

SUMMARY

Key words: compact-structured meat products, injection, enzymatic maturation, functional ingredients

In the current context, marked by rapid lifestyle changes, accelerated urbanization, demographic transformations, and increasingly diverse consumer preferences, the food industry is compelled to adapt by developing products that not only meet basic nutritional needs but also actively contribute to disease prevention and the maintenance of health.

Meat and meat products, despite the controversies generated in recent decades regarding ethical, environmental, and health implications, remain an important source of high biological value proteins, essential amino acids, polyunsaturated fatty acids, and other micronutrients with a fundamental role in maintaining the metabolic and physiological balance of the body. Nevertheless, excessive meat consumption, especially in processed forms, has been associated with several health risks, including cardiovascular diseases, metabolic dysfunctions, and certain types of cancer. Thus, the current challenge does not lie in eliminating meat from the diet, but rather in redefining it through intelligent and sustainable reformulations that maximize the nutritional and functional value of products without compromising their safety, taste, and sensory acceptability.

Within this framework, the reformulation of meat products to reduce or replace components considered unhealthy, such as saturated fat, salt, or nitrites, and, conversely, to add functional ingredients (natural antioxidants, enzymes, dietary fibers, probiotic cultures), has become a priority strategy. Recent research has demonstrated that the application of exogenous proteolytic enzymes, such as papain and bromelain, can improve meat tenderness, digestibility, and protein bioavailability, thereby favoring the efficient assimilation of essential amino acids in the gastrointestinal tract. At the same time, the use of natural extracts from marine algae has gained momentum as a sustainable solution to increase the nutritional value of meat products, due to their high content of proteins, soluble fibers, polyphenols, ω -3 fatty acids, and essential minerals.

The doctoral thesis entitled “Research on the influence of the injection process on the qualitative parameters and shelf-life of certain meat products” was structured into two parts, comprising seven chapters, 29 figures, 37 tables, and 250 bibliographic references, integrating the literature review on the chosen topic, the author’s own research, the results obtained, conclusions, and the consulted references.

The first chapter presents current perspectives on modern technological processes used to improve meat quality and derived products, as well as a description of the meat quality concept, including nutritional and sensory aspects, along with the challenges of reformulating products to reduce salt and fat content. Furthermore⁷⁵, modern processing strategies and their effects on meat products are discussed.

The second chapter focuses on a detailed description of the meat injection technological process and the role of proteolytic enzymes in intensifying tenderization reactions, improving digestibility, and stabilizing protein structure. The main techniques involved— injection, tumbling, and vacuum mixing—are analysed, as well as key factors in meat preservation.

The third chapter addresses the functional factors involved in the preservation of meat and derived products. The roles of sodium chloride, nitrites, proteolytic enzymes, and the studied algae are described, both from the perspective of their antimicrobial, antioxidant, or flavor-forming properties, and in relation to current concerns about reducing their use.

The fourth chapter outlines the research objectives and hypotheses, alongside the experimental design of the study, by describing the selection criteria for raw materials, the elaboration of control and experimental batches, and the treatments applied by injection with functional brines containing red algae extract and proteolytic enzymes.

The fifth chapter details the technology for obtaining the meat assortments – “cotlet haiducesc” (smoked pork loin) and pork pastrami – through the description of the complete technological flow, including brine preparation and injection, tumbling, cooking, cooling, packaging, and product storage. All stages were carried out according to a standardized protocol to ensure technological reproducibility and the applied relevance of the results.

The research results, presented in chapters six, seven, and eight, reflect the impact of treatments with red algae extracts (*Palmaria palmata*) and proteolytic enzymes (papain and bromelain) on the quality of the obtained assortments, by analyzing the physicochemical, compositional, sensory, and microbiological changes in smoked pork loin and pork pastrami. Evaluations allowed for a detailed characterization of relevant functional parameters such as amino acid profiles, fatty acid composition, texture, color, oxidative stability, and microbial load, as well as a comparison between control and treated batches, facilitating the identification of optimal treatment combinations from nutritional, sensory, and preservation perspectives.

The experiment was structured through the manufacture of 14 distinct batches of meat products: one control batch for each assortment (smoked pork loin and pork pastrami), one batch prepared without functional additives, and 12 experimental batches obtained by injecting functional brines containing red algae extract (*Palmaria palmata*) at a constant dose of 1 g/5 kg meat, in combination with two types of proteolytic enzymes – papain and bromelain – applied in three different concentrations: 0.015 g/5 kg meat (low level), 0.036 g/5 kg meat (medium level), and 0.045 g/5 kg meat (high level). Evaluations carried out on these assortments included: determination of pH and water activity (A_w), color analysis (L^* , a^* , b^* parameters), assessment of proximate composition (moisture, protein, fat, ash), textural analysis (shear force, work of shear, hardness, elasticity, cohesiveness, chewiness), determination of fatty acid profiles (by identifying 15 individual fatty acids and calculating nutritional indices – saturated fatty acids (SFA), monounsaturated fatty acids (MUFA), polyunsaturated fatty acids (PUFA), atherogenicity index (AI), thrombogenicity index (TI), health-promoting index (HPI)), analysis of essential and non-essential amino acids, evaluation of lipid and protein oxidation, determination of total volatile basic nitrogen (TVB-N), as well as microbiological analysis (total viable counts, coliform bacteria). Sensory evaluation was performed using descriptive and affective methods, applied to heat-treated samples simulating real consumption conditions.

In terms of proximate composition, treated batches showed significant variations in water, protein, and fat content, depending on enzyme type and concentration, suggesting an influence on the retention of major components in the meat matrix. The amino acid profile revealed higher levels of essential and non-essential amino acids, especially in batches with papain, reflecting the potential of enzymes to intensify proteolysis and contribute to improved biological value of the product. Regarding the lipid profile, the addition of algae extract promoted an increase in polyunsaturated fatty acid content and an improvement of nutritional indices (AI, TI, HPI), contributing to the formulation of a product with potential health benefits.

Textural analyses confirmed the efficiency of enzymes in meat tenderization, especially in batches with bromelain, which showed a significant decrease in hardness, shear force, and chewiness, resulting in a structure that was easier to chew. In parallel, color parameters were influenced both by the pigments specific to algae and by the structural modifications induced by enzymes, with variations observed in L^* , a^* , and b^* components.

From a sensory perspective, batches treated with papain were the most appreciated by the panel of evaluators, particularly in terms of tenderness, juiciness, and balanced taste, with LCP2 and LPP2 batches obtaining higher scores for overall acceptability. Microbiological evaluations demonstrated a reduced microbial load in treated batches, especially in those with algae extract, which acted as a natural inhibitor of spoilage flora, contributing to extended shelf life. Finally, effective inhibition of lipid and protein oxidation was observed, supported by the low levels of thiobarbituric acid reactive substances (TBARS) and carbonyl compounds, highlighting the antioxidant potential of algae and the synergistic protective role of enzymes in maintaining the integrity of the final product.