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Review

Application of natural antioxidants for the formulation of functional meat products

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ABSTRACT

There is growing interest in finding healthier meals that offer more than just nutritional benefits. Meat and meat products are consumed all over the world, so it is possible to use them as matrices to make sure that people get enough bioactive components from their food. Besides extending the meat product's shelf-life and improving its composition (by integrating antioxidant molecules), it could also help people stay healthy by lowering lipid oxidative products. In this review, we look at whether developing and eating functional meat products is a viable method for improving meat composition and stability and reducing the oxidative consequences associated with the consumption of meat intake. The inclusion of plant bioactive compounds and antioxidants in meat products should protect the composition and quality of functional meat and meat products as well as the customers' health status. The key plant components with antioxidant capabilities employed in the composition of functional meat products will be discussed in this review.

Introduction

Recent developments in meat products, changes in customer needs for nutrition, health, well-being, and natural goods. In meat industry is being compelled to manufacture high-quality, safe meat products. As a result, novel techniques for meat production, preparation, storage, and distribution may alter the qualitative and quantitative composition of meat products and maximize their positive aspects for human health. Meat and meat products are perishable items that need additives to avoid deterioration and assure the absence of pathogenic bacteria and foodborne pathogens.[1-3] As a result of these processes, the nutritional content and sensory quality of meat products are diminished. Meat products lose nutritional value and sensory quality as a result of these processes. The changes that occur during oxidation may affect customer acceptability (color and texture changes, as well as the appearance of rancid odor and taste) or even the product's safety (harmful compounds).[4] In this case, antioxidants are added to help

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delay or stop these adverse effects.[5] Toxicological concerns have led to a search for new sources of antioxidants and antimicrobials. So, more and more people want to use plant extracts because they are thought to be safe and are Generally Recognized as Safe (GRAS).[6] Natural extracts should be used to prepare meat to preserve it from external influences and lengthen its shelf life.

Summary of the Literature

Natural and synthetic antioxidants are used to inhibit the development of oxidative reactions.[7] Antioxidants comprise the free radicals scavengers, metal chelators, and intrinsic antioxidants that are hindering the off odor in meat and meat products.[8, 9] Lipid oxidation is a non-microbial factor, occurs in high fatty food such as milk, meat, etc.[10] deteriorates various quality parameters due to the formation of hydroxyl acids that altered the flavor, aroma could change by the formation of new volatile odorous compounds. The color changed due to the reaction between oxidation products of protein and lipid for the development of dark-colored meat.[11] During meat processing, the reaction between unsaturated fatty acids and cytosolic pro-oxidants increased lipid oxidation. Meat has several endogenous pro-oxidants and antioxidants that play a vital role in the potential of lipid oxidation in meat. Stored meat, formed ferryl-myoglobin (activated metmyoglobin or H_2O_2 activated metmyoglobin), is the main factor of lipid oxidation in meat. Lipid oxidation in meat starts immediately after slaughter as after which there are various biochemical reactions involved in the conversion of muscle to the meat that leads to a decrease in antioxidative capacity.[9] Natural antioxidant substances can be extracted from natural sources such as plants or animals. These are usually phenolic compounds that have good antioxidant potential and generally comprise tocopherols, flavonoids, and phenolic acids. α- tocopherol, the vital antioxidant, has a lower antioxidant capacity in edible oils than other tocopherols.[12]

Natural antioxidants occur in various leafy vegetables and seeds, such as vitamin E, ascorbic acid, and phenolic compounds, that can minimize the oxidative damage connected with lots of diseases, such as cardiovascular disease, atherosclerosis, cataracts, arthritis, diabetes, aging, cancer, and immune deficiency.[13] In recent years, the use of natural antioxidants in meat and meat products has skyrocketed. Different pure natural compounds and crude extracts have antioxidant properties that are used for retardation of lipid oxidation and deterioration of food (Table 1).[14] Phenolic compounds possess antioxidant properties found in the Plant kingdom, including α-tocopherol (vitamin E), an efficient naturally occurring liposoluble antioxidant.[15] Numerous studies show consumers are using α-tocopherol, a lipid-soluble chain-breaking antioxidant, and customer-friendly.[16] Polyphenols contain aromatic organic compounds with at least a single hydroxyl group attached directly to a benzene ring. They consist of flavonoids, flavones, flavanols, polymeric phenolic substances, tannins, coumarins, and phenolic compounds with fused benzene and pyrone groups.[17,18] However, fenugreek protects lipid peroxidation and enzymatic antioxidants, whereas the extraction of fenugreek seeds has the potential of reducing power, antioxidant/radical scavenging, and chelating activity (1,1-diphenyl-2-picryl-hydrazyl (DPPH) free radical scavenging activity).[19] Total phenolic is the aromatic secondary plant metabolites that play a major role in food color, nutritional, antioxidant and sensory properties.[20] Whereas the presence of hydroxyl group in a phenolic compound is a vital plant constituent that mostly contributes to free-radical scavenging ability. Various authors reported leaves and fruit had possessed the great source of an antioxidant substance such as seed, juice, and pericarp, free radicals like Reactive Oxygen Species (ROS), Reactive Nitrogen Species (RNS), hydroxyl radicals (OH), superoxide (O_2), hydrogen peroxide (H_2O_2), and Nitric Oxide (N_2O). These are proficiently quenched from juice and aqueous extract of leaves and their effect is superior to the fruit extracts even juice can suppress the production of low-density lipoprotein (LDL) in vivo and in vitro in rats effectively reduce the LDL level.[21,22]

Table 1: Researches related to natural antioxidant properties incorporated in meat products

No.	Developed Product condition	Effect on meat products quality
1	Apple peel and kinnow (citrus fruit) rind Functional ingredients: antioxidants; Developed products: Formulated Buffalo meat fillets; Storage time: Under aerobic conditions for 21 days in the refrigerator.	As compared to the control, the antioxidant-treated products considerably slowed in the oxidation process. The color value redness and yellowness showed a significant declining trend, but drop being more prominent in a control sample. Apple peel and kinnow rind powders increase storage life, as well as maintain the sensory quality at a refrigerated temperature under aerobic conditions.[36]
2	Moringa flower (MF) extract Functional ingredients: antioxidants; Developed products: Chicken nuggets; Storage time: Storage at 4°C for up to 20 days	MF extract, improve nutritional quality, and reduce lipid oxidation in cooked chicken nuggets.[34]
3	Dragon fruit peel (DFP) powder at different concentrations (1.5% and 3.0%) Functional ingredients: antioxidants; Developed products: Chicken nuggets; Storage time: 20 days of refrigerated storage	DFP rich chicken nuggets improve nutritional quality without affecting the quality and organoleptic acceptability of products up to 20days.[37]
4	Amla fruit (AF) and curry leaf (CL) extracts Functional ingredients: antioxidants; Developed products: Goat meat nuggets; Storage time: Refrigeration storage	The total flavonoid content of the CL extract was greater, whereas the total phenolic content of the AF extract was greater. Antioxidants increased the texture and sensory qualities of the AF and CL nuggets and reduced oxidation during refrigerated storage. Natural AF and CL extracts may be employed instead of the artificial BHT in goat meat nuggets to boost the antioxidant capacity.[38]
5	Guarana seed extracts (GSE) Functional ingredients: antioxidants; Developed products: Pork patties; Storage time: 2 ± 1 ^{0}C for 18 days	During storage of dosages of GSE (GSL) were able to sustain the color values. GSE incorporated samples had fewer TBARS (Thiobarbituric acid reactive substances) and carbonyls than control and BHT samples. Sample with GSL and GSM had better antioxidants as compared to synthetic antioxidants (0.08 and 0.07 mg MDA/kg). The result shows GSE is very efficient in preventing color degradation, lipid and protein oxidation. It has the potential to be a natural antioxidant in pork patties.[39]
6	Corn bran (CB), dried apple pomace (DAP), and dried tomato pomace (DTP) at different levels (3%, 6%, and 9 % levels) Functional ingredients: antioxidants; Developed products: Chicken sausages; Storage time: 4°C storage up to 20 days	Fiber-enriched chicken sausages containing 3% corn bran, 6 % dried apple pomace and 6 % dried tomato pomace were microbiologically safe and organoleptically acceptable up to the 15th day.[27]

Other causes of quality degradation of meat during storage are lipid oxidation. In this process, the occurrence of free radicals leads to the development of aldehydes responsible for the production of rancid flavours and alter meat color (apart from membrane phospholipids, the complex mechanics involved in this oxidation affects proteins, causing loss of protein solubility, color, and nutritional value. The range of lipid oxidation in meat products is monitored by malonaldehyde (MDA) formation through the TBARS (Thiobarbituric acid reactive substances) assay. Its reaction of MDA with thiobarbituric acid (TBA) results formed a red-colored complex, which can be measured to estimate the concentration of MDA. Workers previously reported that meat samples with a TBARS score of less than 1 have no off

odor.[23] Lipid peroxidation refers to a wide variety of oxidation products, with the reaction between oxygen and unsaturated fats.[24] Lipid peroxidation can proceed by enzymatic or non-enzymatic mechanisms.

One study investigated the impact of varying quantities of crude fenugreek leaves on lipid oxidation and microbiological deterioration in post-mortem refrigerated storage of mutton and cattle meat. Mutton and cattle samples were integrated with crude fenugreek leaves at four different concentrations: 0, 0.5, 1.0, and 1.5%. Mutton and cattle patties were refrigerated for 7 and 10 days post-mortem, respectively. On days 7 and 10, post-mortem, mutton, and cattle meat marinated with fenugreek leaves had considerably less MDA. Bacterial counts have decreased in mutton and cattle meat containing fresh fenugreek leaves at 3, 5, 7, and 10 post-mortems compared to control. The addition of chopped fenugreek leaves to mutton and cattle meat showed significant antibacterial activity and antioxidant activity.[25] One study developed mutton patties from two sheep breeds such as Munjal and Harnali and stored 20 days in refrigerated condition. In both mutton patties, TBARS values were found in the range of 0.15 to 2.11 mg malondialdehyde /kg up to the 20th day at refrigerated storage. Higher values of TBARS after every five days were found ($p \leq 0.05$) in the storage of both patties. However, the TBARS values on the same day had no significant difference.[26] Significantly higher TBARS value in dietary fiber (dried apple and tomato pomace) enriched chicken sausages during refrigerated storage. No effect on chicken sausages with the addition of fiber on TBARS value up to 10th day of storage. On the other hand, significantly lower TBARS values in dried apple and tomato pomace added chicken sausages than compared to the control sample determined by Yadav et. al. (2016).[27] One study determine the effect of antioxidants in dried rosemary (1 g/kg) in combination with yeast extract 1 g/kg (1st group) and 2 g/kg (2nd group) and compare to control sample in non-fermented heat-treated product Inovec salami. During shelf-life TBARS values in rosemary-treated cooked salami were lesser ($p \leq 0.05$) than control. So the result showed that the rosemary extracts had not been effective in preserving the color, but it is effective as the natural antioxidant potential for shelf-stable in non-fermented cooked salami.[28]

One study used curry leaves (*Murraya koenigii*) and fenugreek leaves (*Trigonella foenum-graecum*) (aqueous extracts) in raw chicken meat as a natural antioxidant and prepared four types of products such as control sample, BHT sample (0.1% BHT), 2% curry leaves extract sample (CLE) and 2% fenugreek leaves extract sample (FLE) compared for TBARS during 8 days of 4^0C. Sample with CLE and FLE had average phenolic content and free radical scavenging activity, CLE sample was improved reducing activity (2.4) than FLE (2.2). TBARS had significantly higher control during storage periods, followed by BHT, and CLE showed lesser enhancement in TBARS. Results showed that the inclusion of CLE and FLE extract decreases oxidation compared to the control sample, and curry leaves and fenugreek leaves have higher antioxidants than BHT.[29]

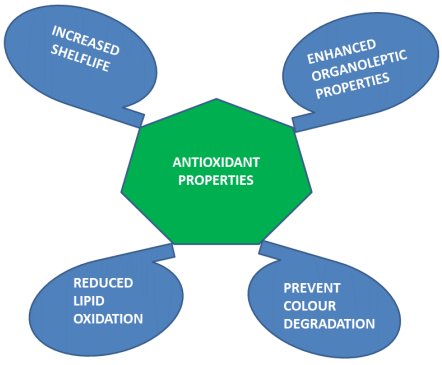
Another research analyzed the curry leaf powder (CLP) as a source of antioxidants in the ground and cooked goat meat patties and evaluated lipid peroxide and lipid oxidation during refrigerated storage. The incorporation of CLP reduces the lipid peroxidase rates and TBARS formation in raw meat as compared to control. These results indicated that CLP concentrations as low as 0.2% are a very active inhibitor in the raw ground and cooked goat meat patties.[30] Hydrolysable tannins were isolated from *P. granatum* pericarp have an essential antioxidant potential. Furthermore, it has been reported that pomegranate has an antioxidant activity due to the presence of two tannins such as ellagic acid and punicalagin.[31] Prophylaxis effect reported of *Trigonella foenum graecum* L. seeds on renal stone formation in rats. Fenugreek is used to treat patients with calcic urolithiasis, whereas fenugreek has anti-inflammatory potential[32] other factors that affect meat lipid oxidation include the presence of free metal

ions, oxygen availability, mechanical processes, heme pigments, cooking, and salt addition during processing.[33]

Formulated functional chicken nuggets with moringa flower (MF) extract with 1% and 2% and compared them to the control sample. The incorporation of MF extracts in both samples significantly improves emulsion stability, cooking yield, ash, protein content, phenolic value, and dietary fiber compared to control nuggets. MF extract (2%) added in chicken nuggets did not significantly increase lightness and redness value and lesser hardness, gumminess, and chewiness than the control sample. During refrigeration storage, up to 20 days significantly enhance the oxidative stability and odor scores by decreasing lipid oxidation in MF added chicken nuggets. MF extracts shows have active natural functional ingredients that improve product quality and minimize lipid oxidation in functional chicken nuggets. So the addition of MF extracts not affect the sensory attribute of nuggets, and nuggets remain stable and acceptable up to 15 days of storage.[34]

Inclusion of dried drumstick flowers (at 1% and 2%) as an antioxidant and functional ingredient in goat meat nuggets. Additions of dried drumstick flower in goat meat nuggets significantly improve the dietary fibre and enhance antioxidants properties that make such products healthier and more stable (Figure 1). Drumstick flower-added meat nuggets have a darker color and softer texture profiles without affecting overall sensory properties. During refrigeration storage, it reduces TBARS value and total plate count when compared to the control sample. Two percent incorporated drumstick flowers in meat nuggets successfully improve their functional properties and stability during refrigerated conditions.[35]

Figure 1: Effects of Antioxidants in Meat Products



Conclusion

Natural antioxidants derived from plants, boost the antioxidant capacity of meat and meat products, also preventing or delaying the development of reactive species and oxidation products, thereby increasing the shelf life and quality of products. Promising findings from various research indicate that natural antioxidants derived from plants may be utilized to increase the shelf life of meat products, providing consumers with food that includes only natural additives. Their usage enhanced nutritional quality decreased lipid oxidation and boosted the stability of meat products during their shelf life while keeping or improving sensory characteristics. Additionally, new functional meat products would be created to make use of the inherent antioxidant advantages for human health. Given the beneficial benefits of antioxidants on human health, the health implications of meat products reformed with natural antioxidants should be researched as well.

Conflicts of Interest

The author declares that there are no conflicts of interest relevant to this article.

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