



Effect of selected food additives on quality of meat and meat products, recent advances

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ABSTRACT

Fresh meat is perishable and has a short shelf life due to spoilage by facultative anaerobes and psychotropic aerobes which produce a foul odor. Biogenic amines are formed during the storage of meat products such as sausage and ground beef by decarboxylation of amino acids and specific enzymes produced by microorganisms. This review paper presents an overview regarding the application of several functional food materials in meat and meat products to improve their quality as well as health benefits. A comprehensive literature search was performed for studies published prior to July 2024, utilizing multiple databases and employing topic keywords in the search strategy. The use of synthetic preservatives in meat and meat products could cause adverse effects on human health. There is a pressing need to use natural preservatives for this reason. The benefits of these functional materials mostly relate to reducing lipid oxidation, microbial growth, cholesterol levels and preventing the risk of several chronic diseases such as heart disease and cancer. The benefits of selected functional food additives utilized to improve meat quality have been summarized. The functional food materials include, but are not limited to, green tea leaf extracts, grape extracts, grape seed extracts, oregano and oregano essential oil, cinnamon, rosemary, rosemary extract, and cinnamon essential oil, flaxseed, thyme, milk proteins, dietary fibers and surimi. The added substance(s) could have a variety of benefits on meat products' quality, such as

reducing lipid oxidation, spoilage, and pathogenic microorganism growth, therefore extending the meat's shelf life. Furthermore, health benefits such as lowering the risk of cardiovascular disease, obesity, and colon cancer may be dramatically diminished.

Novelty: This review summarizes recent advances in the application of natural functional food additives, including plant extracts, essential oils, and proteins, to enhance meat and meat product quality. It uniquely focuses on their potential to replace synthetic preservatives, offering health benefits like reduced risks of cardiovascular diseases and cancer, while extending shelf life and controlling spoilage.

Key words: meat products, meat quality, food additives, natural antioxidants, essential oil



Graphical abstract: Effect of selected food additives on quality of meat and meat products, recent advances

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INTRODUCTION

Several food materials could be used in the field of meat processing and production to improve composition, fatty acid profile, reduce levels of fat and cholesterol and enhance the health status of the consumers. Consumers

demand healthier products due to the recent rise in diseases related to the consumption of meat and meat products, such as obesity, stroke and cancer. These health benefits could be obtained by adding functional ingredients such as conjugated linoleic acid, vitamin E,

selenium, spices, herbs, n-3 fatty acids, essential oils of medicinal plants, extracts of natural antioxidants, surimi and dietary fiber to the meat to improve its functional value [1]. According to Butnariu and Sarac [2], the three basic requirements to be considered for a functional food ingredient are 1) the food should be naturally occurring, 2) it should be consumed as part of the diet, and 3) the risk of disease from such an ingredient must be prevented. Meat stored in the refrigerator could be spoiled by psychotropic aerobes, facultative anaerobes, and characterized by the development of an odor. He also claimed that psychotropic *Lactobacillus* causes gas-packaged and vacuum-packaged meat spoilage. Generally, sliminess, souring, and greening are the three types of spoilage in meat and meat products. Moreover, during manufacturing and storage periods of meat products such as sausage and ground beef, biogenic amines are formed by decarboxylation of amino acids through the action of a substrate of specific enzymes produced by several microorganisms such as *Streptococcus*, *Lactobacillus*, *Enterobacteriaceae*, *Bacillaceae*, and *Pediococcus*. Many functional food materials have been used to improve the quality of meat and meat products [3-5]. Table 1 presents selected ingredients used to improve the quality of meat and meat products. This article aims to highlight the functionality of food chosen ingredients to improve the quality of meat and meat products.

Methodology: A comprehensive literature search was performed for studies published before July 2024, utilizing multiple databases, including ScienceDirect, Elsevier, PubMed, ResearchGate, SCOPUS, Web of Science, Google, and Google Scholar. Keywords related to meat products, meat quality, food additives, natural antioxidants, and essential oils were employed in the search strategy.

SELECTED STUDIES ON UTILIZATION OF FUNCTIONAL FOOD INGREDIENTS AS MEAT QUALITY IMPROVERS

Green tea leaf extracts. Green tea leaf extracts are used in meat and meat products as antioxidants due to their high polyphenol content. It contains many antioxidant compounds such as *Epicatechins*, *Catechins*, *epigallocatechin*, *Epicatechin Gallate*, and *Epigallocatechin gallate* [6]. The active ingredients in green tea have high lipid antioxidant activity and prevent lipid oxidation in addition to antibacterial activity [7]. The utilization of green tea leaf extracts in meat and meat products was reported [8]. Tea contains a group of compounds, particularly catechins, known for their antioxidant-related effects [9]. The major tea catechins are (i)-*epicatechin* (EC), (i)-*epigallocatechin*, and (i)-*epigallocatechin gallate*. These phenolics may represent about 30% of the dry weight of fresh tea leaves [10]. It was reported that the crude methanolic extract of black tea diluted in ethanol revealed good bactericidal activity at nearly all concentrations. However, the extract of green tea was also evaluated and resulted in antibacterial activity against microorganisms such as *P. aeruginosa*, *S. aureus*, and *S. typhus* [11]. The extract also showed potent antibacterial activity against *S. aureus* with an even minimum inhibitory concentration of 150 μ L, where the zone of inhibition was only 27 mm [12]. Xingyong [13] investigated green tea powder as a functional additive in broiler chicken feed on meat quality and bacterial growth. It was found that the meat powder significantly increased both the intramuscular fat content of breast muscle and the redness (a^*) value of the meat. The green tea powder also inhibited *E. coli* proliferation in the cecum and the ileum of the broiler chicken. Moreover, when the green extract was combined with polyamide

for fresh minced meat active packaging applications, it extended the shelf life of the meat for 23 days [14].

Rosemary extract. Rosemary is considered a good source of natural antioxidants; hence, it has been used in many types of food for shelf-life extension. It has been investigated as a meat quality improver [15]. Due to the presence of many phenolic compounds such as *carnosol*, *carnosic acid*, *isorosmanol*, *rosmanol*, *rosmariquinone*, *rosemary-diphenol*, and *rosmaridiphenol*, which can break free radical chain reactions by hydrogen donation, rosemary and rosemary extracts are excellent meat lipid oxidation inhibitors [16]. Rosemary (*Rosmarinus officinalis* Linn.) has been widely used in the food industry because of its inherent high antioxidant activity [17]. It was investigated in the concentration of (200 – 350 ppm in chicken meat) to evaluate the quality and stability of ground chicken meat stored in vacuum bags at 4 °C for up to 7 days [18]. The study revealed that the extract of rosemary in the concentration of 350 ppm was very effective as an antioxidant, comparable to other commercial antioxidants, and could be used as a good substitution for many synthetic antioxidants used in the meat industry.

Grape extracts. Grapes have high phenolic compound content and provide a good alternative to conventional antioxidants [19]. The most common phenolic acid in grapes is syringic acid, which displays various pharmacological properties, including antioxidant, anti-inflammatory, neuroprotective, and antimicrobial properties [20]. Grape extract can be found in various forms such as dietary fiber, seed extract, grape wine, and pomace. The grape seed extract is rich in oligomers and polymers of *polyhydroxy flavan-3-ols* like catechin and epicatechin [21]. The antioxidant effect of grape seed extract was evaluated in many research works. It has a practical impact on shelf life and quality of beef and beef

products [22], chicken meat and chicken patties in refrigerated storage [23], raw and cooked beef and pork in refrigerated storage conditions [24], cooked pork meatballs in refrigerated storage conditions [25]. It was reported that grapes in concentrate form are rich in flavonoids, including epicatechin, catechins, epicatechin-3-O-gallate, tetrameric procyanidins, and *dimeric*, *trimeric* [26]. When grape antioxidant dietary fiber was used in cooked chicken patties, it showed effective results during refrigerated storage in reducing yellowness and lightness and increasing redness in raw and cooked chicken hamburgers without affecting the acceptability of the products [27]. It revealed excellent antioxidant properties, improved microbiological quality, and superior sensory evaluation scores [28].

Oregano and oregano essential oil. Due to its antioxidant activity, oregano (*Origanum vulgare*) is used in several meat products. Oregano contains more than 30 compounds, with thymol and carvacrol being the main compounds responsible for its antioxidant activity [29]. A reduction in the microbial growth in beef when active films containing oregano essential oil were used was observed [30]. On the other hand, films formulated using oregano oil and applied to beef muscle slices resulted in significant inoculation of both *Salmonella typhimurium* and *E. coli* O157: H7. Oregano essential oil was also used to evaluate its effect on the storage stability of cooked chicken meat. The addition of the oregano essential oil at 100 and 150 ppm to ground chicken breast and thigh meat resulted in a significant reduction of lipid and protein oxidation. It demonstrated effectiveness in enhancing the storage stability of chicken meat, comparable to the effect obtained with synthetic meat preservatives such as E-300, E-250, and BHA. This could make oregano essential oil an important functional ingredient for meat storage stability, and it may be used to replace synthetic antioxidants to improve the storage stability of chicken meats. The essential oregano oil was

also used as a nano emulsion with resveratrol as an edible coating to preserve fresh pork loin under high oxygen modified atmosphere packaging stored at 4 °C for 15 days. The results revealed that the oregano essential oil had significant fresh meat stability and preservation. In many recent research works, Oregano and its essential oils were reported to have significant anti-oxidative and antimicrobial activities [31].

Cinnamon and cinnamon essential oil. Cinnamon and cinnamon essential oil are used in meat treatment due to their scavenging capacity for hydroxyl radical (OH radical) and 2, 2-Diphenyl-1-Picryl Hydrazyl Radical. According to Diniz do Nascimento *et al.* [32], the scavenging property of OH and DPPH radicals is attributed to the hydrogen donated by the phenolic component. The scavenging property of OH and DPPH radicals is attributed to the hydrogen donated by the phenolic component of cinnamic oil. The antioxidant effect of cinnamon essential oils on beef meat during 10 days of refrigerated storage was investigated. It was found that cinnamon significantly reduced the thiobarbituric acid reactive substances (TBARS) in the minced beef meat. There was a proven significant reduction of ground beef's microbial and lipid oxidation kept at 4 ± 1 °C for up to 16 days under vacuum packaging [33]. Concentrations of essential oil microcapsules from 0.5% - 1% w/w of the meat showed significant inhibition of lipid oxidation and microbial growth. Dietary supplementation of cinnamon in broiler chicken was investigated [34]. The quality of the 216-day-old chicken meat was evaluated, and a significant decrease in cholesterol level was observed.

Flaxseed and flaxseed essential oil. Flax is a functional food ingredient because it contains polysaccharides other than starch and alpha-linolenic acid lignans. The seed of flax contains approximately 20% protein, 30% dietary fiber, and 40% lipids [35]. The oil of flaxseed is considered α -linolenic richest source of α -linolenic acid. It is widely used in meat applications and is regarded as one of the best functional food ingredients for enriching

the meat with total polyunsaturated fatty acids (PUFA) and omega-3 [36]. Treatments of bologna-type meat products designed for older adults improved better nutritional profiles and acceptable sensory properties [37]. Two varieties of flaxseeds were investigated to evaluate their effect on lipid oxidation in pork meatballs [38]. During the meat storage period, cholesterol degradation and stabilization of the fatty acid composition of stored meatballs were observed. A combination of flaxseed and tomato paste in a percentage of 0-20% of beef patties showed a decrease in cholesterol content and saturated fatty acids, and an increase in polyunsaturated fatty acids was observed [39].

Whey protein. Whey protein provides dietary protein and could make up to 20% of total milk protein due to consumer concerns about emerging antibiotic-resistant strains of microbiota (40). Whey protein is used in poultry diets to maintain the meat quality as an alternative functional food material to antibiotics [41]. Whey protein has prebiotics as well as non-resistant properties [42]. Whey is also used in fresh turkey in combination with chitosan as an antimicrobial incorporated in edible films [43]. It stopped the microbiological deterioration of turkey meat and the development of *S. Typhimurium*, *C. Jejuni*, and *E. coli* pathogenic microorganisms in coated fresh meat cuts for at least six days. The effect of whey protein concentrates in 1-4% concentrations on the quality and shelf life of buffalo meat was evaluated at day 25 of refrigeration storage [44]. The treatment significantly improved the quality and shelf life of the meat.

Thyme. Thyme and essential oils are natural, non-toxic, and safe plant secondary metabolites. They contain phenolic substances, namely carvacrol and thymol. They have excellent antibacterial effects on various bacteria including *Salmonella* and *Escherichia coli* (*E. coli*) O157: H7. Thyme was investigated for its antioxidant activity in fresh chicken breast meat stored at 4 °C for 3 weeks.

There are several compounds of phenolic acids in thyme, such as ferulic acid, caffeic acid, rosmarinic acid, and gallic acid [45]. It was reported that thyme reduced lipid peroxidation, deterioration of sarcoplasmic proteins, and DPPH radical formation. This helped prolong the meat's shelf life even after 2 weeks of storage. The essential oil of thyme also exhibited a strong free-radical scavenging ability and inhibited Fe^{2+}/H_2O_2 and $Fe^{2+}/ascorbate$ induced lipid oxidation [46]. The effect of thyme leaves extract in concentrations of 3.7% and 7.5% was evaluated on lamb meat [47]. The quality of the meat stored in a modified atmosphere of 70% O₂:30% CO₂ was evaluated. The extract significantly delayed lipid oxidation, color deterioration, and bacterial counts and imparted a better appearance to the fresh lamb meat, and the treatment kept the meat quality for 21 days. The effect of thyme oil was also investigated on poultry meat quality [48]. The daily addition of the thyme oil to the chicken meat at 200 - 600 mg/kg levels significantly improved oxidative stability and meat quality.

Dietary Fiber. Dietary fiber has been utilized as a functional ingredient in meat for its antioxidants and physiological properties. Moreover, high dietary fibre intake reduces the risk of obesity, cardiovascular diseases, colon cancer, and many other disorders [49]. Extracts and/or dried fruit powders of some plants and their by-products can be good sources of such functional materials [50]. Gum arabic, for instance, is considered a good natural functional ingredient because of its excellent dissolving property that reaches 85% of its weight [51]. Gum arabic has low viscosity, impartial taste, and high molecular weight. It contains more than 80% fiber. It is utilized in meat products with high concentrations (up to 50%) and reported as a heart disease controller by diminishing total cholesterol and lowering low-density lipoprotein cholesterol. The wheat fiber in percentages of 0-4% combined with pork back fat in percentages of 0-10% was studied on the quality of bologna sausage. The treatment improved the sausage using wheat fiber as a fat substitute.

Table 1 Selected food functional ingredients used as meat and meat products quality improvers.

S.no.	Functional food product used	Type of meat used	Function in the meat product	Reference
1	Green tea extract	Beef patties	Stabilizing color of the meat compared to untreated meat	[52]
2	Curry & mint leaves to extract	chicken meat	Lipid oxidation was reduced in chicken patties	[53]
3	Unripe papaya extract	beef kabab	Stabilize protein, fat, ash of the product	[54]
4	Oregano essential oil	Dry fermented sausage	Lower the content of aldehyde in the treated samples	[55]
5	Clove essential oil	Red meat	Improve quality stability of raw samples when incorporated with starch as an edible film	[56]
6	Orange dietary fiber	Sausages	improvement in the products Shelf-life	[57]
7	Banana peels extract	Chicken meat	Decreasing lipid oxidation	[58]
8	Grape seed flour	Frankfurter	Oxidative stability, the addition of dietary and improving water holding capacity of the product	[59]
9	Cinnamon essential oil	Red meat	Improving the shelf life of the raw red meat when incorporated as an edible film	[60]
10	papaya leaves extract	Chicken meat	Improve the tenderness of the meat	[61]
11	Whey protein concentrate	Chicken breast	Improves sensory and textural attributes	[62]
12	Gum Arabic	Beef round	Improves and increases cooking yield	[63]
13	Fish surimi	Fish nuggets	Improves sensory evaluation of the product	[64]

Scientific Innovation and Practical Implications: This review innovatively consolidates current research on using natural functional food additives in meat products, emphasizing their potential as alternatives to synthetic preservatives. By systematically analyzing the effects of green tea, grape extracts, oregano, cinnamon, rosemary, flaxseed, thyme, milk proteins, dietary fibers, and surimi, this study highlights their multifaceted benefits, including the reduction of lipid oxidation, microbial growth, and cholesterol levels. This comprehensive approach addresses the pressing need for safer meat preservation methods and underscores the potential for these additives to mitigate chronic disease risks.

The practical implications of this research are substantial. The identified natural additives offer food producers viable strategies to enhance meat quality and extend shelf life without compromising consumer health. This shift towards natural preservatives could revolutionize the meat processing industry, leading to products with improved nutritional profiles and reduced health risks. Furthermore, the review's focus on these additives' cardiovascular and anticancer benefits provides a foundation for developing functional meat products that cater to health-conscious consumers. By consolidating this information, this review is a valuable resource for researchers and industry professionals seeking to innovate meat product development and promote healthier dietary choices.

CONCLUSION

The effects of selected functional food ingredients used as meat quality improvers were summarized. The added ingredient could have many potential effects on the quality of different types of meat and meat products, such as controlling lipid oxidation, spoilage, and pathogenic microorganisms, hence extending the shelf life of the meat. Furthermore, health benefits like

controlling cardiovascular diseases, obesity, and colon cancer could be significantly reduced.

Authors' Contribution: Moamed Abd Elgadir designed the analysis, collected the raw data, contributed to analysis tools, and wrote the first draft of the paper. Abdalbasit Adam Mariod conceived formatting and checked writing and grammar.

Conflict of Interest: The authors declare no conflict of interest related to this article.

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