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Review Based Book Chapter

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REVIEW BASED BOOK CHAPTER

FUNCTIONAL MEAT PRODUCTS

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Abstract

Functional meat products have emerged in response to the demands of health-conscious consumers seeking additional health benefits beyond the traditional nutritional contributions of meat. These products, derived from species such as beef, pork, rabbit, lamb, and poultry, have been fortified or enriched with fibers, probiotics, antioxidants, vitamins, minerals, and essential fatty acids. Both in their fresh and processed forms, they have shown improvements in their technological characteristics before processing, as well as in their nutritional and sensory value, and shelf-life extension. Furthermore, it has been demonstrated that these products can have positive effects on consumer health, combating cardiovascular diseases, gastrointestinal disorders, and immune system issues. The incorporation of ingredients such as fibers, probiotics, omega-3 fatty acids, antioxidants, and phytochemicals allows these products to go beyond basic nutrition, providing additional health benefits. Despite the traditional nutritional benefits of meat, such as its high-quality protein content, vitamins, and minerals, its negative perception is due to its content of saturated fats and cholesterol, which are associated with prevalent diseases in Western societies. The addition of functional components can enhance the nutritional properties of meat and its acceptance by consumers. Moreover, the meat industry is modernizing, adopting automated and continuous processes to maintain quality and reduce costs, which positively influences consumer perception regarding the safety, quality, and sustainability of functional meat products. The integration of novel ingredients into these processes presents challenges that require ongoing research and development, but it offers a comprehensive solution to improve health through diet.

Keywords
Meat Products, Functional Foods, Meat Process, Functional Compounds

1. Introduction

Currently, consumers have identified a direct relationship between food intake and its impact on health, which has significantly altered their expectations and requirements concerning food products. Beyond merely satisfying hunger [1], food is now expected to provide essential nutrients that contribute to health improvement, including the potential to control and prevent diseases. This awareness has driven a notable increase in the demand for functional foods, as reflected in a study by Khan *et al.* [2], which highlights a significant rise in this market segment. Additionally, modern consumers seek foods that are not only safe and nutritious but also healthy and natural [3, 4]. This transformation in consumer preferences underscores a clear trend towards health-conscious and mindful eating.

In this context, meat constitutes an outstanding source of high biological value proteins, as it contains a well-balanced combination of essential amino acids, particularly those containing sulfur [5]. Moreover, meat is an important vehicle for obtaining minerals and vitamins [6], which are crucial for strengthening the immune system, facilitating the conversion of food into energy, and repairing cellular damage, thus contributing to overall health and the prevention of various diseases. It is noteworthy that the bioavailability of minerals present in meat surpasses that of those found in vegetables. Nevertheless, consumers frequently perceive meat and its derivatives negatively, associating them with high levels of fats, saturated fatty acids, and cholesterol, which impacts their perception as healthy foods [7-9].

In response to these perceptions, the meat industry is adopting specific strategies to confer functional properties to meat and its derivatives, focusing primarily on modifying their nutritional composition both at the animal production level and in post-mortem handling. One of the techniques applied involves changes in livestock feeding, which can significantly alter the lipid content, fatty acids, and vitamin E in meat [7]. Subsequently, at the carcass processing level, techniques such as mechanical fat removal can be applied to further improve the nutritional profile of the final product [10-11].

Regarding processed meat products, efforts are concentrated on their reformulation. This reformulation may include modifying the lipid and fatty acid content, as well as incorporating a variety of functional ingredients. These ingredients include fiber, vegetable proteins, monounsaturated or polyunsaturated fatty acids, vitamins, calcium, phytochemicals, among others; with the aim of not only improving the nutritional profile but also offering specific health benefits to the consumer [12, 13]. These innovations respond to the growing demand for foods that actively contribute to the improvement of well-being and the prevention of diseases.

2. Functional Foods

Functional foods not only aim to provide basic nutrition but also offer specific health benefits [14], maintaining the characteristics of conventional foods intended for regular consumption. These products have been designed to fulfill physiological functions that go beyond the mere provision of essential nutrients. According to Drozen and Harrison [15], they are characterized by their abundance of biologically active components that offer health benefits surpassing traditional nutrients.

Niva [16], points out that a functional food not only includes additional ingredients developed through specific technologies but is also designed to provide a clearly defined health benefit. On the other hand, Hasler [17], argues that all foods have inherent functions, whether in terms of taste, aroma, or nutritional value, suggesting a broader perspective on food functionality.

Goldberg [18], establishes three essential criteria for a product to be considered a functional food: it must be a real food, derived from natural ingredients (not capsules, tablets, or powder); it must be a regular part of the habitual diet; and once ingested, it must positively influence specific processes such as improving biological defense mechanisms, preventing and treating diseases, controlling physical and mental conditions, and delaying aging. The fundamental purpose of functional foods, according to Vasconcellos [19], is to reduce the incidence of chronic diseases by modifying the consumption patterns of regular foods, thus offering a preventive and therapeutic strategy within the daily diet.

3. Functional Meat Products

Meat products, derived from animal meat and processed in various ways for human consumption, encompass a wide range including fresh meat, cured meat, sausages, among others [20]. However, functional meat products represent an innovation within the food industry, going beyond mere basic nutrition by providing additional health benefits specifically designed to improve well-being and prevent diseases in consumers [21-22].

Unlike traditional meat products, such as fresh meat cuts or conventional sausages, consumed primarily for their high-quality protein content, vitamins, and minerals, functional meat products incorporate additional ingredients with health-promoting properties. These may include, for example: fibers, probiotics, omega-3 fatty acids, antioxidants, and phytochemicals, aimed at specific functions such as improving the cardiovascular system, strengthening the immune system, reducing inflammation, or promoting gastrointestinal health.

Functional meat products add significant value by acting directly on specific biological and physiological mechanisms, resulting in therapeutic or preventive benefits. This feature responds to the growing demand of health-conscious consumers who seek foods that not only nourish but also offer specific health benefits. In contrast to traditional meat products, whose primary function is to meet basic nutritional needs, functional meats are integrated as an essential part of a healthy lifestyle [13].

Interest in foods that provide additional physiological benefits has increased due to growing scientific evidence on the relationship between diet and health. To be considered functional, a food must meet three basic requirements: be derived from natural ingredients, be part of the daily diet, and regulate specific processes once ingested [23]. Meat and meat products, known for their high biological value protein content, B vitamins, minerals, and trace elements, also contain bioactive compounds.
Despite their nutritional benefits, the negative perception of meat among consumers is due to its content of saturated fats, cholesterol, sodium, and other substances associated with prevalent diseases in Western societies, such as cardiovascular diseases, diabetes mellitus, and cancer [24-26]. This discrepancy between perception and the nutritional benefit of meat highlights the importance of developing functional meat products that address these health concerns without compromising their intrinsic nutritional value.

4. Active Components in Functional Meat Products

Our perception of food has significantly evolved over the centuries. Initially, food was considered merely a source of essential nutrients and energy for the body [27]. With the advancement of nutritional science, its role in supporting proper growth and development of the organism became understood [28]. Today, nutrition is recognized as a crucial factor in the prevention of diet-related diseases [29]. Consequently, the food industry has focused its efforts on improving the healthfulness of foods [30].

To enhance the nutritional value and health benefits of foods, the addition of functional substances has been implemented [31]. Traditionally, plants were considered the primary sources of functional ingredients. However, recent research has shown that animal products also contain these substances [29]. The fortification of original products with health-promoting ingredients forms the basis for producing foods with a greater positive health impact [32].

Meat and meat products offer a suitable matrix for designing innovative products. The development of functional meat and meat products can be carried out in two stages: during the animal nutrition stage and the processing stage. However, the addition of these functional ingredients can alter the appearance, taste, and texture of the original products. These changes are largely responsible for the rejection of many recently developed functional foods by consumers [33].

4.1. Fibers

Most meat products are rich in fats and proteins but deficient in complex carbohydrates such as dietary fiber [34]. Dietary fiber is a complex polysaccharide that exhibits a wide range of functionalities, including emulsification, fat replacement, gel formation, cryoprotection, thickening, and stabilization [35]. These technical functionalities are highly influenced by the physicochemical properties of dietary fibers, including water-holding and binding capacity, oil-binding capacity, solubility, and viscosity [36, 37]. The incorporation of fiber can significantly enhance the physicochemical properties of meat [38]. Adding fiber to meat products results in reduced cooking loss, alterations in pH, and increased emulsion stability [39]. From a technological and economic standpoint, a crucial parameter for achieving higher cooking yield in emulsion-based meat products is achieving greater emulsion stability [40]. The pH change due to the addition of a dietary fiber source largely depends on the pH of the added fiber [41].

4.2. Probiotics

Awareness among contemporary consumers regarding nutritional diseases has increased the relevance of functional foods. Therefore, increasing the consumption of functional foods, such as those enriched with dietary fiber, in the daily diet has been recommended. Dietary fiber intake of 28 to 36 g/day is advised for adults, with 70% to 80% of this ideally being insoluble fiber [42]. Dietary fiber, both insoluble and soluble, serves various functions: insoluble fiber aids in intestinal regulation, while soluble fiber helps lower cholesterol levels and absorbs intestinal glucose, thereby preventing health risks [41, 43].

Meat is a potential source of nutrients such as proteins, fat-soluble vitamins, and minerals with high bioavailability compared to other nutritional sources [44], but it is deficient in dietary fiber [34]. In meat products, incorporating fiber from various sources such as cereals, pseudocereals, fruits, and vegetables can enhance both the appeal and functional properties of these products [38]. Additionally, agricultural by-products and wastes represent a relatively economical source of dietary fiber, and their inclusion at different levels in meat products can reduce economic costs [41, 45].

4.3. Antioxidants

Lipid oxidation is one of the main deterioration processes in meat and its derivatives, affecting interactions between lipids and proteins and causing undesirable changes [46]. Therefore, controlling lipid oxidation in meat products is crucial to improve consumer acceptability. In this context, peptide antioxidants have garnered considerable attention among the various antioxidants used in meat products [47].

Recent studies have highlighted the presence of peptide antioxidants generated through enzymatic hydrolysis of various proteins such as soy protein, β-lactoglobulin, ovalbumin, and α-lactalbumin [36], which have positive effects on liver and kidney function by reducing oxidative stress [48]. These antioxidant peptides can neutralize free radicals in meat products, contributing to their oxidative stability [49]. Furthermore, antioxidant enzymes exert their effects through multiple mechanisms such as metal ion chelation and scavenging of free radicals, influencing the efficacy of antioxidant compounds [50].

Recent advances in antioxidant research have enabled scientists to consider mitigating chemical toxins in meat products through different strategies, such as moderate conditions of thermal processing to reduce toxin formation, bio-accessibility restriction technology, and antioxidant interventions [51, 52]. Therefore, the current industrial trend has shifted towards natural antioxidants derived from various plant materials rich in radical-scavenging polyphenols [51, 53].

4.4. Vitamins and Minerals

Meat and meat products represent a valuable source of bioactive compounds with positive effects on human health, such as vitamins, minerals, peptides, and fatty acids. Increasing consumer awareness and global competition among meat producers drive the need to develop healthier meat products. To meet these expectations, producers resort to supplements with functional properties for animal diets and as direct additives for meat products, such as vitamins (E, D, C, and B) and minerals [29, 54, 55].

An effective approach to address micronutrient deficiencies and avitaminosis in the population is the development and widespread implementation of products enriched with a complex of vitamins and minerals based on natural components. An example is the consumption of meats enriched with bee pollen through a fermentation process [56].

Vitamin E, known for its potent antioxidant activity, is added to animal diets through feed fortification, with a-tocopherol acetate standing out as an effective additive. Although vitamin E deficiency is rare in the human diet, it is common in animal feed, and meats become a moderate source thanks to fortification [30, 57]. Supplementation increases its content in animal muscles, improving meat quality in terms of color, texture, and water retention [58].

On the other hand, vitamin D, enriched in animal feed, enhances meat quality, especially in terms of color and tenderness, although excessive doses before slaughter do not optimize these traits [59-61]. Vitamin C, added to fodder, also improves meat texture due to increased collagen turnover [62]. Meats rich in B-group vitamins, such as thiamine and vitamin B12, may lose these vitamins during cooking, necessitating direct fortification to compensate for this loss. Studies have shown that fortifying meat products with B vitamins is effective even after severe heat treatments, highlighting the importance of fortification in meat's nutritional quality [63, 64].

Meat, as a prominent source of iron, is essential in the human diet. During cooking, iron content can concentrate up to 26% more than in raw meat, making it a valuable option to combat iron deficiency. Furthermore, implementing semi-intensive feeding systems for cattle and prolonging the animals' lifespan contribute to higher iron doses in meat, strengthening its nutritional value [65]. Varieties like emu and ostrich meat stand out for their high iron content, making them functional foods [66].

Adding selenium to animal feed and its inclusion in meat offers benefits for both lipid oxidation stability and the sensory quality of the final product [67]. Similarly, using calcium and magnesium salts as substitutes for sodium chloride in meat products presents sensory challenges that can be mitigated using masking agents [68]. Finally, zinc and iodine supplementation in animal feed and their subsequent impact on meat quality and nutrition underscore the importance of nutritional management in animal-origin food production [69, 70].

4.5. Essential Fatty Acids

The composition of fatty acids in meat plays a crucial role in its nutritional properties. While saturated fatty acids (SFAs) have been associated with diseases such as heart failure and cancer pathogenesis, polyunsaturated fatty acids (PUFAs), especially n-3 PUFAs, are recognized for their beneficial health effects, such as reducing blood clotting tendencies and decreasing coronary artery disease in humans [71, 72]. Fat, as the richest dietary source of energy, provides essential nutrients including essential fatty acids and precursors of compounds that regulate various physiological functions, such as prostaglandins. Additionally, it facilitates the absorption of fat-soluble vitamins (A, D, E, and K) [41]. Fatty acids can be classified as saturated or unsaturated, depending on the presence of double bonds. Unsaturated fatty acids are further subdivided into monounsaturated and polyunsaturated depending on the number of double bonds. Polyunsaturated fatty acids (PUFAs) are key structural components of cell membranes and play a vital role as nutrients in treating non-alcoholic fatty liver, autoimmune reactions, and various chronic diseases [73, 74].

Although meat is rich in saturated fatty acids, it contains low levels of polyunsaturated fatty acids, especially in ruminant meats such as beef and lamb. This imbalance in fatty acid composition, if maintained throughout the diet, can increase the risk of cardiovascular diseases. It is important to note that the fatty acid composition in meat can vary significantly due to factors such as diet, age, weight, sex, and breed of the animal [75]. Therefore, meat production should focus on balancing the proportion of fatty acids to enhance its nutritional benefits and reduce health risks. Continuous research and implementation of appropriate feeding practices in animal husbandry are essential to achieve this goal.

5. Healthy Benefits of Functional Meat Products

The evidence supporting health benefits associated with specific components in meat and meat products is progressively gaining credibility. Recently, considerable attention has been devoted to the development of meat and meat products with physiological functions aimed at promoting health and preventing disease [12, 76].

Meat has significant potential to provide essential nutrients in the diet [30]. These products can be enhanced through genetic manipulation and the addition of functional compounds in animal feed [77, 78]. Examples of such compounds include conjugated linoleic acid, omega-3 fatty acids, vitamins, antioxidants, and minerals, which optimize carcass composition and meat quality. Furthermore, functional ingredients like plant proteins, whey proteins, dietary fibers, garlic, sage, minerals, herbs, spices, probiotics, and prebiotics can be directly incorporated into meat products during processing, thereby enhancing their functional value [76].

Saturated and polyunsaturated fatty acids, antioxidants, and dietary fiber play fundamental roles in promoting health through nutrition [30, 79, 80]. The inclusion of omega-3 fatty acids in functional foods has been highlighted for its potential benefits in reducing cardiovascular risk and other health issues such as depression and arthritis [79]. Dietary fiber, classified as soluble and insoluble, has shown effectiveness in reducing cholesterol and blood sugar levels, and contributes to weight loss [30].

Additionally, antioxidants like vitamins A, C, and E, are essential for strengthening the immune system and preventing chronic diseases. Their incorporation into functional foods could further enhance these beneficial effects [81]. The combination of these nutrients in functional meat products could provide a comprehensive solution to improve health through diet, benefiting cardiovascular health, immune function, and metabolism [30].

6. Technologies and Production Processes

As the meat manufacturing sector progressively industrializes, new processing approaches and advances in ingredient systems are being developed to create innovative meat products. In Germany, where meat consumption is considerably high, particularly for products like sausages and hams, there has been a notable shift from small-scale manufacturing to large-scale industrial production [82]. This trend is driven by significant pressure from large discount chains, leading consumers to predominantly opt for low-cost, industrially produced products.

To meet the demand for consistent quality and cost control, the meat industry is adopting fully automated and continuous production processes, inspired by sectors such as automotive manufacturing and pharmaceuticals [83, 84]. These processes aim to reduce quality variations and increase efficiency. With advancements in mechanical engineering, new specialized machines for meat processing are being developed, incorporating knowledge from various industries [85].

Science and technology play a crucial role in improving consumer perception of meat and meat products, particularly in terms of safety, quality, and product stability. Many valuable scientific contributions, widely adopted by the industry, have succeeded in enhancing this perception [86]. However, the industry faces additional challenges regarding consumer perception, especially in the areas of health (nutrition), animal welfare, and convenience.

Consumer perceptions are dynamic and can change, making it difficult to predict their behavior [87]. For the food industry to remain viable, consumers must have positive perceptions and be willing to pay for products. In the context of meat, quality perception includes safety, sensory aspects, shelf life, nutrition, welfare, and health [88]. Integrating advanced technologies and innovative production processes is crucial to improving consumer perception. These advances can address safety, quality, and sustainability concerns, positively influencing consumer perception and ensuring market viability [86].

Nonetheless, integrating novel ingredient systems into these new processing schemes presents challenges [82]. Factors such as high-shear continuous grinding systems can affect the functionality of enzymes, antioxidants, preservatives, and fibers differently than traditional methods. Addressing these challenges requires closing significant gaps in fundamental research on the interaction between ingredient systems and continuous meat manufacturing lines [10]. To enhance the integration of new ingredients into the meat production process, ongoing research and the development of new ideas will be necessary in the coming years.

7. Examples of Successful Applications

Currently, research in the field of meat products focuses on the development and characterization of products that not only meet basic nutritional needs but also offer additional health benefits, classifying them within the category of functional meat products [89]. These efforts encompass a variety of meat species, including beef, pork, poultry, rabbit, and lamb, and range from fresh cuts to processed, ready-to-eat products [90].

By exploring the incorporation of components such as omega-3, antioxidants, fibers, probiotics, and vitamins, research is redefining the potential and impact of meat products in the modern diet. These ingredients not only enrich the nutritional profile of meat but also enhance its health effects, contributing to an improved quality of life for consumers [2, 91-99].

7.1. Beef

Beef, traditionally valued for its nutritional contribution and presence in various culinary cultures, is being reinvented as a functional food with the potential to combat chronic diseases, particularly cardiovascular diseases. This approach focuses on enriching beef with bioactive ingredients to improve its nutritional profile and functionality.

Olmedilla-Alonso *et al.* [89], developed an innovative product combining veal with walnuts, a food rich in unsaturated fatty acids, proteins, fiber, and micronutrients such as magnesium and potassium, in addition to key antioxidants like γ-tocopherol. This development addresses both technological and nutritional aspects to reduce the risk of cardiovascular diseases. The methodology applied includes the specific incorporation of crushed walnuts into the meat, with adjustments in preparation and freezing to ensure the integrity of the final product.

El-Refai *et al.* [100], studied the production of functional beef burgers with the addition of dried mushrooms, observing improvements in physical and organoleptic properties, as well as an increase in protein and mineral content. This incorporation not only enhances the nutritional profile of the burgers but also contributes to better water retention and texture, potentially increasing their acceptance in the health-conscious market.

Angiolillo *et al.* [101], continued this line of research by developing beef burgers enriched with prebiotics such as fructooligosaccharides, inulin, and oat bran. These compounds not only benefit intestinal health but also improve the sensory properties of the burgers, such as tenderness and juiciness, making these options more attractive to health-conscious consumers.

Jalarama-Reddy *et al.* [102], highlighted the use of olive oil in meat products, emphasizing how this ingredient, known for its high oleic acid and antioxidant content, can replace animal fats in meat products, thereby improving their nutritional and functional quality. This substitution not only brings benefits for cardiovascular health but also enhances the physicochemical and sensory properties of the products, maintaining their quality and extending their shelf life.

These studies demonstrate how beef, when fortified with functional ingredients such as walnuts, mushrooms, prebiotics, and olive oil, can become a key component of a health-promoting diet. This approach addresses concerns about chronic diseases and improves consumer satisfaction through innovative and nutritionally enriched products.

7.2. Pork

Pork, often underestimated for its nutritional potential, has been the subject of recent studies highlighting its capability to be fortified with bioactive compounds, making it an ideal vehicle for functional foods aimed at cardiovascular health and disease prevention.

Bermejo *et al.* [97], explored the consumption of functional foods enriched with omega-3 and rosemary extract, identifying pork as an ideal candidate for incorporating these nutrients due to its underlying nutritional properties. These bioactive compounds can improve lipid profiles and reduce inflammation associated with cardiovascular diseases, offering a healthy alternative within the diet.

Jalarama-Reddy *et al.* [102], investigated the integration of olive oil into pork for making burgers. This study highlights how the combination of pork and olive oil not only enhances flavor and texture but also incorporates beneficial monounsaturated fatty acids, known for their ability to reduce LDL cholesterol and protect against cardiovascular diseases.

Schnettler *et al.* [95], focused on consumer acceptance of processed meat products, including those enriched with omega-3 derived from pork. The results revealed a clear preference for these enriched products, underscoring the importance of aligning product properties with consumer expectations and needs regarding health and nutrition.

Fernández *et al.* [93], studied the impact of inulin, a prebiotic fiber, in pork products such as chorizo and cooked ham. The results demonstrated that inulin can effectively prevent colorectal cancer by modifying the gut microbiota and producing beneficial short-chain fatty acids.

Munekata *et al.* [92], explored the feasibility of enriching pork with probiotics, highlighting the opportunities and challenges associated with incorporating these microorganisms into meat products. Microencapsulation was noted as a promising technique to improve the viability of probiotics during processing and storage, ensuring their effectiveness and acceptance by consumers.

Pork is emerging as an important vehicle for integrating functional compounds aimed at improving cardiovascular health and preventing chronic diseases. Components such as omega-3 fatty acids, rosemary extract, olive oil, inulin, and probiotics not only enrich the nutritional profile of pork but also offer significant benefits, ranging from improving lipid profiles and anti-inflammatory properties to promoting a healthy gut microbiota and preventing diseases such as colorectal cancer.

7.3. Poultry

Poultry, due to its neutral flavor, consistent texture, and good color, is an ideal candidate for the development of functional meat products. Its adaptability allows it to meet specific market needs and consumer preferences, which is reflected in ongoing research and development aimed at enhancing its nutritional and functional value.

Petracci *et al.* [103], highlight how functional ingredients, such as salts and organic compounds, can significantly modify the technological and sensory characteristics of poultry meat. The addition of these substances not only improves the functionality of muscle proteins but also influences water and fat retention, enhancing the texture of the final products. This management of ingredients allows producers to optimize the use of raw materials and reduce costs while increasing processing yield.

Charoensin *et al.* [104], explored the potential of native Thai chicken and their crossbreeds as a source of functional meat, identifying bioactive compounds such as the dipeptides anserine and carnosine using advanced techniques like nuclear magnetic resonance (NMR) spectroscopy. These compounds, known for their antioxidant properties, were found in higher concentrations in native varieties compared to commercial broiler chickens, suggesting superior nutritional value and antioxidant potential that could be commercially exploited.

Munekata *et al.* [92], investigated the incorporation of probiotics into poultry meat, expanding the possibilities of developing fermented meat products with additional health benefits. Although the use of probiotics has been extensively explored in meats like pork, their application in poultry meat represents an emerging field with specific challenges, such as ensuring the viability of probiotics during thermal processing and their effect on the sensory characteristics of the product.

These studies collectively demonstrate a multidimensional approach to improving poultry meat, not only in terms of flavor and texture but also in its nutritional and health functionality. They underscore the importance of careful selection and management of functional ingredients to maximize benefits without compromising the desirable characteristics of poultry meat. As research deepens in these areas, new opportunities for innovation in the food industry are emerging, offering poultry meat products that meet the demands of an increasingly health-conscious market.

7.4. Rabbit Meat

Rabbit meat, with its exceptional nutritional properties, stands out as a prominent functional food in the human diet, capable of significantly contributing to overall well-being and health. Its unique composition, characterized by high-quality protein content, low levels of saturated fats, and a rich source of polyunsaturated fatty acids, along with its low cholesterol content, positions it as a highly favorable dietary option.

Dalle-Zote and Szendrő [96], delve into the nutritional characteristics of rabbit meat, highlighting its fatty acid profile, vitamins, and antioxidants. The study emphasizes how flaxseed supplementation from weaning to slaughter can substantially modify the omega-3 fatty acid profile in the meat, as well as impact other essential fatty acids. This has direct implications for the prevention of cardiovascular diseases and the improvement of cognitive health. The research also examines how diets rich in saturated fatty acids (SFA) and unsaturated fatty acids (UFA) can significantly alter levels of specific fatty acids such as linolenic acid (C18:3 n-3) and eicosapentaenoic acid (C20:5 n-3), among others, suggesting that controlled feeding strategies can optimize the functional and nutritional properties of rabbit meat.

Petrescu *et al.* [94], emphasize the bioeconomic benefits of rabbit meat, highlighting its efficient utilization of economical plant resources and high reproductive rate. This study underscores the natural richness of rabbit meat in essential nutrients such as vitamin B12, iron, and zinc, which are crucial for various biological processes, including red blood cell formation and immune function. This reinforces the perception of rabbit meat as an optimal food source for a balanced and healthy diet.

Both studies converge on the idea that rabbit meat not only provides lean proteins and essential nutrients but also has considerable potential to be developed and promoted as a functional food in markets where its consumption is still limited.

7.5. Lamb Meat

Lamb meat, renowned for its rich and distinctive nutritional profile, provides a solid foundation for the development of functional meat products. In a study conducted by Schnettler *et al.* [95], consumer acceptance of functional processed meat products in southern Chile was explored, using various meat sources including lamb. The aim was to evaluate the importance of various product attributes such as meat source, packaging, region of origin, price, and the presence of functional ingredients, specifically omega-3.

The study involved 411 consumers aged 18 and older, responsible for purchasing meat products for their households, selected through non-probabilistic sampling. The results highlighted that meat source is a more decisive factor than other considered attributes. Specifically, there was notable preference for products made with lamb and pork enriched with omega-3. Through cluster analysis, three distinct market segments were identified, each with significant differences in the importance assigned to product attributes and demographic characteristics such as family size, presence and age of children, ethnic background, and various health and quality of life indicators. These disparities underscore the diversity in consumer preferences and suggest that the acceptance of functional meat products is influenced by a complex interaction of sociodemographic and cultural factors.

The findings have critical implications for producers and marketers of functional meat products. Differentiated marketing strategies are suggested to consider the specific preferences of each identified segment. Furthermore, there is an emphasis on the need for additional research to deepen understanding of consumer preferences and how these impact the acceptance of functional meat products, thus guiding the development of products that better align with market expectations.

7.6. Processed Meat Products: Sausages

Functional meat products represent an innovative approach in the food industry, targeted towards consumers concerned with balancing health and culinary pleasure. Several studies have investigated the inclusion of functional ingredients in these products, aiming to optimize not only their nutritional profile but also their sensory characteristics and shelf-life. Fernández-López *et al.* [99], explored the incorporation of citrus peel residues, such as lemon albedo and orange fiber powder, in cooked sausages. This study revealed improvements in chemical composition and physical properties such as color and texture, as well as a reduction in residual nitrite levels, thereby enhancing the sensory quality of the sausages. Additionally, they evaluated how these ingredients affect the drying process of dry-cured sausages, suggesting a holistic approach in using natural ingredients to improve both production and consumption of sausages.

In another study, Leroy *et al.* [98], focused on the use of functional starter cultures in the production of fermented sausages. These cultures accelerate the acidification of meat mass and enrich the sensory profile of the final product. By using bacteria such as Lactobacillus sakei, Lactobacillus curvatus, and Staphylococcus xylosus, efficient fermentation is promoted, improving aroma and flavor while incorporating probiotic benefits and reducing the production of undesired compounds like biogenic amines.

Similarly, Khan *et al.* [2], took functionality a step further by introducing fortified probiotic sausages. These sausages, enriched with cultures like Lactobacillus acidophilus and Lactobacillus plantarum, not only preserve an appealing flavor but also offer digestive and immunological benefits, highlighting the potential of functional sausages as vehicles for promoting health.

Lastly, Bermejo *et al.* [97], conducted research on sausages enriched with omega-3 fatty acids and rosemary extract for individuals at risk of cardiovascular disease (CVD). This study underscores the positive impact of functional sausages on cardiovascular health, showing a significant reduction in inflammation markers and oxidative stress following regular consumption, thus paving new paths for dietary management of chronic diseases.

These studies illustrate the evolution of meat products from simple food items to complex formulations that can significantly contribute to public health. While notable advancements have been achieved, continuous research and development of new ingredients and techniques will be essential to further expand the benefits of functional meat products.

8. Conclusion

In the development of functional meat products, efforts have focused on incorporating various ingredients aimed at enhancing the nutritional value and positive health effects of meat for consumers. Research has concentrated on improving cardiovascular functionality, reducing the risk of chronic diseases, and bolstering the immune system, among other benefits. Meat species such as beef, pork, rabbit, lamb, and poultry (Table 1) have been fortified or enriched with substances that enhance their nutritional profiles, potentially improving or preventing disease symptoms through dietary consumption. This integrated approach not only enhances the utility of meat products but also meets the growing consumer demand for foods that actively contribute to their well-being and overall health.

Table 1. Functional meat products from different species.

Meat Specie	Meat Product	Treatment	Characteristics	Reference
Beef	Steak	Enriched with walnuts	Functional meat product with heart-protective properties	[89]
	Ground beef for hamburgers	Enriched with mushrooms (*Pleurotus ostreatus*)	Functional beef burgers with mushrooms	[100]
		Enriched with fructo-oligosaccharides, inulin, and oat bran	Burgers enriched with prebiotics and soluble fibers	[101]
	Fresh meat	Enriched with extra virgin olive oil	Beef enriched with extra virgin olive oil	[102]
Pork	Pork ham	Enriched with omega-3 and rosemary extract (*Rosmarinus officinalis)*	Enriched cooked pork ham	[97]
	Fresh meat	Enriched with extra virgin olive oil	Pork meat enriched with extra virgin olive oil	[102]
		Enriched with omega-3	Processed meat product enriched with omega-3	[95]
		Fortified with beetroot, grapes, apples, berries, and tomatoes	Fortified meat product	[91]
	Sausage and cooked ham	Enriched with inulin and prebiotic fiber	Sausages enriched with inulin	[93]
	Fermented meat	Enriched with probiotics	Fermented meat product enriched with probiotics (*Bifidobacterium longum*, *Enterococcus faecium*, *Lactiplantibacillus plantarum*, *Lactobacillus fermentum*, *Enterococcus faecium*, *Lactobacillus sakei*, *Lactobacillus rhamnosus*, *Bifidobacterium animalis subsp. lactis* y *Lactobacillus casei*)	[92]
Poultry	Fresh meat	Fortified with inorganic salts (sodium chloride, phosphates, and bicarbonate)	Fortified meat product	[103]
		Enriched with dipeptides (anserine and carnosine)	Enriched meat product	[104]
	Fermented meat	Enriched with probiotics	Fermented meat product enriched with probiotics (*Lactiplanti bacillus*	[92]

			plantarum, *Lactobacillus fermentum*, *Lactobacillus sakei*, *Lactobacillus casei*, *Bifidobacterium longum*, *Bifidobacterium animalis subsp. lactis*),	
Rabbit	Fresh meat	Fortified with antioxidants, vitamin E, selenium, and fatty acids (omega-3 and conjugated linoleic acid)	Fortified meat product	[96]
		Naturally enriched with vitamins, minerals, iron, and zinc	Enriched meat product	[94]
Lamb	Fresh meat	Enriched with omega-3	Processed meat product enriched with omega-3	[95]
Others	Cooked sausages	Lemon albedo and orange fiber	Cooked sausage enriched with functional ingredients from industrial waste	[93]
	Fermented sausages	Starter cultures of lactic acid bacteria and catalase-positive cocci	Fermented sausages with *Lactobacillus sakei*, *Lactobacillus curvatus*, *Pediococcus acidilactici*, *Pediococcus pentosaceus*, *Staphylococcus xylosus* y *Staphylococcus carnosus*	[98]
	Sausages fortified with probiotics	Fortified with meat starter cultures	Probiotic sausages fortified with *Lactobacillus plantarum*, *Lactobacillus casei*, *Lactobacillus paracasei*, *Lactobacillus acidophilus*, *Bifidobacterium lactis* y *Bifidobacterium longum*	[2]
	Turkey ham	Enriched with omega-3 and rosemary extract (*Rosmarinus officinalis)*	Cooked turkey ham enriched	[97]

Author Contributions

Frixia Galán-Méndez: conceptualization, writing—review and editing; Yetzalli A. Saldaña-Carmona: writing—original draft preparation; Laura Acosta-Domínguez: writing - review. All authors have read and agreed to the published version of the manuscript.

Conflicts of Interest

The authors have no conflicts of interest to be declared.

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