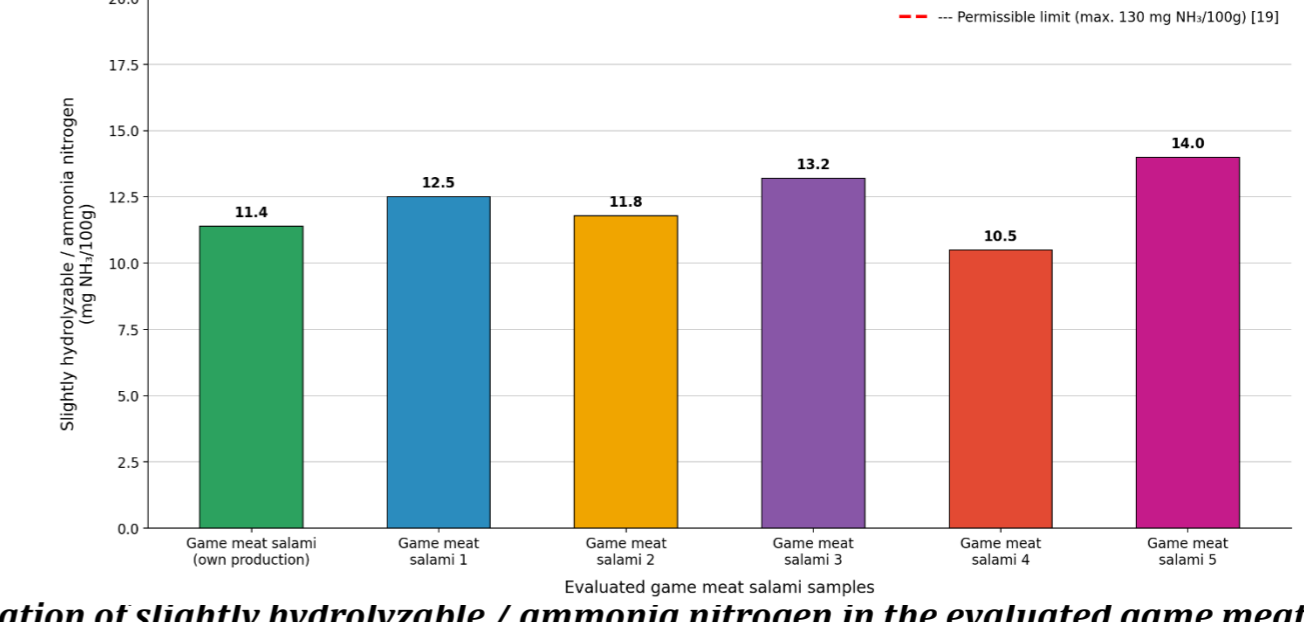


**Figure 5. Variation of pH in the evaluated game meat salami samples**

The pH values of all samples ranged from 5.6 (Game meat salami 5) to 6.0 (Game meat salami 3), all within the optimal range of 5.3–6.0 for fermented raw-dried sausages [1], [2], [18]. The own production sample (pH 5.8) and Game meat salami 1 (pH 5.8) confirm highly effective lactic acid bacteria activity during fermentation and appropriate acidification ensuring microbiological safety. Game meat salami 4 (pH 5.7) and Game meat salami 5 (pH 5.6) record the lowest pH values, indicating a more pronounced fermentation, possibly favored by the higher pork content and its lower ultimate pH. Game meat salami 2 (pH 5.9) and Game meat salami 3 (pH 6.0) present slightly higher values, which may reflect the naturally higher ultimate pH of roe deer meat compared to pork [2], [7].

#### Comparative evaluation of slightly hydrolyzable / ammonia nitrogen (mg NH<sub>3</sub>/100g) in the evaluated game salami samples.

In the following figure, the variation of slightly hydrolyzable / ammonia nitrogen in the evaluated game meat salami samples is graphically represented.

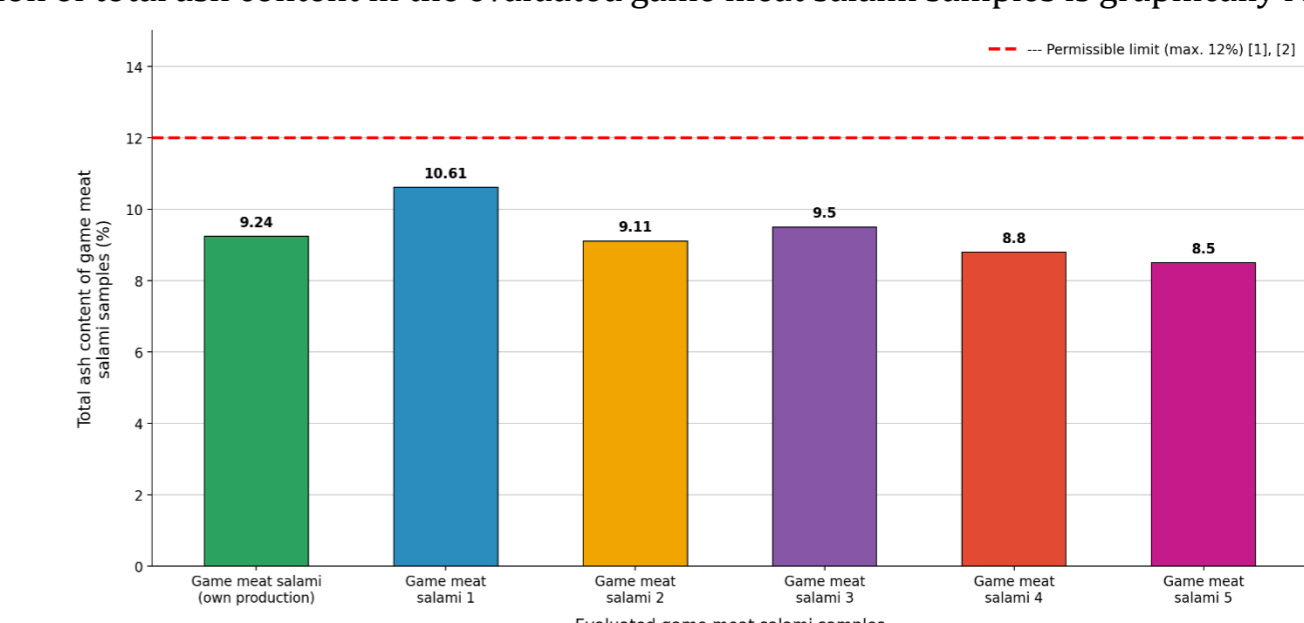


**Figure 6. Variation of slightly hydrolyzable / ammonia nitrogen in the evaluated game salami samples**

All slightly hydrolyzable nitrogen values were substantially below the critical threshold of 130 mg NH<sub>3</sub>/100g established by the Romanian sanitary norms (Ordin MS 975/1998) [19], ranging from 10.5 mg NH<sub>3</sub>/100g (Game meat salami 4) to 14.0 mg NH<sub>3</sub>/100g (Game meat salami 5). Game meat salami 4 (10.5 mg NH<sub>3</sub>/100g) and the own production sample (11.4 mg NH<sub>3</sub>/100g) present the lowest values, confirming the use of raw materials of remarkable freshness and rigorous hygiene management throughout the technological flow. Game meat salami 5 (14.0 mg NH<sub>3</sub>/100g) and Game meat salami 3 (13.2 mg NH<sub>3</sub>/100g) record the highest values, potentially associated with more intensive proteolytic activity during the maturation period. All values remain far below the critical spoilage threshold, confirming the microbiological integrity and freshness of all evaluated game meat salami variants [1], [2], [19].

#### Comparative evaluation of total ash content (%) in the evaluated game salami samples.

In the following figure, the variation of total ash content in the evaluated game meat salami samples is graphically represented.

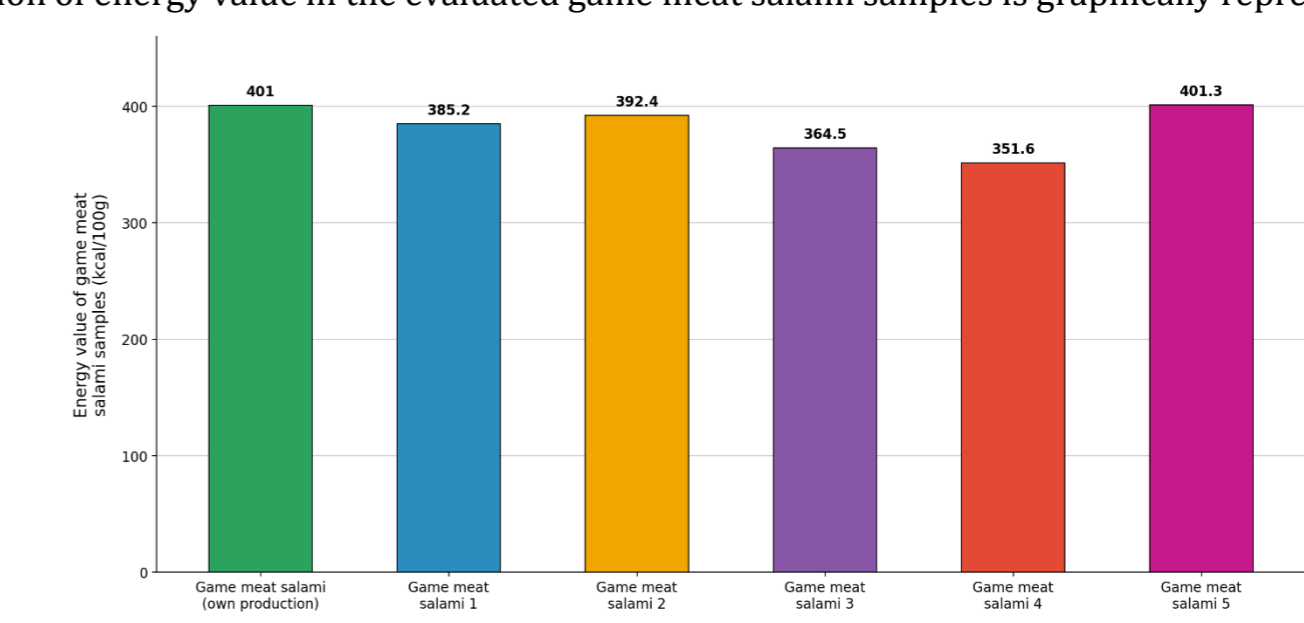


**Figure 7. Variation of total ash content in the evaluated game meat salami samples**

The total ash content ranged from 8.8% (Game meat salami 4) to 10.61% (Game meat salami 1), all values below the maximum limit of 12.0% [1], [2]. Game meat salami 1 (10.61%) and the own production sample (9.24%) present the highest ash contents, correlated with their higher salt concentrations (4.66% and 4.7%, respectively). Game meat salami 4 (8.8%) and Game meat salami 5 (8.50%) record the lowest mineral contents, in accordance with their lower NaCl levels. The direct correlation between salt content and total ash across all samples confirms that NaCl is the predominant mineral contributor in the composition of the evaluated raw-dried game meat salami [1], [4].

#### Comparative evaluation of energy value (kcal/100g) in the evaluated game salami samples.

In the following figure, the variation of energy value in the evaluated game meat salami samples is graphically represented.



**Figure 8. Variation of energy value in the evaluated game meat salami samples**

The energy value of the analyzed samples ranged from 351.6 kcal/100g (Game meat salami 4) to 401.3 kcal/100g (Game meat salami 5), directly reflecting the respective fat contents of each variant. Game meat salami 5 (401.3 kcal/100g) and the own production sample (401 kcal/100g) recorded the highest energy values, consistent with their fat contents of 34.79% and 30.076%, respectively. Game meat salami 4 (351.6 kcal/100g) and Game meat salami 3 (364.5 kcal/100g) present the lowest caloric density, associated with their reduced fat content and the higher proportion of lean venison in the formulation. No specific regulatory standard exists for the energy value of game meat salami; however, all variants present a high caloric density characteristic of raw-dried matured sausages with a significant fat content [1], [7].

#### Conclusions

Raw-dried game meat salami, including the own-production sample, fully complies with the physicochemical limits established by current regulations, confirming both the safety and the stability of the product during storage. At the same time, the obtained values highlight a high nutritional density, characteristic of game-based products, which are distinguished by a significant content of high biological value proteins and a moderate lipid intake. The own-production sample stands out in particular due to its favorable protein-to-energy ratio, reflecting a carefully balanced formulation and an efficient utilization of raw materials. Furthermore, it achieves an optimal balance between the specific sensory attributes of game meat — such as its intense flavor, characteristic color, and firm texture — and the technological requirements necessary for the proper progression of fermentation and maturation processes.

The results demonstrate that the rigorous application of technological parameters, especially during fermentation and drying stages, together with the appropriate selection of the game meat-pork fat ratio, leads to the production of a finished product that is microbiologically safe, physicochemically stable, and of superior quality. In this context, raw-dried game meat salami can be considered a premium product with high nutritional and commercial value.