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Application of Natural Antioxidants in the Development of Nitrite-Free Meat Products with Improved Stability and Nutritional Properties

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Abstract:

The paper analyzes the role and effectiveness of natural antioxidants in preventing oxidative processes that affect the quality of meat products. Lipid oxidation, a process that transforms unsaturated fatty acids into volatile compounds, degrades the sensory and nutritional properties of the product. Natural antioxidants interrupt oxidative reactions, thereby maintaining product stability during storage.

Amid concerns regarding the safety of synthetic antioxidants (BHT, BHA), research has focused on natural sources such as rosemary, oregano, sage, garlic, grape seeds, and pomegranate, which, due to their high phenolic content, may provide superior antioxidant activity. However, their effectiveness depends on the extraction method, concentration used, and compatibility with the food matrix, requiring a balance between antioxidant action and the preservation of sensory attributes. In thermally processed or high-pressure treated products, natural antioxidants can reduce the formation of oxidative compounds; for instance, extracts derived from tomato by-products and rosemary have been shown to extend the oxidative stability of chicken meat treated at 600–800 MPa. Horseradish (*Armoracia rusticana*) also exhibits antioxidant, antimicrobial, and antifungal properties due to its essential oils rich in limonene and phthalides. Owing to its high nitrate content, it is used as a natural curing agent in the meat industry, although its intense aroma limits the permissible dosage. The main objective of this study was to develop an innovative "nitrite-free" meat product, designed to provide additional functional and nutritional value while offering protection against lipid oxidation. The production technology followed specific processing stages, after which the final product was analyzed from a physico-chemical and sensory perspective. The physico-chemical analysis focused on determining the main compositional parameters—moisture, protein, carbohydrate, lipid, and energy content—while the sensory evaluation assessed the product's appearance, taste, odor, and texture. The results demonstrated that replacing nitrite with natural antioxidants in meat products contributes to maintaining their quality, stability, and safety, aligning with current trends in the modern food industry.

Keywords: natural antioxidants, lipid oxidation, meat products, nitrite-free, functional food

• Introduction

Antioxidants are added to meat and meat products to prevent lipid oxidation, which causes discoloration, unpleasant odors, and a reduction in nutritional quality. They can be classified as natural or synthetic, but synthetic antioxidants are increasingly avoided due to their potential toxic and carcinogenic effects, leading the food industry to favor natural antioxidants. The active compounds in natural antioxidants — primarily phenolics, flavonoids, phenolic acids, and tocopherols — inhibit oxidative reactions by neutralizing free radicals. Their antioxidant activity depends on chemical structure, particularly on the number and position of hydroxyl (-OH) groups, which influence their radical-scavenging and metal-chelating abilities. Natural antioxidant sources include fruits, vegetables, seeds, leaves, roots, and bark, providing effective alternatives to synthetic additives. However, certain plant extracts may alter the color, flavor, or texture of meat products and may contain antinutritional or toxic components. Current research focuses on optimizing the extraction and application of these compounds to ensure product stability and consumer safety. In conclusion, natural antioxidants represent a sustainable and health-promoting alternative for maintaining quality and extending the shelf life of meat and meat-based products. The objectives set in the second part of the paper were: (i) to establish the recipe for product; (ii) to obtain the product; (iii) to evaluate the proximate composition of the product; (iv) to characterize the organoleptic properties of the product.

• Material and method

The objectives established in the experimental section aimed to characterize the sensory and physico-chemical properties of the four samples; Assess the antioxidant activity and the potential to increase oxidative stability of the liver sausage samples through the addition of spice plants. The raw materials used in the production of traditional pork sausage are the following: pork head meat, firm pork fat, pork organs, pork rind, ears, liver, diaphragm fat, hydrated rice, and broth obtained from boiling the pork head.

The technological process for obtaining the traditional pork sausage is shown in Figure 1.

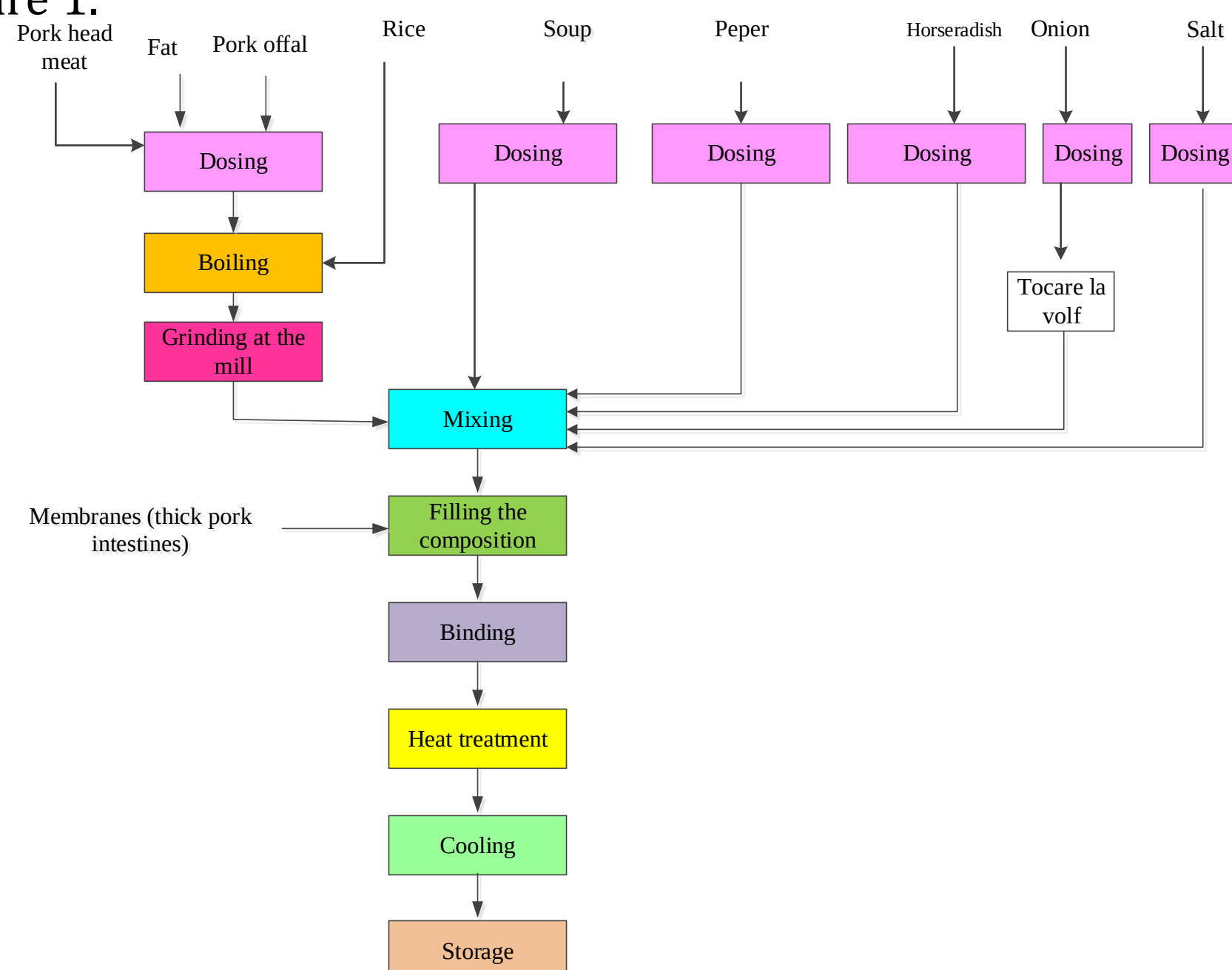


Figure 1. Technological diagram for obtaining the traditional sausage with horseradish

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Physico-chemical analysis was performed according to the following standards: Determination of moisture content (SR ISO 1442:2010); Determination of protein content (SR ISO 937:2007); Determination of mineral substances (SR ISO 936:2009 ver.eng.); Determination of lipid content (SR ISO 1443:2008); Determination of carbohydrate content (EC Regulation 1169/2011); Determination of the energy value of the product (Conf. Regulation EC 1169/2011).

• Results and discussions

Proximate composition of the samples

The sausage with added horseradish and pine seeds was compared with a white bread made using a similar technology.

Table 2. Proximate composition of the sausages samples

Sample	Chemical Parameters					
	Moisture content (g/100 g)	Ash (g/100 g)	Protein (g/100 g)	Lipids (g/100 g)	Carbohydrates (g/100 g)	Energy Value (kcal/100 g)
SH	57.16	0.64	18.41	20.37	0.58	259.29
MLA	< 72	-	> 8	< 27	-	-

SH – Traditional sausage with horseradish; MLA – maximum/minimum limit accepted by current legislation

The SH sample (traditional sausage with horseradish) complies with legislative limits for meat products, showing a moisture content of 57.16% (<72%), protein 18.41% (>8%), and fat 20.37% (<27%). The obtained values indicate a nutritionally balanced product, with a stable texture and moderate energy value (259.29 kcal/100 g). The low carbohydrate and ash content reflects a traditional composition. The addition of horseradish may contribute to increased oxidative stability and improvement of the sensory profile due to its bioactive compounds, providing the product with additional functional potential.

Oxidative stability

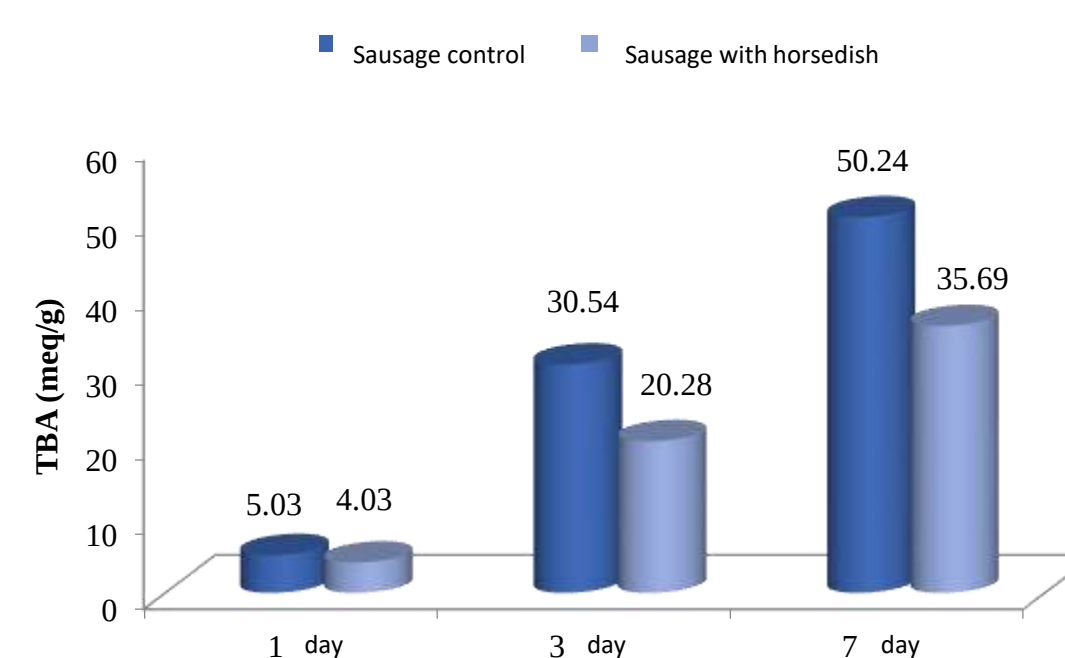


Figure 2. TBA values of the sausage samples studied

The determination of oxidative activity aimed to evaluate the degree of fat oxidation in sausage samples, comparing a control sample with one containing horseradish. The test used was the thiobarbituric acid (TBA) test, based on measuring the amount of malondialdehyde formed during oxidation. The results showed an increase in TBA values during refrigerated storage (7 days), indicating the intensification of oxidation over time. However, the samples with horseradish addition showed significantly lower TBA values than the control, demonstrating the antioxidant effect of horseradish and its ability to reduce lipid oxidation, thereby improving the oxidative stability of the product.

• Conclusions

The research in the present study focused on obtaining a pork traditional pork sausage with added horseradish and its physicochemical characterization. Moisture, lipid, protein, NaCl content, and oxidative capacity were determined, and the values were compared with the requirements of Order No. 210/2006. The results showed that the product complied with legal limits: 57.16% moisture, 18.41% protein, 20.37% fat, and 2.84% NaCl. The Kreiss reaction was negative, and the addition of horseradish reduced lipid oxidation, demonstrating its antioxidant role and its contribution to improving the oxidative stability of the product.