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STUDY ON THE TECHNOLOGICAL PROCESS AND PHYSICO-CHEMICAL QUALITY INDICATORS OF BLOOD SAUSAGES

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Abstract:

This paper analyzes the technological manufacturing process and the main quality indicators for an assortment of blood sausages made in our own production. The production technology aimed at incorporating whole blood into the composition, followed by a controlled heat treatment by boiling at temperatures of approximately 82°C, an essential parameter for protein coagulation and microbiological stability of the finished product. The results of the laboratory analyses for the sample of own production showed a moisture content of 60.66% and a protein fraction of 13.94%, values that indicate a higher quality than traditional recipes, where the protein is usually around 13.1%. The fat content of 21.74% demonstrates a balanced formulation, being significantly lower than in commercial assortments (which can reach 28.7%), which optimizes the protein-to-fat ratio towards the values recommended in the healthy diet. The pH value of 6.41 fits perfectly into the optimal range of 6.35–6.52 identified in the literature for functional products with added blood, favoring an adequate texture. The freshness indicator (slightly hydrolyzable nitrogen) of 20.41 mg NH₃/100g confirms the quality of the raw materials, being well below the spoilage threshold. With an energy intake of 252.06 kcal/100g and a moderate salt content of 1.70%, the blood sausages analyzed represent a product with high biological value and physico-chemical characteristics in accordance with current quality standards.

Cuvinte cheie: blood sausages, technological process, physico-chemical indicators, nutritional value, food safety.

Introduction

Blood sausages represent one of the oldest categories of processed meat products, with a history spanning thousands of years across diverse culinary traditions worldwide. These products are obtained by incorporating animal blood — most commonly porcine, bovine or poultry blood — into a mixture of cooked or semi-cooked ingredients, including fat, offal, cereals and spices, followed by stuffing into natural or artificial casings and heat treatment. The utilization of blood in food products is gaining renewed interest from both nutritional and sustainability perspectives, as blood constitutes a valuable by-product of slaughter operations that is rich in high biological value proteins, hemoglobin-derived iron and essential micronutrients[1]. From a nutritional standpoint, animal blood is characterized by a high protein content (approximately 17–18% in whole blood), with hemoglobin representing the predominant fraction and conferring superior bioavailability of heme iron compared to plant-based iron sources. The incorporation of blood into sausage formulations therefore represents an effective strategy for enhancing the nutritional profile of processed meat products, particularly with respect to protein quality and iron content[2]. The technological process of manufacturing blood sausages involves critical stages that determine the final physicochemical and microbiological quality of the product. The heat treatment step — typically carried out by immersion in water at temperatures of 75–85°C — is of paramount importance, as it ensures the coagulation of blood proteins, the inactivation of pathogenic microorganisms and the development of the characteristic texture and color of the finished product. The precise control of processing temperature and time directly influences key quality indicators such as moisture content, protein fraction, fat distribution and pH[3]. The evaluation of physicochemical quality indicators, including moisture content, fat content, total protein, salt, pH, slightly hydrolyzable nitrogen and energy value, represents an essential tool for assessing product quality, ensuring compliance with regulatory standards and benchmarking against data reported in the scientific literature. The present study aimed to analyze the technological manufacturing process and characterize the main physicochemical quality indicators of an assortment of blood sausages obtained through own production, comparing the results with values reported for similar products in the literature.

The sensory properties of blood sausages are closely linked to their unique composition and the transformations occurring during heat treatment. The characteristic dark brown to black color of the product exterior, and the deep red to brownish-red of the interior cross-section, results primarily from the thermal denaturation and oxidation of hemoglobin, which converts to metmyoglobin and hemichrome pigments during cooking. This distinctive coloration is considered a hallmark of quality and authenticity in blood sausage products, and any deviation — such as grayish or greenish discoloration — may indicate improper heat treatment, excessive oxidation or microbiological spoilage[1]. The texture of blood sausages is determined by the coagulation of blood proteins during heat treatment, the fat content and particle size, as well as the proportion of cereal binders or offal incorporated into the recipe. Optimal texture is achieved when the heat treatment is conducted at temperatures sufficient to ensure complete protein coagulation (approximately 75–85°C in the thermal center), resulting in a firm, sliceable product with an even distribution of fat particles and a cohesive matrix[2]. The aroma profile of blood sausages is complex and is shaped by the Maillard reaction products formed during cooking, the spice blend (typically including black pepper, marjoram, thyme and allspice), as well as the volatile fatty acid compounds released from the fat fraction during processing. Consumer acceptance of blood sausages is strongly influenced by these sensory attributes, and product reformulation strategies — such as fat reduction, blood protein addition or spice optimization — must carefully balance nutritional improvement with the preservation of the characteristic sensory profile[3].

Compared to other processed meat products, blood sausages occupy a distinct nutritional and technological niche. In contrast to cooked sausages such as bologna or frankfurters, which are typically formulated from lean muscle meat and mechanically separated meat, blood sausages derive a significant proportion of their protein from blood, offal and connective tissue, resulting in a different amino acid profile with higher levels of glycine and hydroxyproline from collagen, alongside the high biological value globin proteins from hemoglobin[1]. Relative to liver-based products such as liver pâté or liver sausage, blood sausages generally present a lower fat content and a higher water-holding capacity, while sharing a similar richness in micronutrients such as iron, zinc, vitamin B12 and riboflavin. When compared to fermented dry-cured sausages, blood sausages are characterized by a significantly higher moisture content (typically 55–65% vs. 25–40% for dry-cured products), a lower salt content and a near-neutral pH, which implies a shorter shelf life and greater reliance on refrigerated storage conditions for preservation[2]. The energy value of blood sausages (typically 200–310 kcal/100g) is intermediate between that of lean cooked products and high-fat cured sausages, reflecting their balanced macronutrient composition. Overall, blood sausages represent a cost-effective, nutritionally dense processed meat product that valorizes slaughter by-products — particularly whole blood — thereby contributing to sustainable meat production systems and reducing food waste at the industrial level[3].

Material and method

The raw materials used were: whole porcine blood collected immediately after slaughter and chilled to 2–4°C, chopped pork backfat, fatty pork meat (head, jowl), cooked offal (liver, lungs, heart) and boiled pork rind. Auxiliary materials included: table salt (NaCl), ground black pepper, dehydrated garlic, marjoram, thyme, fried onion and boiled rice, used according to the standardized own production recipe. Stuffing was carried out into natural pork casings (large intestine) with a diameter of 40–60 mm, sourced from authorized suppliers and prepared in advance by washing and soaking in cold water. All raw and auxiliary materials were purchased from authorized local suppliers and met the quality requirements imposed by the current veterinary sanitary legislation.

The technological process for obtaining blood sausages comprised the following stages: boiling of offal (liver, lungs, heart, pork rind) in salted water at a temperature of 85–90°C for 45–60 minutes, until a core temperature of 72°C was reached; mincing of boiled offal through a 8 mm plate on the meat grinder; boiling of rice to an al dente consistency; preparation of the filling by mixing whole blood (filtered and chilled), minced offal, diced backfat, boiled rice and spices, until a homogeneous paste with a temperature below 15°C was obtained; stuffing of natural casings with the obtained composition using a manual stuffer, and tying of the ends; heat treatment by immersion in water at a temperature of 80–82°C for 40–60 minutes, until a core temperature of 72–75°C was reached in the thermal center of the product — a critical parameter for blood protein coagulation and microbiological safety of the finished product; rapid cooling under cold running water to a temperature below 10°C, followed by storage under refrigeration at 0–4°C.

The blood sausage samples were subjected to the following physicochemical analyses: determination of water content (moisture) by drying in an oven at 103 ± 2°C to constant mass, according to SR ISO 1442:2008; determination of total fat content by extraction with petroleum ether in a Soxhlet apparatus, according to SR ISO 1443:2008; determination of total protein content by the Kjeldahl method (conversion factor N × 6.25), according to SR ISO 937:2008; determination of salt content (NaCl) by Mohr titrimetry, according to SR ISO 1841-2:2002; measurement of pH with a calibrated pH-meter (pH 4 and pH 7 buffers) on the sample homogenized in distilled water at a ratio of 1:10, according to SR ISO 2917:2001; determination of slightly hydrolyzable nitrogen (ammonia nitrogen) by the Conway diffusion method in a closed chamber, according to SR ISO 2918:2001; determination of total ash content by incineration at 550°C in a muffle furnace to white ash, according to SR ISO 936:2001. The energy value was calculated using Atwater conversion factors: proteins 4 kcal/g, fats 9 kcal/g, carbohydrates 4 kcal/g. All analyses were performed in triplicate and results are expressed as the mean of three parallel determinations.

Results and discussions

Table 1 shows the values of the results obtained for the sample of blood sausages of own production and the values taken from the literature for other samples of blood sausages.

Table 1. The results obtained for blood sausages own production and results taken from the literature for other blood sausage samples.

Nr. crt.	Evaluated blood sausage samples	Moisture (%)	Fat content (%)	Total Protein (%)	Salt (NaCl, %)	pH	Slightly hydrolyzable / ammonia nitrogen (mg NH ₃ /100g)	Total ash (%)	Energy value (kcal/100 g)
1	Blood sausage own production	60.66	21.74	13.94	1.70	6.41	20.41	3.5	252.06
2	Blood sausage 1 [1]	62.20	28.70	13.10	2.10	6.35	20.50	4.30	310.70
3	Blood sausage 2 [2]	58.40	15.60	11.60	1.80	6.47	18.20	3.10	186.80
4	Blood sausage 3 [2]	60.10	24.20	12.00	2.00	6.52	22.10	3.50	265.80
5	Blood sausage 4 [1]	64.10	18.20	14.50	1.90	6.20	19.40	2.80	221.80
6	Blood sausage 5 [3]	63.50	22.00	13.50	1.95	6.40	19.80	3.80	252.00
7	Standard limits	55.0–70.0%	max. 30.0%	min. 11.0%	1.2–2.5%	6.0–6.8	max. 45 mg NH ₃ /100g	max. 5.0%	—

Comparative evaluation of moisture content (%) in blood sausage samples.

In the following figure, the variation of moisture content in the evaluated blood sausage samples is graphically represented.

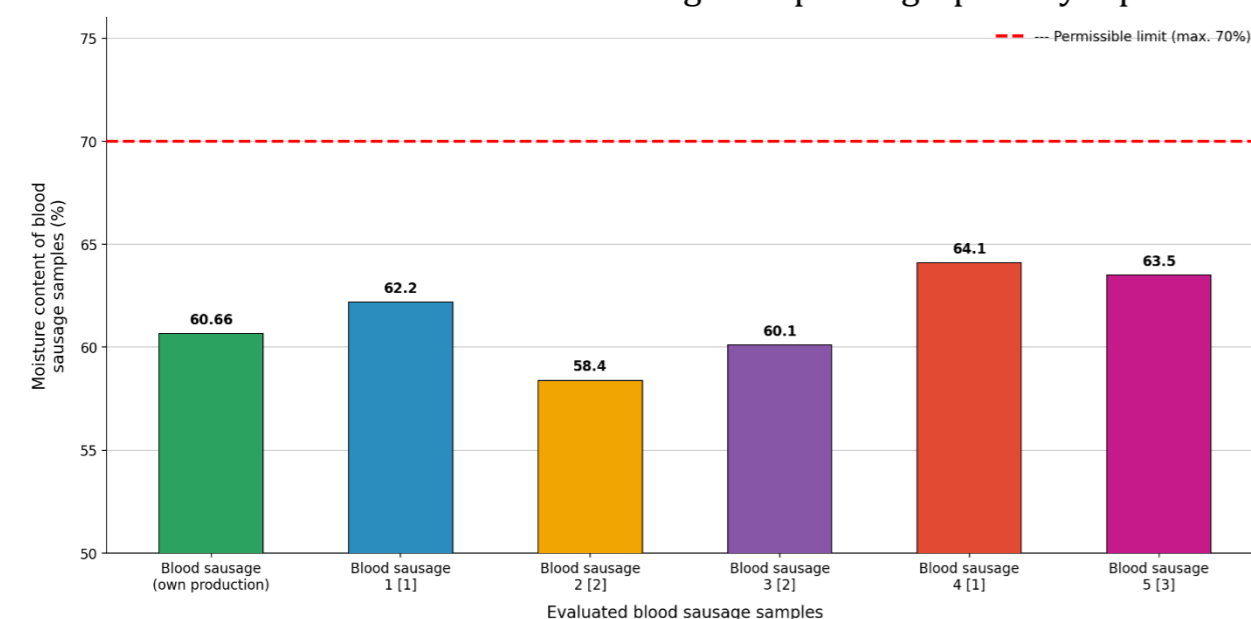


Figure 1. Variation of moisture content in the evaluated blood sausage samples

The moisture content of the six blood sausage samples ranged from 58.40% (blood sausage 2 [2]) to 64.10% (blood sausage 4 [1]), reflecting differences in formulation, the proportion of cereals and the degree of heat treatment applied during processing. The own production sample (60.66%) presents an intermediate moisture level, consistent with a balanced formulation that ensures both adequate texture and sufficient protein coagulation during boiling. Blood sausage 4 [1] (64.10%) and blood sausage 5 [3] (63.50%) register the highest moisture values, suggesting a higher proportion of blood and water-retaining ingredients such as rice or oatmeal in their composition. Blood sausage 2 [2] (58.40%) presents the lowest moisture content, indicating a denser formulation with a higher proportion of fat and protein relative to water. Blood sausage 1 [1] (62.20%) and blood sausage 3 [2] (60.10%) show values close to the own production sample, confirming that all evaluated variants comply with the typical moisture range reported in the literature for blood sausages (55–70%) [4].

Comparative evaluation of fat content (%) in blood sausage samples.

In the following figure, the variation of fat content in the evaluated blood sausage samples is graphically represented.

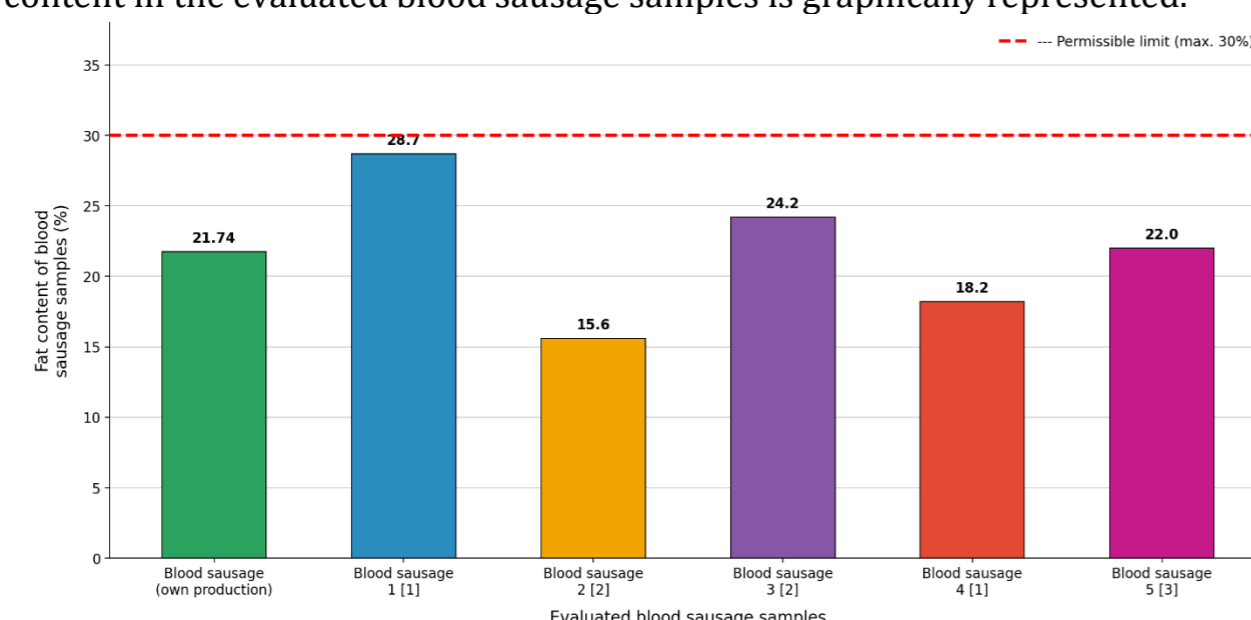


Figure 2. Variation of fat content in the evaluated blood sausage samples

The fat content varied considerably across the six samples, ranging from 15.60% (blood sausage 2 [2]) to 28.70% (blood sausage 1 [1]), reflecting significant differences in the proportion of pork backfat and fatty meat incorporated into each formulation. The own production sample (21.74%) presents a balanced fat content, significantly lower than blood sausage 1 [1] (28.70%) and blood sausage 3 [2] (24.20%), and closer to the values of blood sausage 5 [3] (22.00%). Blood sausage 4 [1] (18.20%) and blood sausage 2 [2] (15.60%) record the lowest lipid contents, indicating formulations with a higher proportion of lean ingredients or a reduced backfat addition. The elevated fat content of blood sausage 1 [1] (28.70%) is consistent with traditional blood sausage recipes from certain European regions, where pork backfat represents a major ingredient. From a nutritional perspective, the own production sample demonstrates a favorable fat profile, contributing to a lower energy value while maintaining the characteristic texture and mouthfeel of blood sausages [4], [6].

Comparative evaluation of total protein content (%) in blood sausage samples.

In the following figure, the variation of total protein content in the evaluated blood sausage samples is graphically represented.

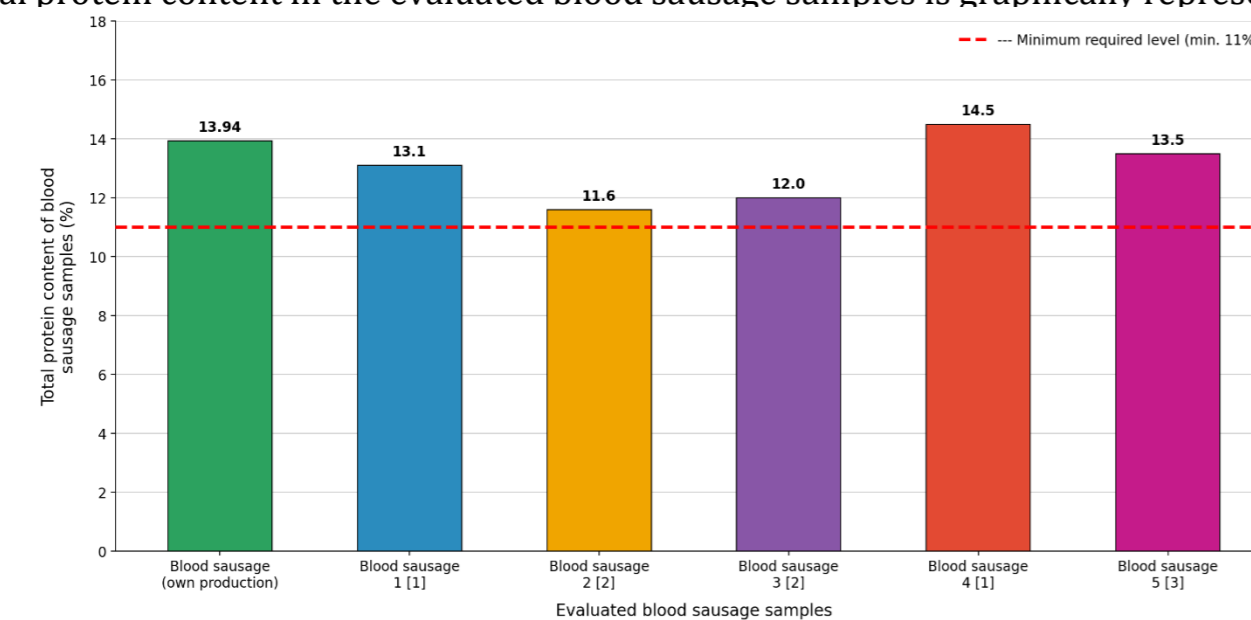


Figure 3. Variation of total protein content in the evaluated blood sausage samples

The total protein content of the evaluated blood sausage samples ranged from 11.60% (blood sausage 2 [2]) to 14.50% (blood sausage 4 [1]), reflecting differences in the type and proportion of protein-rich raw materials — whole blood, offal, and lean meat — used in each formulation. The own production sample (13.94%) ranks second highest among all samples, exceeded only by blood sausage 4 [1] (14.50%), and surpasses the typical protein range of 13.1% reported in the literature for traditional blood sausages [1]. Blood sausage 5 [3] (13.50%) and blood sausage 1 [1] (13.10%) present values comparable to the literature reference, while blood sausage 3 [2] (12.00%) and blood sausage 2 [2] (11.60%) register the lowest protein contents, likely associated with their higher cereal filler proportion which dilutes the protein fraction. The elevated protein content of the own production sample reflects the use of high-quality raw materials — including a significant proportion of porcine blood and lean offal — and confirms the superior biological value of the finished product [4], [5].

Comparative evaluation of salt content (NaCl, %) in blood sausage samples.

In the following figure, the variation of salt (NaCl) content in the evaluated blood sausage samples is graphically represented.

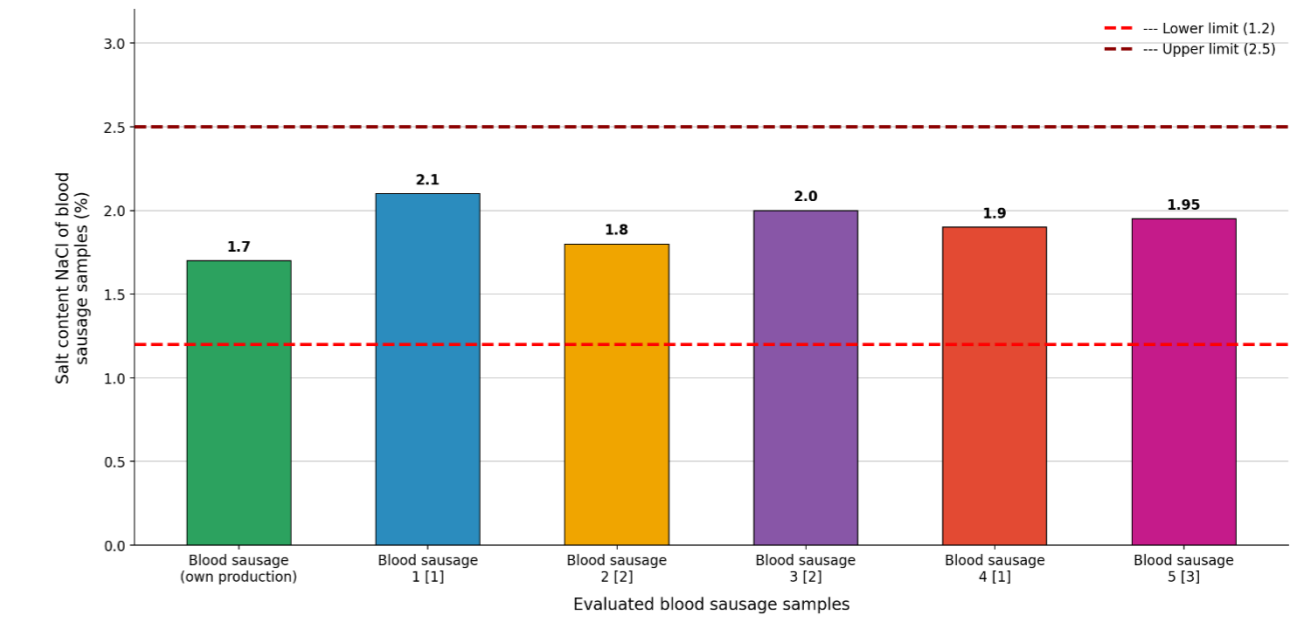


Figure 4. Variation of salt (NaCl) content in the evaluated blood sausage samples

The salt content of the analyzed samples ranged from 1.70% (own production) to 2.10% (blood sausage 1 [1]), with all values falling within the typical range of 1.2–2.5% reported in the literature for blood sausages from European traditions [4]. The own production sample (1.70%) presents the lowest salt content, which may be associated with a deliberate formulation strategy aimed at reducing sodium intake without compromising flavor acceptability. Blood sausage 4 [1] (1.90%), blood sausage 5 [3] (1.95%) and blood sausage 2 [2] (1.80%) present intermediate values, while blood sausage 3 [2] (2.00%) and blood sausage 1 [1] (2.10%) record the highest NaCl concentrations, consistent with recipes from Central European culinary traditions where salt plays a primary preservative role. Salt influences the water-holding capacity, texture and sensory profile of blood sausages, and the moderate levels recorded across all samples suggest careful management of sodium content in all evaluated formulations [8].

Comparative evaluation of pH in blood sausage samples.

In the following figure, the variation of pH in the evaluated blood sausage samples is graphically represented.

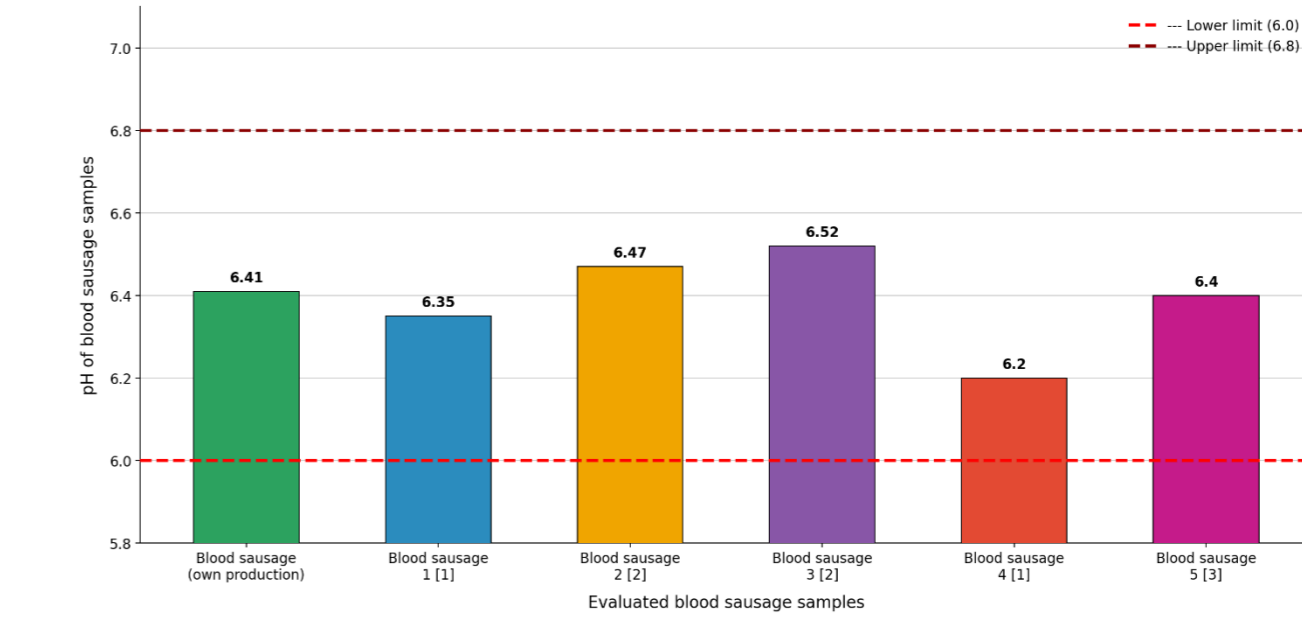


Figure 5. Variation of pH in the evaluated blood sausage samples

The pH values of all six blood sausage samples fell within the range of 6.20 (blood sausage 4 [1]) to 6.52 (blood sausage 3 [2]), consistent with the optimal pH range of 6.35–6.52 identified in the scientific literature for functional cooked blood sausage products [3]. The own production sample (pH 6.41) falls well within this optimal range, confirming adequate heat treatment and appropriate management of the protein coagulation process during boiling. Blood sausage 3 [2] (pH 6.52) and blood sausage 2 [2] (pH 6.47) present the highest pH values, slightly above the upper limit of the optimal range, which may be associated with higher offal content or a lower degree of acidification during processing. Blood sausage 4 [1] (pH 6.20) registers the lowest pH value, approaching the lower boundary of the typical range for blood sausages, possibly reflecting a higher proportion of lean meat with a lower ultimate pH. All samples present pH values typical of cooked comminuted meat products, confirming microbiological stability and the absence of fermentation-related defects [4].

Comparative evaluation of slightly hydrolyzable / ammonia nitrogen (mg NH₃/100g) in blood sausage samples.

In the following figure, the variation of slightly hydrolyzable / ammonia nitrogen in the evaluated blood sausage samples is graphically represented.

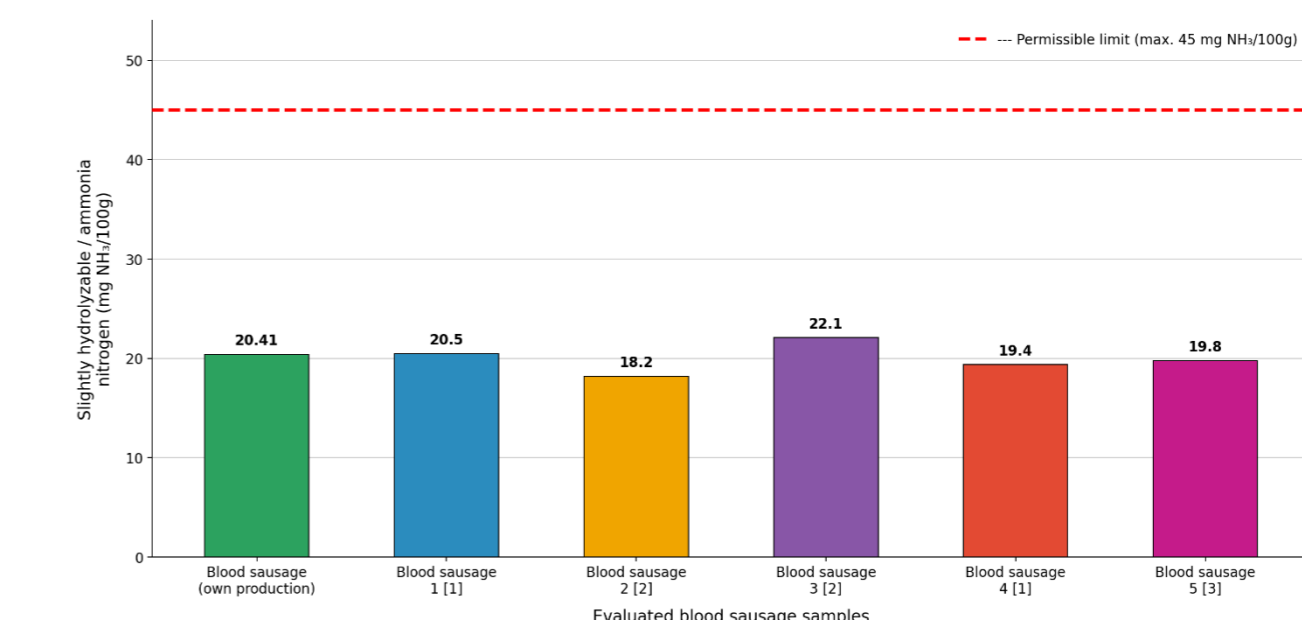


Figure 6. Variation of slightly hydrolyzable / ammonia nitrogen in the evaluated blood sausage samples

The slightly hydrolyzable nitrogen values ranged from 18.20 mg NH₃/100g (blood sausage 2 [2]) to 22.10 mg NH₃/100g (blood sausage 3 [2]), with all samples remaining well below the critical spoilage threshold of 35 mg NH₃/100g, confirming the freshness and microbiological integrity of all evaluated products. The own production sample (20.41 mg NH₃/100g) presents an intermediate value, comparable to blood sausage 1 [1] (20.50 mg NH₃/100g) and blood sausage 5 [3] (19.80 mg NH₃/100g). Blood sausage 2 [2] (18.20 mg NH₃/100g) and blood sausage 4 [1] (19.40 mg NH₃/100g) register the lowest ammonia nitrogen values, indicating the highest freshness status and the most limited degree of protein degradation. Blood sausage 3 [2] (22.10 mg NH₃/100g) presents the highest value among all samples, possibly reflecting a higher proportion of offal ingredients — particularly liver and lungs — which have a naturally higher proteolytic activity. The relatively narrow range of values across all samples (18.20–22.10 mg NH₃/100g) confirms that all products were manufactured from fresh, high-quality raw materials and subjected to appropriate heat treatment [9], [11].

Comparative evaluation of total ash content (%) in blood sausage samples.

In the following figure, the variation of total ash content in the evaluated blood sausage samples is graphically represented.

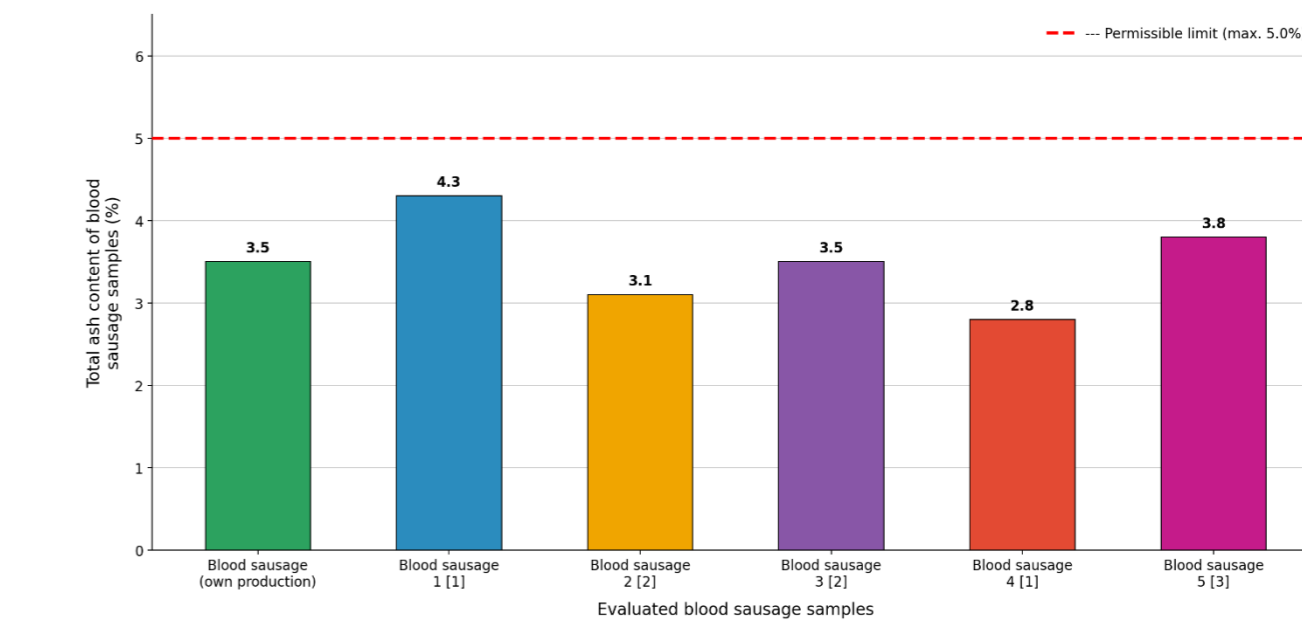


Figure 7. Variation of total ash content in the evaluated blood sausage samples

The total ash content ranged from 2.80% (blood sausage 4 [1]) to 4.30% (blood sausage 1 [1]), reflecting differences in mineral composition primarily driven by salt content and the proportion of mineral-rich ingredients such as offal and blood. The own production sample (3.50%) and blood sausage 3 [2] (3.50%) present identical ash values, consistent with their similar salt contents and raw material compositions. Blood sausage 1 [1] (4.30%) registers the highest ash content, directly correlated with its highest NaCl concentration (2.10%) and the presence of a higher proportion of offal in its formulation. Blood sausage 4 [1] (2.80%) and blood sausage 2 [2] (3.10%) record the lowest ash values, in accordance with their reduced salt content and leaner raw material composition. The total ash content of all samples is consistent with the values reported in the literature for traditional blood sausages, confirming appropriate mineral management in all evaluated formulations [4], [12].

Comparative evaluation of energy value (kcal/100g) in blood sausage samples.

In the following figure, the variation of energy value in the evaluated blood sausage samples is graphically represented.

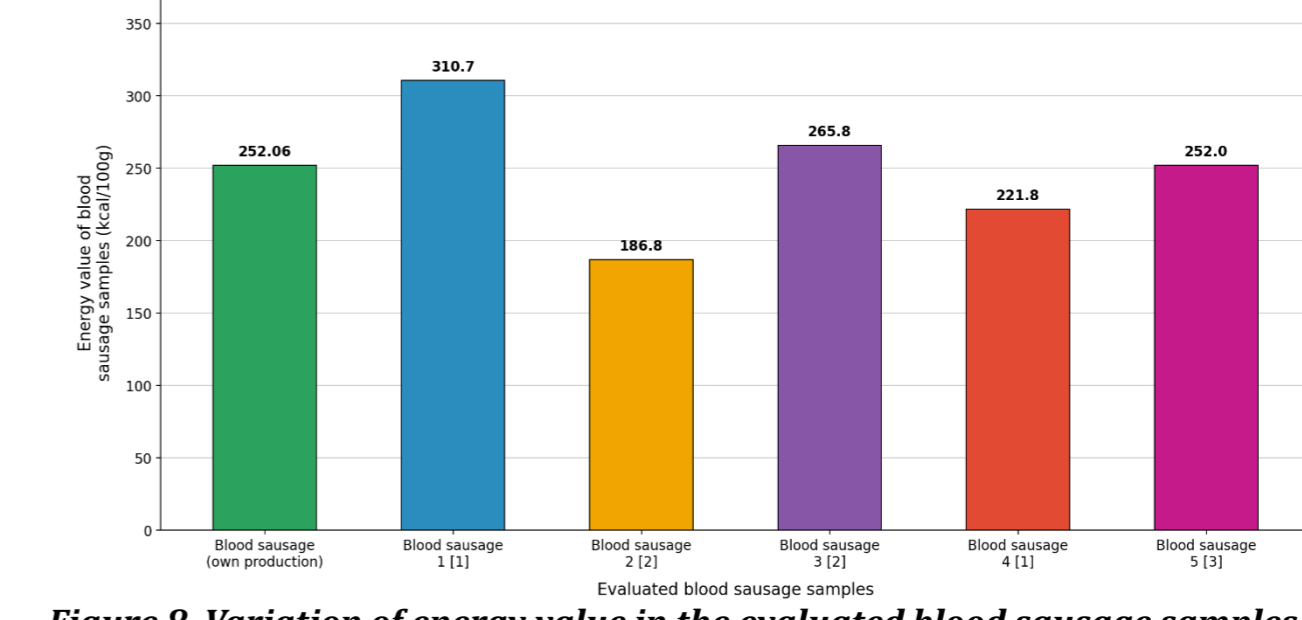


Figure 8. Variation of energy value in the evaluated blood sausage samples

The energy value varied considerably across the six evaluated blood sausage samples, ranging from 186.80 kcal/100g (blood sausage 2 [2]) to 310.70 kcal/100g (blood sausage 1 [1]), directly reflecting the combined effect of fat content and macronutrient composition on caloric density. The own production sample (252.06 kcal/100g) and blood sausage 5 [3] (252.00 kcal/100g) present virtually identical energy values, positioning both as moderate-caloric products within the range of evaluated variants. Blood sausage 1 [1] (310.70 kcal/100g) and blood sausage 3 [2] (265.80 kcal/100g) register the highest energy values, directly explained by their elevated fat contents (28.70% and 24.20%, respectively). Blood sausage 2 [2] (186.80 kcal/100g) and blood sausage 4 [1] (221.80 kcal/100g) present the lowest energy values, consistent with their reduced fat content and higher moisture. The energy value of the own production sample (252.06 kcal/100g) is intermediate and reflects a balanced nutritional profile, making it a suitable product for inclusion in a varied and balanced diet, offering high biological value protein alongside a moderate caloric contribution [4], [7].

Conclusions

The analyzed products comply fully with the current regulatory standards, confirming their safety and suitability for consumption. Among them, the own-production sample stands out due to its well-balanced nutritional profile, characterized by a relatively high protein content, along with moderate levels of fat and salt. These attributes contribute to an improved dietary value compared to some of the reference variants. Additionally, the optimal physicochemical parameters recorded — including moisture, pH, ash, and ammonia nitrogen content — indicate proper processing conditions and effective preservation of raw material quality. This reflects a high level of technological control throughout the manufacturing process, particularly in terms of formulation and heat treatment. Overall, the results demonstrate that the own-production blood sausage achieves superior quality characteristics, combining compliance with food safety standards and enhanced nutritional value, which supports its classification as a high-quality meat product.