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STUDY ON THE TECHNOLOGICAL PROCESS AND PHYSICOCHEMICAL PARAMETERS OF OSTRICH MEAT SALAMI

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Abstract:This paper analyzes the technological manufacturing process and the main quality indicators for an assortment of ostrich meat salami made in our own production. The production technology aimed to capitalize on the superior nutritional characteristics of ostrich meat, by combining it with pork fat and controlled fermentation to obtain a raw-flavored salami-type product. The maturation process allowed the reduction of water activity and the establishment of an optimal pH for microbiological safety. The results of the laboratory analyzes for the sample of our own production highlighted a product with outstanding physicochemical characteristics. The protein content of 26.268% is particularly high, exceeding the typical values for ostrich salami in the literature (which range from 19.99% to 22.14%), which gives the product a superior biological value. The fat content of 21.994% indicates a balanced formulation, significantly lower than in commercial pork salami (which can exceed 34%), but sufficient to ensure the characteristic texture and flavor. The pH value of 5.04 is excellent, falling below the critical threshold of 5.3 identified in studies on fermented ostrich salami, which guarantees microbiological stability and efficient lactic fermentation. The moisture content of 44.454% reflects a proper maturation process with controlled weight loss. The freshness indicator (slightly hydrolyzable nitrogen) of 13.12 mg NH_3/100g confirms the quality of the raw materials and the integrity of the product. With an energy intake of 317.39 kcal/100g and a salt content of 3.11%, the analyzed ostrich salami demonstrates that compliance with technological parameters allows obtaining a product with optimal physicochemical properties, superior nutritional profile and distinctive sensory characteristics.

Cuvinte cheie: ostrich meat, salami, technological process, maturation, physico-chemical indicators, nutritional value.

• Introduction

Ostrich meat, known for its low fat content, high protein, and favorable fatty acid profile, presents a compelling alternative to traditional red meats in the development of functional food products like salami. This lean meat characteristic, coupled with precise control over processing parameters, allows for the creation of salami with reduced fat and energy content while maintaining high protein levels, as demonstrated in various studies on fermented and cured meat products [1], [2]. The precise management of pH and water activity (aw) during the maturation process is critical for ensuring both the microbiological stability and the desired textural properties of such products [3]. For instance, studies on fresh ostrich meat sausages have explored methods to optimize physiochemical and microbiological quality, alongside sensory attributes, to enhance market viability [4]. The inclusion of ostrich meat in salami formulations also presents opportunities to develop products with distinct organoleptic profiles, differentiating them from conventional pork or beef-based alternatives. Specifically, the fermentation and drying processes are pivotal in achieving the desired physicochemical parameters, with pH values typically decreasing due to lactic acid bacteria activity and then potentially increasing in later stages due to protease activity [5]. The optimization of curing conditions, including salt concentration and temperature, further influences these parameters, impacting water retention and overall product texture [6]. This paper details the technological process for producing an ostrich meat salami and evaluates its physicochemical quality indicators, emphasizing the impact of controlled heat treatment and maturation on the final product's nutritional and safety profile. Moreover, the utilization of ostrich meat, often classified as a healthy protein source due to its leanness and favorable fatty acid profile, offers advantages in processed meat products where it can improve water holding capacity, though its high ultimate pH can influence shelf life and flavor [7], [8]. The development of novel meat products, such as those incorporating ostrich meat, often necessitates a thorough understanding of ingredient interactions and processing parameters to achieve desirable physiochemical attributes and consumer acceptance [9]. The present study aimed to meticulously analyze the intricate technological manufacturing process and the principal quality indicators inherent in an assortment of ostrich meat salami developed through in-house production. This approach allows for a comprehensive assessment of how specific processing conditions, such as controlled fermentation and aging, contribute to the distinctive physicochemical and sensory characteristics of the final product. This research specifically investigates the incorporation of ostrich meat, known for its lean profile and nutritional advantages, into a fermented and cured sausage product, focusing on how this substitution impacts key quality indicators. The observed pH values, particularly those around 5.06 in similar fermented products, underscore the critical role of microbial activity, predominantly lactic acid bacteria, in achieving desirable acidification for product safety and preservation [10], [11]. Furthermore, the precise control over water activity (aw) during the drying phase is paramount for inhibiting the proliferation of spoilage microorganisms and ensuring an extended shelf-life, as evidenced in other fermented meat products [12]. This detailed examination provides crucial insights into optimizing processing methodologies to enhance both the nutritional value and market appeal of ostrich-based processed meats. The research methodology encompassed a comprehensive evaluation of physicochemical parameters, including moisture content, protein, fat, salt, pH, and freshness indicators, alongside an assessment of the product's energy intake.

• Material and method

This thorough analysis aimed to benchmark the quality of the ostrich salami against established industry standards and traditional meat products. The experimental design involved meticulous control over variables such as fermentation temperature and humidity, which are crucial for achieving the targeted pH range and water activity necessary for product safety and quality [13]. This rigorous approach facilitated the elucidation of optimal processing conditions for ostrich meat salami, allowing for the precise calibration of parameters to meet specific compositional and sensory targets. The detailed procedures involved in the production of ostrich salami, including ingredient ratios, starter culture selection, and environmental controls during fermentation and drying, were carefully documented to ensure replicability and facilitate further optimization. The physicochemical analyses were performed to determine the moisture content, fat content, total protein, salt, pH, easily hydrolyzable nitrogen/ammoniacal nitrogen, total ash, and energy intake in kcal/100g. pH values were assessed using a Crison 507 pH-meter, and salt content was confirmed via the Volhard method as described in ISO 1841-1 [14]. Moisture and ash contents were determined by gravimetric methods following desiccation at 102°C and incineration at 550°C, respectively. Protein content was quantified using the Kjeldahl method, while total fat content was measured by extraction with petroleum ether in a Soxhlet apparatus. Water activity, a critical parameter influencing microbial growth and biochemical reactions, was assessed using a water activity meter [15]. These comprehensive physicochemical measurements are crucial for ensuring compliance with regulatory standards and for elucidating the impact of processing conditions on the final product's quality attributes [16]. Volatile basic nitrogen was also estimated to assess the freshness and degree of protein degradation [17], [18]. Energy value was calculated using the Atwater general factor system, which assigns specific caloric values per gram for macronutrients [19], [20].

• Results and discussions

Table 1 shows the results obtained from the physicochemical analyses on the sample of ostrich meat salami own production and results for other samples of ostrich meat salami taken from the literature.

Table 1. Results of physicochemical analyses for ostrich meat salami sample own production and results taken from the literature for other ostrich meat salami samples

Crt. no.	Ostrich meat salami samples	Humidity (%)	Fat content (%)	Total Protein (%)	Salt (NaCl, %)	pH	Slightly hydrolyzable / ammonia nitrogen (mg NH_3/100g)	Total ash (%)	Energy value (kcal/100 g)
1	Ostrich meat salami own production	44.454	21.994	26.268	3.11	5.04	13.12	3.69	317.39
2	Ostrich meat salami 1 [21]	30.50	26.20	28.40	3.80	5.35	12.50	4.10	349.40
3	Ostrich meat salami 2 [22]	61.37	10.97	22.14	2.15	6.05	15.20	3.21	208.50
4	Ostrich meat salami 3 [23]	32.10	31.50	25.80	4.10	5.12	14.80	4.30	386.70
5	Ostrich meat salami 4 [24]	63.80	12.10	18.50	1.85	6.25	16.50	2.45	182.90
6	Ostrich meat salami 5 [25]	29.50	34.20	26.50	4.35	5.25	13.90	4.50	413.80
7	Standard limits (literature)	max. 45%	max. 35%	min. 19.99%	2.0 - 4.5%	5.0 - 5.3	max. 35 mg NH_3/100g	max. 5.0%	-

Comparative evaluation of humidity (%) in ostrich meat salami samples.

In the following figure, the variation of humidity content in the evaluated ostrich meat salami samples is presented.

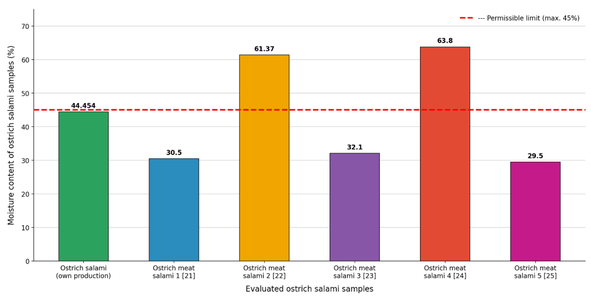

Figure 1. Variation of humidity in the evaluated ostrich meat salami samples

The humidity values recorded across all six ostrich meat salami samples ranged from 29.50% (Ostrich meat salami 5) to 63.80% (Ostrich meat salami 4), reflecting significant differences in the degree of maturation and drying applied during processing. The lowest moisture values were recorded for Ostrich meat salami 5 (29.50%) and Ostrich meat salami 1 (30.50%), indicating an advanced drying process and a correspondingly longer shelf life. Ostrich meat salami 3 (32.10%) also falls within the category of well-matured products, with a relatively low moisture content characteristic of dry-cured salami. The own production sample (44.454%) presents an intermediate moisture level, consistent with a semi-dry salami-type product that has undergone controlled maturation without excessive drying. In contrast, Ostrich meat salami 2 (61.37%) and Ostrich meat salami 4 (63.80%) display markedly higher moisture contents, suggesting either a shorter maturation period or the use of formulations with higher water retention capacity, more characteristic of semi-cooked or fresh sausage products. These differences in moisture content directly influence the texture, energy density and microbiological stability of the final products.

Comparative evaluation of fat content (%) in ostrich meat salami samples.

In the following figure, the variation of fat content in the evaluated ostrich meat salami samples is presented.

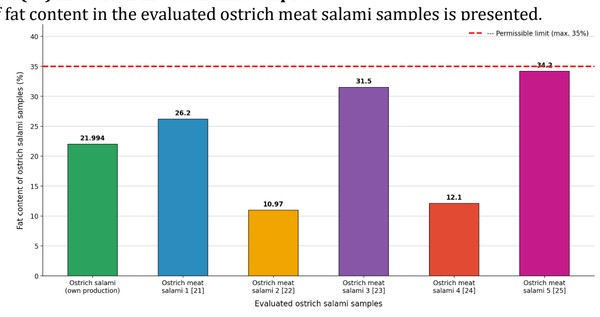

Figure 2. Variation of fat content in the evaluated ostrich meat salami samples

The fat content of the analyzed samples varied considerably, from 10.97% (Ostrich meat salami 2) to 34.20% (Ostrich meat salami 5), indicating substantial differences in the lipid formulations and raw material compositions used across variants. Ostrich meat salami 5 (34.20%) and Ostrich meat salami 3 (31.50%) present the highest fat contents, reflecting formulations with a high proportion of pork backfat or fatty trimmings, which contribute to characteristic texture and flavor of dry-cured salami. Ostrich meat salami 1 (26.20%) maintains a moderate-to-high fat content, typical of traditional fermented sausage recipes. The own production sample (21.994%) demonstrates a more balanced fat content, substantially lower than Ostrich meat salami 5 and closer to the range recommended for functional meat products with improved nutritional profiles. Ostrich meat salami 4 (12.10%) and Ostrich meat salami 2 (10.97%) register the lowest lipid levels, consistent with their elevated moisture content and possibly reflecting reduced fat addition during processing. The inverse relationship between fat content and moisture content observed across samples aligns with the expected compositional dynamics of fermented and dried meat products, where water loss concentrates the remaining macronutrients.

Comparative evaluation of total protein (%) in ostrich meat salami samples.

In the following figure, the variation of total protein content in the evaluated ostrich meat salami samples is presented.

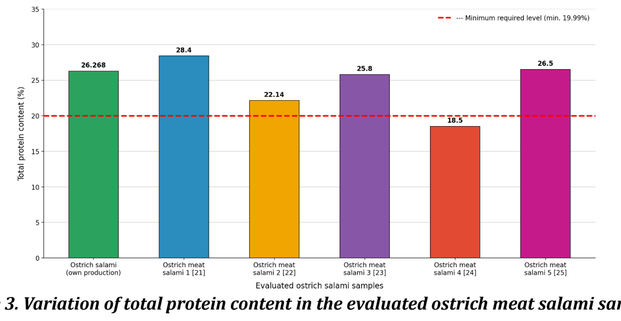

Figure 3. Variation of total protein content in the evaluated ostrich meat salami samples

Total protein content ranged from 18.50% (Ostrich meat salami 4) to 28.40% (Ostrich meat salami 1), reflecting differences in meat-to-fat ratios, maturation degrees and raw material quality. Ostrich meat salami 1 (28.40%) registered the highest protein content, indicating a lean formulation with a high proportion of muscle tissue relative to fat. The own production sample (26.268%) and Ostrich meat salami 5 (26.50%) present similar protein values, both exceeding the typical range reported in the literature for ostrich salami (19.99%–22.14%), demonstrating the superior nutritional quality of these formulations. Ostrich meat salami 3 (25.80%) also exhibits a high protein level, consistent with its advanced maturation stage. Ostrich meat salami 2 (22.14%) falls at the upper limit of the literature reference range, while Ostrich meat salami 4 (18.50%) records the lowest protein content, associated with its high moisture level and less concentrated composition. The high protein content of the own production sample is particularly noteworthy given that it was achieved with a moderate fat level (21.994%), conferring a superior protein-to-fat ratio compared to Ostrich meat salami 3 and 5.

Comparative evaluation of salt content (NaCl, %) in ostrich meat salami samples.

In the following figure, the variation of salt (NaCl) content in the evaluated ostrich meat salami samples is presented.

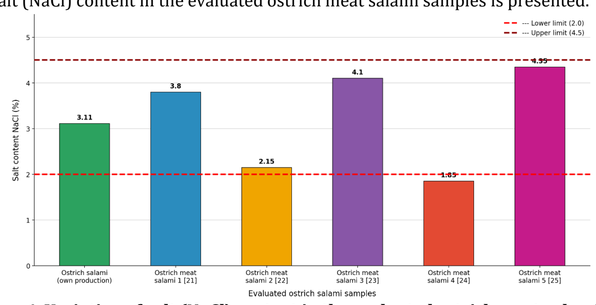

Figure 4. Variation of salt (NaCl) content in the evaluated ostrich meat salami samples

Salt content across the evaluated samples ranged from 1.85% (Ostrich meat salami 4) to 4.35% (Ostrich meat salami 5), reflecting different salting strategies and their impact on fermentation, preservation and sensory profile. Ostrich meat salami 5 (4.35%), Ostrich meat salami 3 (4.10%) and Ostrich meat salami 1 (3.80%) present the highest salt concentrations, which contribute to water activity reduction, enhanced antimicrobial protection and characteristic salty taste. The own production sample (3.11%) records an intermediate salt level, consistent with good technological control and within the typical range for fermented dry salami. Ostrich meat salami 2 (2.15%) and Ostrich meat salami 4 (1.85%) present the lowest salt contents, which may be associated with formulation strategies aimed at reducing sodium intake, though these levels may provide less microbiological protection compared to higher-salt variants. The direct correlation between salt content and pH reduction is evident across the samples, as higher salt concentrations generally support lactic acid bacteria activity and more effective acidification during fermentation.

Comparative evaluation of pH in ostrich meat salami samples.

In the following figure, the variation of pH in the evaluated ostrich meat salami samples is presented.

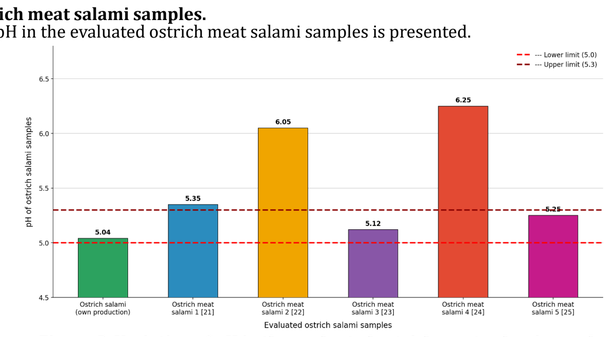

Figure 5. Variation of pH in the evaluated ostrich meat salami samples

pH values varied markedly across all samples, ranging from 5.04 (own production) to 6.25 (Ostrich meat salami 4), reflecting different degrees of fermentation and lactic acidification achieved during processing. The own production sample (pH 5.04) registered the lowest pH value, falling below the critical threshold of 5.3 considered optimal for microbiological safety in fermented salami, indicating highly effective lactic acid bacteria activity and excellent product stability. Ostrich meat salami 3 (pH 5.12) and Ostrich meat salami 5 (pH 5.25) also present pH values below 5.3, confirming adequate fermentation and corresponding microbiological safety. Ostrich meat salami 1 (pH 5.35) is slightly above this threshold, while Ostrich meat salami 2 (pH 6.05) and Ostrich meat salami 4 (pH 6.25) display markedly higher pH values, more characteristic of fresh or lightly fermented sausages than dry-cured salami. The elevated pH values of samples 2 and 4 correlate with their higher moisture contents and lower salt concentrations, suggesting limited fermentation activity and a correspondingly different processing approach. These pH differences have direct implications for product safety, texture and shelf life.

Comparative evaluation of slightly hydrolyzable / ammonia nitrogen (mg NH_3/100g) in ostrich meat salami samples.

In the following figure, the variation of slightly hydrolyzable / ammonia nitrogen in the evaluated ostrich meat salami samples is presented.

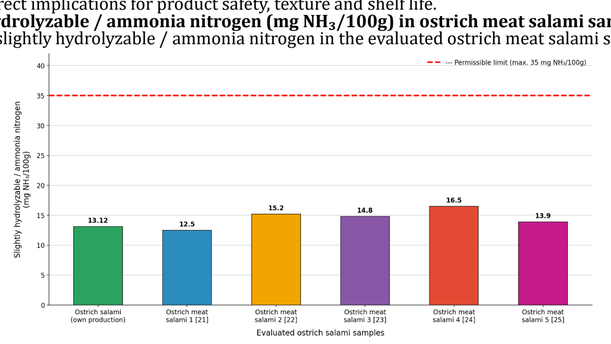

Figure 6. Variation of slightly hydrolyzable / ammonia nitrogen in the evaluated ostrich meat salami samples

Slightly hydrolyzable nitrogen values ranged from 12.50 mg NH_3/100g (Ostrich meat salami 1) to 16.50 mg NH_3/100g (Ostrich meat salami 4), with all samples remaining well below the critical threshold of 35 mg NH_3/100g, confirming excellent freshness and appropriate protein integrity across all variants. Ostrich meat salami 1 (12.50 mg NH_3/100g) and the own production sample (13.12 mg NH_3/100g) recorded the lowest values, indicating minimal proteolytic degradation and the highest freshness status among the evaluated samples. Ostrich meat salami 5 (13.90 mg NH_3/100g) and Ostrich meat salami 3 (14.80 mg NH_3/100g) present slightly higher values, consistent with a more advanced degree of protein hydrolysis during prolonged maturation, which contributes to the development of characteristic salami aroma. Ostrich meat salami 2 (15.20 mg NH_3/100g) and Ostrich meat salami 4 (16.50 mg NH_3/100g) register the highest ammonia nitrogen values, possibly related to their elevated moisture content and higher pH, which may favor proteolytic enzyme activity, though all values remain within acceptable freshness limits. The progressive increase in hydrolyzable nitrogen with higher moisture and pH values observed across samples reflects the expected biochemical dynamics of protein degradation in fermented and aged meat products.

Comparative evaluation of total ash (%) in ostrich meat salami samples.

In the following figure, the variation of total ash content in the evaluated ostrich meat salami samples is presented.

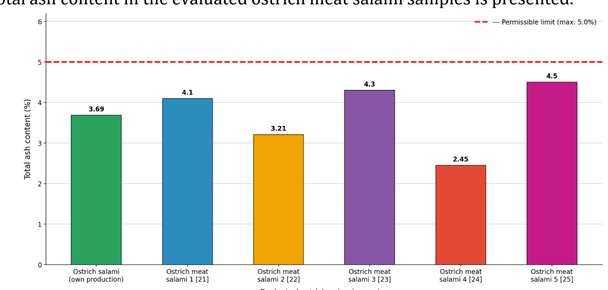

Figure 7. Variation of total ash content in the evaluated ostrich meat salami samples

Total ash content ranged from 2.45% (Ostrich meat salami 4) to 4.50% (Ostrich meat salami 5), reflecting differences in mineral composition largely determined by salt content and the degree of concentration achieved through drying. Ostrich meat salami 5 (4.50%), Ostrich meat salami 3 (4.30%) and Ostrich meat salami 1 (4.10%) recorded the highest ash values, consistent with their elevated salt concentrations and advanced drying, which concentrate mineral content in the product matrix. The own production sample (3.69%) and Ostrich meat salami 2 (3.21%) present intermediate ash levels, consistent with their respective moisture and salt contents. Ostrich meat salami 4 (2.45%) registers the lowest total ash, directly correlated with its lowest salt content (1.85%) and highest moisture, resulting in the least concentrated mineral fraction. The strong correlation between salt content, moisture content and total ash across all samples confirms that ash content is primarily driven by sodium chloride concentration and the degree of water removal during processing.

Comparative evaluation of energy value (kcal/100g) in ostrich meat salami samples.

In the following figure, the variation of energy value in the evaluated ostrich meat salami samples is presented.

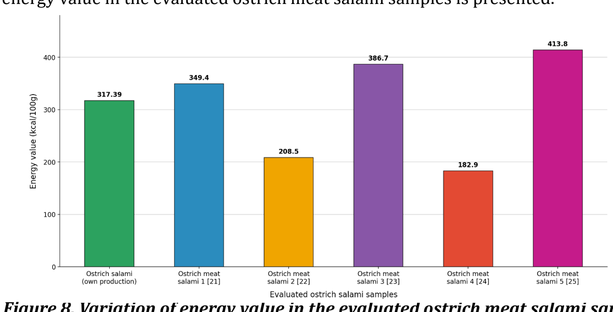

Figure 8. Variation of energy value in the evaluated ostrich meat salami samples

Energy value varied considerably across the six samples, ranging from 182.90 kcal/100g (Ostrich meat salami 4) to 413.80 kcal/100g (Ostrich meat salami 5), directly reflecting the combined effect of fat content and moisture on caloric density. Ostrich meat salami 5 (413.80 kcal/100g) and Ostrich meat salami 3 (386.70 kcal/100g) recorded the highest energy values, explained by their elevated fat contents (34.20% and 31.50% respectively) and reduced moisture levels. Ostrich meat salami 1 (349.40 kcal/100g) presents a moderately high caloric density, consistent with its fat content of 26.20%. The own production sample (317.39 kcal/100g) demonstrates a favorable energetic profile, being notably lower than samples 1, 3 and 5, while maintaining a high protein content (26.268%), which translates into a superior protein-to-energy ratio. Ostrich meat salami 2 (208.50 kcal/100g) and Ostrich meat salami 4 (182.90 kcal/100g) record the lowest energy values, a direct consequence of their high moisture and low fat contents. These results confirm that the own production sample achieves a nutritional balance between adequate energy supply and elevated protein content, positioning it as a product with a superior nutritional profile compared to higher-fat variants.

•Conclusions

The analysis highlighted significant differences among the six ostrich salami samples, determined by formulation and processing technology.

The own production salami meets all standard limits for fermented dry-cured salami and shows a balanced profile: appropriate moisture, low fat content, high protein level, optimal pH, and good microbiological safety. It also has a moderate energy value, making it a nutritionally superior product.

Among the reference samples: Salami 1 and 3 generally meet the standards for dry-cured salami; Salami 5 complies with most parameters but is close to the upper limits for fat, salt, and ash; Salami 2 and 4 do not meet the requirements for fermented salami, showing high moisture and pH values typical of fresh products.

Overall, the own product stands out through the best balance between safety, technological quality, and nutritional value.