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Analytical Study on the Influence of Meat Mixture on the Quality of Smoked Sausages

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Abstract
This study aims to analyze the processing and quality characteristics of smoked sausages formulated from a balanced recipe using different proportions of meat mixtures consisting of pork, beef and mutton. Furthermore, it evaluates the influence of meat composition on product quality through sensory and physicochemical analyses. The results are intended to provide a better understanding of how different meat combinations affect the technological, physicochemical, and sensory properties of smoked sausages. The sausages were manually processed by grinding the meat and fat, blending them with spices, stuffing them into natural casings, and smoking over hardwood. The findings indicate that the composition of the meat mixture plays a significant role in determining physicochemical and sensory quality. The formulation with 25% mutton provided the best balance between physicochemical parameters and sensory attributes, making it the most suitable option for obtaining a stable and acceptable traditional product. Additionally, all formulations maintained appropriate pH and mineral content levels, ensuring good technological performance and microbiological stability.
Keywords: sausages; smoked sausages; meat mixture sausages; pork, beef and mutton sausages.

1. Introduction

Since ancient times, people have sought effective methods for preserving meat, and smoking, salting, and drying have become essential practices in the evolution of food processing technologies. Smoked sausages emerged as an ingenious way to make full use of animal resources while providing a product with extended shelf life and complex flavors [1-4].
In Central and Eastern Europe, smoked sausages have gained a special status, being associated with rural traditions and household customs passed down from generation to generation. In Romania, they are part of the national gastronomic identity, varying according to region, spices used, smoking technique, and the blend of meats employed [5,6].
Meat itself is a complex food, rich in complete proteins, lipids, B-complex vitamins, and essential minerals such as iron and zinc. The nutritional composition and technological properties of meat products are significantly influenced by the animal species, its age and physiological condition, as well as the ratio between muscle, fat, and connective tissue. Smoking, an essential stage in developing the aromatic profile of sausages and extending their shelf life, must be carried out with strict control over the smoke source (resin-free wood), duration, and temperature, in order to prevent the formation of potentially harmful compounds (such as benzo(a)pyrene), while ensuring compliance with current European legislation [7].
Smoked sausages belong to a traditional category of products in which smoking, carried out with natural wood smoke, plays an essential role both in the

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development of sensory characteristics and in extending shelf life. This type of product is particularly appreciated in regions with a strong tradition of meat processing, being associated with homemade preparations whose recipes are passed down from generation to generation [3].

Sausages are meat products obtained by finely or semi-finely mincing meat, mixing it with fat, spices, and other functional ingredients, followed by stuffing the mixture into natural or artificial casings and applying specific technological treatments.

According to the specialized literature, sausages can be classified based on several criteria: by the thermal treatment applied (raw, cooked, smoked, dried), by the type of casing used (natural, collagen, cellulose), and by water content or shelf life [4].

In Romania, smoked sausages have become an integral part of traditional culinary culture, being indispensable during winter holidays or family gatherings. Regional diversity has given rise to unique recipes adapted to local resources; in mountainous areas, mutton is predominant, while in lowland regions, mixtures of pork and beef are preferred. Traditional Romanian products are now recognized at the European level through protected geographical indication (PGI) and designation of origin (PDO) schemes, emphasizing the importance of preserving authenticity and quality [5,6].

Before the development of modern meat preservation and processing methods such as refrigeration and freezing, drying and smoking were traditional techniques used to extend the shelf life of meat, and homemade sausages served as an effective means of preserving and utilizing pork over longer periods [7-10].

This study examines the processing and quality characteristics of raw (unsmoked) and smoked sausages made with varying proportions of pork, beef, and mutton. It focuses on how meat composition influences product quality based on sensory and physicochemical analyses, providing insights into the impact of different meat combinations on the technological and sensory attributes of smoked sausages.

2. Materials and method

2.1. Materials

Three experimental batches of sausages were prepared using different proportions of pork, beef, and mutton to evaluate the influence of meat composition on product quality in both raw (unsmoked) and smoked forms. Pork (40%) served as the base meat, complemented by varying ratios of beef and mutton, while pork fat (10%) was added to ensure adequate texture and flavor balance. The formulations used were as follows:

- Sample 1 (control): 40% pork, 20% beef, 30% mutton, 10% pork fat;
- Sample 2: 40% pork, 30% beef, 20% mutton, 10% pork fat;
- Sample 3: 40% pork, 25% beef, 25% mutton, 10% pork fat.

The raw materials and ingredients used to obtain the traditional sausages, made from different proportions of pork, beef, and mutton (Figure 1) can be grouped into the following categories: meat and fat, spices and natural additives, casings, and auxiliary materials [.

2.1.1. Meat and Fat

Pork meat was obtained from semi-fat cuts (shoulder, neck) with a moderate intramuscular fat content, free of cartilage or tendons.

Beef meat was selected from lower muscle cuts (foreleg), partially trimmed of fat. This meat is high in protein and low in fat.

Mutton was sourced from young carcasses (up to 12 months old), consisting of moderately fatty muscles, carefully trimmed before use.

Pork back fat was obtained from the dorsal layer, with a firm texture, white color, and free of foreign odors.

All raw materials were refrigerated at 0–4°C and processed within 48 hours after slaughter, under hygienic and food safety conditions.

Figure 1. – Traditional sausage made from different proportions of pork, beef, and mutton

2.1.2. Spices and Natural Additives

The spices used were of superior quality, sourced

from reliable suppliers, and carefully measured to achieve an optimal aromatic balance.

2.1.3. Natural Casings

For stuffing the sausage mixture, natural pork casings were used, with a diameter of 32–36 mm, thoroughly cleaned, washed, and desalted before use. The casings were soaked for 2 hours in cold water and then rinsed with warm water to restore elasticity. Natural casings give the product a distinct traditional appearance, excellent smoke permeability, and a characteristic texture that cannot be achieved with artificial alternatives.

2.1.4. Other Auxiliary Materials

A small amounts of water was used (max. 100–150 ml per 10 kg) during mixing to facilitate better homogenization of the sausage paste.

Beechwood sawdust was used exclusively for smoking; sourced from certified suppliers, properly dried (moisture below 20%), free from resin, varnish, or contaminants.

Food-grade film and labels were used for individual packaging of the product after smoking and cooling.

2.2. Method

The sensory quality of raw (unsmoked) and smoked sausages was evaluated based on external appearance, cross-sectional appearance, color, consistency, aroma, and overall taste [20]. The evaluation panel consisted of 10 trained assessors with experience in meat product analysis, aged between 25 and 55 years.

The assessment was carried out under controlled conditions (diffused natural light, ambient temperature of 20–22°C, and absence of interfering odors). A 5-point hedonic scale was used, where 5 = excellent and 1 = unsatisfactory. The results were statistically compiled and analyzed by calculating the arithmetic mean for each parameter, and they are presented and interpreted in the following tables.

Each sample of sausages was subjected to both physicochemical and sensory analyses, first in its raw state (before smoking) and subsequently after the smoking process, in order to evaluate how the different meat compositions influenced the quality characteristics and sensory attributes of the final sausages.

The statistical data were calculated using Microsoft Excel formulas: the arithmetic mean (X) represents the average value of repeated measurements, while the standard deviation (sX) quantifies the degree of variation among them. The combined expression (X ± sX) reflects the standard error, which defines the expected range in which the true mean value lies, ensuring the reliability and reproducibility of the obtained data.

The sensory evaluation criteria and their descriptions are presented in Table 1.

Table 1. Sensory criteria for sausage samples made from a mixture of pork, beef, and mutton

Parameter	Description of Evaluation
External appearance	Uniformity, presence or absence of defects, surface color
Cross-sectional appearance	Granulation, fat distribution, homogeneity, absence of air
Color	Characteristic natural color, uniformity, intensity
Consistency	Firmness, elasticity to pressure, cohesion
Aroma	Intensity and specificity, smoky scent, spices, meat aroma
Taste	Balance between salty, sweet, and spicy notes, aftertaste, overall acceptability

The main physicochemical characteristics reflecting the composition and technological quality of the product, including moisture, fat, ash, salt content, and pH are presented in Table 2.

Table 2. Physicochemical criteria of sausage samples made from a mixture of pork, beef, and mutton

Analyzed Parameter	Method Used	Principle of Determination
(%)	method	at 110°C until constant weight
Moisture	Gravimetric	Drying in an oven
Fat (%)	Van Gulik acidobutyrometric method	Separation and centrifugation (isoamyl alcohol)
Ash (%)	Muffle furnace incineration	Complete combustion at 550–600°C until organic matter is eliminated
Salt content (%)	Mohr method (titration with silver nitrate and indicator)	Volumetric titration with $AgNO_3$ in the presence of potassium chromate
pH	Potentiometric measurement (calibrated pH meter)	Direct measurement in a homogenized suspension

Table 3. Results and observations of the sensory evaluation of raw (unsmoked) and smoked sausage samples made from a mixture of pork, beef, and mutton

Sensory Criteria	Sample 1		Sample 2		Sample 3	
	Raw	**Smoked**	**Raw**	**Smoked**	**Raw**	**Smoked**
External appearance	4.4	4.7	4.2	4.4	4.6	4.9
Cross-sectional appearance	4.2	4.4	4.4	4.6	4.6	4.8
Color	3.9	4.3	4.1	4.5	4.4	4.8
Consistency	4.4	4.6	4.3	4.4	4.4	4.5
Aroma	4.3	4.8	3.8	4.0	4.2	4.6
Taste	4.4	4.9	3.9	4.2	4.3	4.7
Average total score	**4.27**	**4.62**	**4.12**	**4.35**	**4.42**	**4.72**

3. Results and Discussion

3.1. Senzory evaluation of sausage samples made from a mixture of pork, beef and mutton.

The sensory quality of the sausages was evaluated based on external appearance, cross-sectional appearance, color, consistency, aroma, and overall taste.

Three sausage samples were produced under identical conditions, with minor variations in the proportion of beef and mutton, in order to observe their influence on the final product quality.

The numerical and descriptive results of the sensory evaluation are presented in Table 3.

The evaluation results highlight differences between the raw (unsmoked) and smoked sausage samples. Smoking significantly enhanced the overall sensory profile of the products, particularly in terms of aroma, color, and taste, where higher scores were consistently recorded. The raw sausages maintained a pleasant appearance and satisfactory texture, yet their flavor complexity and aromatic intensity were lower due to the absence of smoke-derived compounds.

Among the tested formulations, Sample 3 (40% pork, 25% beef, 25% mutton, 10% fat) achieved the highest overall acceptability in both raw and smoked forms, showing a well-balanced combination of meat flavors and consistent texture.

Sample 1, with a higher mutton proportion (30%), exhibited a stronger, more distinctive flavor and firmer texture, which some evaluators perceived as slightly intense.

In contrast, Sample 2, with reduced mutton content (20%), was described as milder in aroma and taste, aligning with consumer preferences for less pronounced mutton notes.

Overall, the results confirm that smoking contributes decisively to the sensory quality and consumer appeal of traditional sausages, while the optimal balance between pork, beef, and mutton ensures both characteristic flavor and technological properties.

3.2. Physicochemical evaluation of sausage samples made from a mixture of pork, beef and mutton.

The average results of the physicochemical determinations of the examined sausage samples made from a mixture of pork, beef, and mutton, in both raw (unsmoked) and smoked variants are presented numerically in Table 4 and graphically illustrated in Figure 2.

The data presented in Table 4 show some differences between the raw and smoked sausage samples.

The moisture content decreased significantly after smoking (from 62.80% to 55.47%), which is a natural result of the dehydration process caused by heat and smoke exposure. This reduction contributes to improved texture, flavor concentration, and shelf-life.

The fat content increased slightly (from 26.17% to 28.70%), which is consistent with the loss of water during smoking, leading to a relative concentration of lipids in the final product.

The ash content also increased moderately (from 3.18% to 3.45%), indicating a higher concentration of mineral substances due to water loss and salt penetration during processing.

The NaCl content was slightly higher in the smoked samples (2.10%) compared to the raw ones (1.90%), which can be explained by the redistribution and diffusion of salt during the thermal treatment and smoking process.

The pH value decreased slightly after smoking (from 5.80 to 5.68), suggesting the development of mildly acidic conditions. This change may result from the formation of organic acids during the smoking and partial fermentation process, which helps improve microbial stability and flavor development.

An important finding of specialized studies revealed that both the composition of the meat mixture and the smoking process significantly influence the physicochemical and sensory characteristics. Variations in mutton and beef proportions affected

moisture, fat content, and pH, which in turn influenced texture and flavor intensity [11-19].

Table 4. Physicochemical average characteristics score of raw (unsmoked) and smoked sausage samples made from a mixture of pork, beef, and mutton

Sausage assortment	Moisture (%)	Fat (%)	Ash (%)	NaCl (%)	pH
Raw sausage from a mixture of pork, beef and mutton meat	62.80±0.70	26.17±0.60	3.18±0.03	1.90±0.00	5.80±0.02
Smoked sausage from a mixture of pork, beef and mutton meat	55.47±0.70	28.70±0.80	3.45±0.02	2.10±0.00	5.68±0.04

4. Conclusion

The conducted study examined the influence of the proportions of different types of meat - pork, beef, and mutton - on the quality of smoked sausages, by assessing both physicochemical and sensory parameters.

The comparative analysis between the two assortments shows the following:

- moisture content decreased in smoked sausages, as a result of water loss during the smoking and partial drying process. This reduction in moisture contributes to improved texture, flavor concentration, and product stability.
- in terms of fat content, the smoking process led to a slight increase in smoked samples, mainly due to the relative concentration effect following moisture loss. The fat levels are consistent with those typically found in traditional pork-beef-mutton sausage formulations, ensuring juiciness, flavor richness, and structural cohesion. The higher proportion of mutton contributes to an enhanced flavor and aroma profile but may also increase the susceptibility to lipid oxidation during storage.
- the ash content increased slightly in the smoked sausages, reflecting a higher concentration of mineral components (sodium, potassium, calcium, phosphates) due to dehydration and the contribution of the smoking process itself.
- the NaCl content also showed a slight increase for the smoked sausages which is consistent with the concentration effect caused by water evaporation during smoking process. This level ensures both flavor enhancement and microbiological stability.
- the pH values decreased slightly, for smoked samples, maintaining a mildly acidic environment favorable for microbiological safety and preservation.

The results confirm that both the composition of the meat mixture and the smoking process have a significant influence on the physicochemical and sensory characteristics of the sausages. Smoking not only improves flavor and texture but also enhances shelf stability through moisture reduction and pH adjustment. Among the tested formulations, the variant containing 25% mutton provided the most balanced functional and sensory profile, ensuring optimal technological performance and high consumer acceptability.

The overall findings of the study allow for the following conclusions to be formulated:

- the composition of the meat mixture in the recipe significantly influences the moisture, lipid content, and pH values of the final product. Mutton, due to its naturally higher fat content and distinctive aroma, contributes to a firmer texture and a more intense sensory profile.
- sausages made with 30% mutton showed the highest fat levels, confirming greater susceptibility to lipid oxidation, but also achieved the highest flavor and aroma scores in the sensory analysis.
- a 25% mutton proportion provided the best balance between physicochemical parameters (moisture, fat, pH) and sensory evaluation, making it the optimal technological formulation for obtaining a traditional, stable, and well-accepted product.
- the sample with 20% mutton had slightly higher moisture content due to the increased proportion of beef, and exhibited milder sensory notes, suitable for consumers who prefer less intense flavors.
- the pH values remained within the appropriate range for semi-matured smoked products, favoring microbiological stability, while the ash content indicated normal mineralization without excessive salt or additives.

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