A COMPREHENSIVE REVIEW ON THE ROLE OF NATURAL ANTIOXIDANTS IN MEAT AND MEAT PRODUCTS

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Abstract

Oxidation reactions during manufacturing, distribution, and storage of meat and meat products result in undesirable physicochemical changes and aromas, which lead to detrimental effects on the product quality. This could be translated into the consumer dissatisfaction and economic loss. One of the most common practices to overcome this issue is the incorporation of synthetic antioxidants. However, the increasing health-consciousness of consumers and their preference for natural additives leads to the search of natural alternatives to synthetic antioxidants. A number of spices and Moringa oleifera leaves extracts have strong antioxidant properties and are explored as potential alternatives to chemical antioxidants in the meat industry. These compounds are classified as Generally Recognized as Safe (GRAS), and their application single or combined with other ingredients have beneficial effects on meat products. This paper provides an overview of the role of natural antioxidants in meat and meat products.

Key words: meat products, natural antioxidants, Spices extract, Moringa oleifera Lam

INTRODUCTION

Meat and meat products are an essential part of the human diet. This is due to its protein and vitamins content, in addition to the essential fatty acids, which makes it an appropriate formula to fulfill the nutritional requirements of the human body. Lipids are responsible for many desirable characteristics of meats and meat products [21]. They influence the flavor and contribute to improving the tenderness and juiciness of meats [1]. Therefore, fat content and composition are of major importance for consumers due to their importance for meat quality and nutritional value [25].

Due to the previously mentioned ingredients, meat and meat products are subjected to decomposition and spoilage. Among them, the most important, after microbial decomposition, are oxidizing processes that affect fats, pigments, proteins and vitamins. During these reactions, the sensory deterioration of the product occurs, causing the consumer to reject it. In addition, nutritional loss and the formation of toxic substances affect the health of consumers, so controlling oxidizing processes is of vital importance to the meat industry and its products.

Meat as a food has a complex physical structure and chemical composition that is very susceptible to oxidation [25], [22]. The oxidative stability of meat depends upon the balance and the interaction between endogenous anti- and pro-oxidant substances and the composition of substrates prone to oxidation including poly unsaturated fatty acids (PUFA), cholesterol, proteins and pigments [6].

It is well known that fat oxidation and microbial contamination are among the most important major factors that determine the loss of food quality and reduce its suitability for human consumption. Therefore, delaying lipid oxidation and preventing bacterial contamination are of great importance in food treatments [8]. During production, distribution and storage, food is degraded as a result of chemical reactions and microbial activity [12]. The fat oxidation is the main cause of this deterioration due to its negative

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effects on sensory qualities (flavor, color, etc.). Fat oxidation can have a significant negative effect on nutritional value, and may be responsible for the production of toxic compounds [17].

Despite lipid oxidation was investigated for decades, the complex reactions involved in the process, as well as the different pathways and factors that influenced them, make that lipid oxidation mechanisms have not yet been completely understood.

With increased consumer concerns about the amount of chemicals in their foods, processors are looking for more natural ways to protect their products. In the last few years, there has been an increasing interest in the use of natural additives in preference to synthetic substances for the stabilization of fat-containing food stuff. [18], [2]. Natural antioxidants present in foods and other biological materials have attracted considerable interest because of their presumed safety and potential nutritional and therapeutic value. Natural antioxidants, especially phenolics and flavonoids, are safe and also bioactive. The natural antioxidants have been studied in meat from a huge number of plant sources. Some of these natural antioxidants are also available commercially and several studies have been carried out by different researchers applying commercially available natural antioxidants of plant origin to meat [22].

The increased interest in natural antioxidants has led to the antioxidant evaluation of many species of fruits, vegetables, herbs, spices and cereals [24], [14]. For this reason, there is growing interest in separating these plant antioxidants and using them as natural antioxidants.

Thus, the objective of this article is to review the effect of some natural antioxidants of stability of some different meat products during storage.

What is oxidation, and how does it alter food products?

Oxidation is a reaction that takes place when products containing fat or pigments exposed to oxygen. When fats oxidize, they produce “off” odors and flavors (stale, rancid odors). Often, if fats oxidize, vitamins also oxidize and lose their activity, and pigments can change color completely. Red meat turns gray when the meat pigment (myoglobin) oxidizes. In this case, the meat is not unsafe; but looks less appealing to consumers. Packing the food products in a wrap that limits oxidation (such as Saran Wrap) will keep them fresh.

Lipid autoxidation

Lipid oxidation is a very complex process, which includes multiple mechanisms that interact with each other. It starts when unsaturated fatty acids react with molecular oxygen to produce hydroperoxides that are considered to be the first oxidation products. Hydroperoxides are odorless and do not contribute any aroma. However, they are highly unstable, and decompose rapidly resulting in a large number of secondary compounds (hydrocarbons, aldehydes, ketones, alcohols, esters and acids) [23], which cause off-flavors and off-odors in meat and meat products. Aldehydes are considered the most important breakdown products and the largest contributors to volatile flavors in meat [4]. In addition, aldehydes are react with proteins causing modifications that result in changes in nutritional and organoleptic properties [10].

Due to detrimental effects of lipid oxidation on color, flavor, texture, and nutritional value of foods; addition of synthetic antioxidants such as BHT and BHA has been effective because of their low cost, high stability, and effectiveness. However, the use of such compounds has been related to health risks resulting in strict regulations over their use in food products and this has stimulated research for alternative antioxidant sources [13].

With increased consumer concerns about the amount of chemicals in their foods, processors are looking for more natural ways to protect their products. In the last few years, there has been an increasing interest in the use of natural additives in preference to synthetic substances for the stabilization of fat-containing food stuff. Among the natural antioxidants, extracts of herbs such as rosemary and sage have played an important role [18, 2]. The use of antioxidants like vitamin C and E had a significant effect in reducing oxidation of lipids and pigments of

meat during storage. In view of the fact that natural spices are widely used in a variety of food products, it is important to know the effects they have on the keeping qualities of such products. A number of studies have been made on the bactericidal and bacteriostatic properties of spices to evaluate their effectiveness in preventing or retarding spoilage caused by microorganisms in addition to the antioxidant effect of spices on fats in certain foods [20].

Factors affecting lipid oxidation

1. Fat Content and Fatty Acids Composition

The main factors that influence lipid oxidation in meat are fat content and fatty acid composition because fatty acids are the substrate of oxidation processes. In meat, lipids are organized into triglycerides and phospholipids, with low contributions of other types of lipids such as free fatty acids, cholesterol or vitamins. Many researchers pointed out that phospholipids are essential in the development of lipid oxidation.

2. Cholesterol and Cholesterol Oxidation Products

3. Heme-Proteins and Metals

4. Prooxidant Enzymes

Preventing oxidation

Not only does oxidation negatively affect the color, flavor and shelf life of meat and meat products, this harmful process starts as soon as the products leave the processing facility.

We know the fact that consumers 'eat with their eyes', and color makes the first impression, the visual cue that promises freshness, quality and deliciousness. Taste leaves a lasting impact, so flavor changes can negatively influence repeat purchasing decisions. Since oxidation changes both color and flavor, it affects the consumer decision-making process in two ways:

1-Color changes caused by myoglobin oxidation influence initial purchases.

2-Flavor changes caused by lipid oxidation influence repeat purchases.

Oxidation is the enemy, but it can be prevented or delayed through a variety of techniques, including processing techniques, packaging and storage methods such as modified atmosphere packaging (MAP), and the use of antioxidant ingredients.

Antioxidant ingredients provide the most cost-effective oxidation prevention method due to their level of effectiveness, their lack of negative impact on flavor, and their ability to provide targeted solutions.

The addition of antioxidants to meat and meat products to inhibit lipid oxidation is the main strategy used by the meat industry [16, 26, 5, 19, 15, 7, 9].

What do antioxidants do?

- Significantly delay or prevent lipid oxidation
- Delay myoglobin oxidation
- Lengthen shelf life
- Help maintain consumer acceptance

How do antioxidants work?

Antioxidants delay the onset of oxidation by donating hydrogen atoms to quench free radicals, forming a stable antioxidant radical that is unable to participate in propagation reactions, slowing down oxidation.

Antioxidants delay meat color loss caused by oxidation byproducts which interact with myoglobin and make heme iron susceptible to oxidation. Antioxidants delay myoglobin oxidation, maintaining consumer acceptance and therefore, lengthening shelf life.

Antioxidants delay flavor degradation by donating hydrogen atoms to quench free radicals caused by the onset of lipid oxidation. By delaying this onset and its negative effects, antioxidants help extend shelf life.

Natural antioxidants

Industrially, the meat and meat products stability is improved by the addition of synthetic antioxidants, which are compounds that delay the oxidative deterioration and consequently extend its useful life. However, the synthetic antioxidants as we mentioned before, have a restricted use in several countries, as they may present harmful effects to the human organism [11]. Therefore, antioxidants from natural sources have been studied aiming at obtaining safer and more efficient products that may be used in foods, thus substituting partially or completely the synthetic antioxidants [3]. Extracts of many plants have been shown to

have various degrees of antioxidant activity in different food products. The antioxidant activity of these plants and their extracts can be attributed to the presence of flavonoid compounds, phospholipids, tocopherols, and ascorbic acid.

Among the several sources of natural antioxidants studied, is Moringa oleifera Lam.. It is a plant widely cultivated in tropical regions, due to the low requirements of climate and soil and whose leaves, flowers, green fruits and roots display excellent antioxidant activity.

M. oleifera leaves with a high content of phenolics and flavonoids show greater antioxidant activity, anti-radical power, reducing power, inhibition of lipid peroxidation, protein oxidation and OH·-induced deoxyribose degradation, and scavenging power of superoxide anions and nitric oxide radicals than do its fruits and seeds. The antioxidant activity of Moringa oleifera leaf extract was found to be higher than that of standard vitamin E and remain unaffected at pH 4 and pH 9 in the dark at 5ºC and 25ºC respectively for 15 days, although the activity significantly decreases when heated at 100ºC for 15 min [18]. In addition, the activity can vary with such factors as variety, season and production location and stage of maturity.

CONCLUSION

Meat and meat products are very complex matrices with a composition that makes them susceptible to the oxidation processes. The oxidative processes on lipids, proteins, pigments and vitamins are negatively affecting the quality of the meat, including color and texture changes, rancidity development, nutrient losses and even the formation of toxic compounds. Addition of synthetic antioxidants such as BHT and BHA has been effective because of their low cost, high stability, and effectiveness. However, the use of such compounds has been related to health risks resulting in strict regulations over their use in food products and this has stimulated research for alternative antioxidant sources. With increased consumer concerns about the amount of chemicals in their foods, processors were used natural additives to protect their products. Among the natural antioxidants, spices, extracts of herbs and moringa leaves have played an important role.

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Examples of widely used antioxidants in the EU:

E-Number	Substance	Some foodstuffs in which they are used
E 300 E 301 E 302	Ascorbic acid Sodium ascorbate Calcium ascorbate	Soft drinks, jams, condensed milk, sausage
E 304	Ascorbyl palmitate	Sausage, chicken broth
E 306-309	Tocopherols	Vegetable oils
E 310 E 311	Propyl gallate Octyl gallate	Fats and oils for professional manufacture, frying oils and fats, seasoning, dehydrated soups, chewing-gum
E 320 E 321	Butyl hydroxy anisol (BHA) Butyl hydroxy toluene (BHT)	Sweets, raisins, processed cheese, peanut butter, instant soups

Antioxidants isolated from herbs and spice

Spice/herb	Scientific name	Antioxidant compounds	Mode of action
Rosemary	*Rosemarinus officinalis*	Carnosol, carnosic acid, rosmanol, rosmadial, diterpenes (epirosmanol, isorosmanol, rosmaridiphenol, rosmariquinone, rosmarinic acid)	Scavenge superoxide radicals, lipid antioxidant and metal chelator
Sage	*Salvia officinalis* L.	Carnosol, carnosic acid, rosmanol, rosmadial, methyl and ethyl esters of carnosol, rosmarinic acid	Free radical scavenger
Oregano	*Origanum vulgaris*	Rosmarinic acid, caffeic acid, protocatechuic acid, 2-caffeoyloxy-3-[2-(4-hydroxybenzyl)-4,5-dihydroxy] phenylpropionic acid; flavonoids – apigen, eriodictyol, dihydroquercetin, dihydrokaempherol; cavacrol, tymol	Free radical scavenger
Thyme	*Thymus vulgaris* L.	Thymol, cavacrol, ρ-Cumene-2,3-diol, phenolic acids (gallic acid, caffeic acid, rosmarinic acid), phenolic diterpenes, flavonoids	Free radical scavenger
Ginger	*Zingiber officinale*	Gingerol, shogaol, zingerone	Free radical scavenger
Turmeric	*Curcuma domestica* L.	Curcumins, 4-hydroxycinnamoyl methane	Free radical scavenger
Black pepper	*Piper nigrum* L.	Kaempferol, rhamnetin, quercetin	Free radical scavenger
Chili pepper	*Capsicum frutescence* L.	Capsaicin, capsaicinol	Free radical scavenger
Clove	*Eugenia caryophyllata*	Phenolic acids (gallic acid), flavonol glucosides, phenolic volatile oils (eugenol, acetyl eugenol, isoeugenol), tannins	Free radical scavenger, metal chelator
Marjoram	*Majorana hortensis*	Beta-carotene, beta-sitosterol, caffeic-acid, carvacrol, eugenol, hydroquinone, linalool-acetate plant 3–17, myrcene, rosmarinic-acid, terpinen-4-ol	Free radical scavenger
Cumin	*Cumimum cymimum*	Cuminal, γ-terpinene, pinocarveol, linalool, 1-methyl-2-(1-methylethyl)benzene, carotol	Free radical scavenger, metal chelator