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Antioksidant Effect of Medicinal Plants in Meat and Meat Products

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Abstract: *Oxidative deterioration in meat causes discoloration, development of off flavor, formation of toxic compounds, poor shelf life and nutrient losses. Products from lipid oxidation such as malondialdehyde can induce mutagenesis and carcinogenesis. While antioxidants can be of synthetic or natural origin, synthetic antioxidants have been widely used in meat products. But the demand for natural antioxidants, especially of plant origin has increased due to the potential toxicological effects of synthetic antioxidants. The application of medicinal plants including rich-antioxidants in meat can provide functional or nutraceutical meat or meat products and promote consumers health and wellness compared to the use of synthetic antioxidants. Studies have demonstrated that oregano, rosemary, clove, sage, thyme and vanillin showed high antioxidant activities in meat and meat products. The antioxidant properties of medicinal plants depend on the plant, its variety, environmental conditions, climatic and seasonal variations and many other factors. Antioxidant compounds are usually added at a moderate dosage level, since high level of inclusion may mechanistically cause adverse effects through pro-oxidative action in meat. Further research will be needed to evaluate the efficient use of medicinal-plant-rich antioxidants to preserve the functionality of meat and ensure production of meat products with nutraceutical properties.*

Keywords: *Medicinal Plant, Meat Product, Oxidation, Antioxidant.*

1. INTRODUCTION

Meat and meat products have a rich nutritional composition due to protein, lipid, water and small amounts of carbohydrates, regarding this their sensitivity to deterioration is high [1]. In despite of the flavor, food variety, convenience, and good nutritional value desired by the consumer, processed meats are often sensed to be less healthy than many other types of food. Especially, red meat consumption can be associated with chronic heart diseases and several types of cancer [2]. World Health Organization issued a monograph grouping processed meat as carcinogen (Group I) and red meat as probable carcinogen (Group 2A) [3]. Synthetic antioxidants such as butylated hydroxyanisole (BHA) and butylated hydroxytoluene (BHT) have been used in the food industry to prevent lipid oxidation [4]. In recent years, consumer concerns about the safety of synthetic additives in food have led to the use of natural antioxidants and antimicrobials in meat and meat products as alternative compounds to protect the food [5]. Many herbs, spices, fruits and beekeeping products contain natural antioxidants, and these natural antioxidants can provide protection against the undesirable change of oxidation [6]. Plants and plant products always have been important in many parts of human life [7]. Medicinal plants such as thyme, sage, rosemary, oregano are widely used in meat products. Antioxidant activity of medicinal and aromatic plants is related to phenolic compounds which are affected by oxidation in structures [8]. Flavonoids, phenolic acids and phenolic terpenes are the most common among these compounds [9]. The chemical composition of these plants varies depending on many factors and the antioxidant effects can vary [9][10].

2. OXIDATION IN MEAT

2.1. Lipid Oxidation

Lipid Oxidation Oxidation in the lipid and protein fractions of the meat has been shown as the main, non-microbial cause of quality deterioration during processing. Lipids and proteins in the meat are susceptibl to oxidative damage due to the rapid depletion of endogenous antioxidants after slaughter [11]. Also the meat becomes susceptible to oxidative degradation due to high concentrations of

unsaturated lipids in muscle tissue, heme pigments, metal catalysts and a range of oxidizing agents. Each type of meat manifests itself in terms of oxidative deterioration, color change, bad flavor, formation of toxic compounds, shelf life, nutrients and drip losses [12][13].

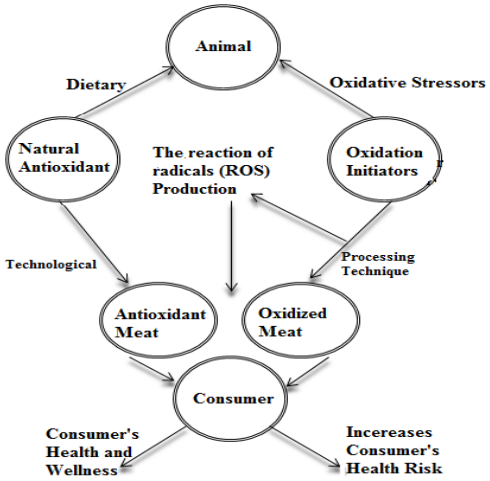

Fig1. *Interaction between oxidative initiation and the potential of natural antioxidants in preventing oxidation in meat [14].*

Lipids are distributed both as intracellular and extracellular spaces as triglycerides, phospholipids and sterols. However, the lipids are chemically unstable. For this reason, they are easily prone to oxidation, especially during post-mortem use and storage.

Oxidation of lipids is a three-step radical chain reaction involving initiation, propagation and termination with the production of freeradicals [14].Products that resulting from lipid oxidation react with food components such as protein and folic acid. These products have been found to cause cardiovascular diseases by inhibiting enzymes, increasing levels of cholesterol and peroxide in the blood. Oxidation products are reported to have carcinogenic effects [15][16].

2.2. Protein Oxidation

Protein oxidation depends on the meat which animal is taken, the muscle used, processing and other internal and external factors. Protein oxidation not only degrades color and texture but also causes the loss of nutrients and the digestibility of proteins such as essential amino acids. [17]. The reaction can be initiated by myoglobin, oxidizing lipids or metal catalysts. Functional groups located on the side chains of amino acids are the main targets of this attack. Further reactions lead to the formation of different protein radicals and hydroxyl derivatives and cause protein carbonylation [17] [18]. The development of protein oxidation depends on the composition of the amino acid in which the meat or product is contained and how the initial reactions are catalyzed. Protein oxidation is influenced by environmental factors such as pH, temperature, water activity and catalysts and inhibitors in the environment. In addition, 3-dimensional structures of proteins and amino acid compositions affect the propensity to oxidation [19] [20].

3. Effects of Antioxidants on Oxidation

Antioxidants are substances that delay the oxidation of readily biodegradable in meat products, thereby protracting the shelf life of products by protecting them from degradation, which is the cause of oxidation. Using catalysts that initiate linking chains such as metal ions, there are effects such as waste cleaning, cracking of the chain reaction, decomposition of peroxides, reduction of localized oxygen concentrations and prevention of chain inhibition [21]. Antioxidants inhibit the chain reaction by giving hydrogen atoms to radicals and the antioxidant free radical can form a stable peroxy-antioxidant compound [22].

Antioxidant activity is related to activation energy, rate constants, oxidation-reduction potential, ease of destroying antioxidants and antioxidant solubility [22] [23]. In addition, inhibitor and chain propagation reactions are both exothermic, therefore when the A:H and R:H bond dissociation energies increase, the activation increases and the antioxidant efficiency decreases [22].

The use of antioxidants in food products is controlled by the regulatory laws of an individual country or international standards. Synthetic antioxidants such as butylated hydroxyanisole (BHA), butylated hydroxy toluene (BHT), propyl gallate (PG) and tertiary butylhydroquinone (TBHQ) are used to prevent harmful changes due to oxidation in meat and meat products. But more study should be done because the potential genotoxic effects of these synthetic antioxidants. For this reason, the industrial trend has shifted towards natural antioxidants derived from various plant materials rich in radical scavenger polyphenols [24]. Most of the natural antioxidants evaluated in meat products are plant-derived foodstuffs, including herbs, spices, fruits, vegetables and oilseed products [25]. Spices and plants are rich in phytochemical sources [26].

4. Antioxidant and Health Effects of Medicinal Plants

Phytochemicals are a large group of bioactive substances derived from plants with potentially protective effects against diseases. This group consists of flavonoids and other phenolic compounds, carotenoids, plant sterols, glucosinolates and other sulfur-containing compounds [27]. Herbs and spices grown in various parts of the world have been used for various purposes since ancient times. Many of these plants are known to be used for cooking purposes. In addition, they are also used as antimuscarinic, antispasmodic, tonic, bronchitis, ulcer and diuretic, depurative, vermifluride carminative agents in folk medicine [28]. Demand for medicinal plants is increasing in both industrialized and non-industrialized countries. Medicinal and aromatic plants are widely used in many food. The antioxidant content and health effects of some medicinal plants are shown in Table 1.

Table1. *Antioxidant components and health effects of medicinal plant species*

Plants	Scientific Name	Antioxidant Compounds	Health Effects	References
Rosemary	*Rosemarinus officinalis L.*	Carnosol, carnosic acid, rosmanol, rosmadial, diterpenes (epirosmanol, isorosmanol, rosmaridiphenol, rosmariquinone, rosmarinic acid)	Carminative, antidepressant, anticarcinogenic, antispasmodic, rubefacient, antimicrobial and anti-inflammatory. Used in pulmonarydiseases and as an anti-diarrhoeic, antidiabetic, antispasmodic andantidepressant.	[29] [30]
Sage	*Salvia officinalis* L.	Carnosol, carnosic acid, rosmanol, rosmadial, methyl and ethyl esters of carnosol, rosmarinic acid	excessive sweating, fever and nervous disorders. Carminative and antiseptic.	[29] [30] [31]
Oregano	*Origanum vulgare*	Rosmarinic acid, caffeic acid, protocatechuic acid, 2-caffeoyloxy-3-[2-(4-hydroxybenzyl)-4,5-dihydroxy] phenylpropionic acid; flavonoids – apigen,eriodictyol, dihydroquercetin, dihydrokaempherol; cavacrol, tymol	antioxidant, carminative, stomachic,diaphoretic and expectorant. Used in colic, coughs, headaches and irregularmenstrual cycles.	[29] [30] [31]
Thyme	*Thymus vulgaris* L.	Thymol, cavacrol, ρ-Cumene-2,3-diol, phenolic acids (gallic acid, caffeic acid, rosmarinic acid), phenolic diterpenes, flavonoids	bronchitis and whooping cough. antimicrobial, antifungal, antioxidant, spasmolytic and antiinflammatory activities.	[29] [30]

Marjoram	*Marjorana hortensis M*	Beta-carotene, beta-sitosterol, caffeic-acid, carvacrol, eugenol, hydroquinone, linalool-acetate plant 3–17,myrcene, rosmarinic-acid, terpinen-4-ol	Antioxidant antispasmodic, antimicrobial, carminative, stimulant and nerve tonic. Used in asthma, coughs, indigestion, rheumatism, tooth ache and heart conditions.	[29] [30]
Urtica dioica	*Urtica dioica*	ursolic acid and quercetin	anti-diabetic therapies and to treat stomach disorders arthritis, rheumatism and eczema	[32] [33]
Lavender	*Lavendula officinalis*	ferulic, rosmarinic, p - coumaric and caffeic, while predominant flavonoids were quercetin, apigenin kaempherol	Carminative, spasmolytic, tonic and antidepressant. Used in headache,neuralagia, rheumatism, depression.	[30] [34]
Rheum ribes	*Rheum ribes* L. (roots and stems)	Chrysophanol, physcion, emodin, quercetin, 5-desoxyquercetin, and quercetin-3-O-rhamnoside	diabetes, hypertension, obesity and diarrhea	[35]
Salvia sclarea	*Salvia sclarea* L.	rosmarinic acid, caffeic acid, ferulic acid	nervous disorders. Carminative andantiseptic.	[29] [30]
Lemon Balm	*Melissa officinalis*	Caffeic asid,kaempherol,rosmarinic acid,p-coumaric acid	reduce stress and anxiety	[34]
Licorice	*Glycyrrhiza glabra*	Flavonoids, licorice phenolics	anti-inflammatory, antiviral, and anti-oxidant properties,anti-diabetic	[36] [37]
Summer savory	*Satureja hortensis* L.	Rosmarinic acid, carnosol, carvacrol, thymbol	Aromatic, carminative and has expectorant properties.	[30]

5. USAGE OF MEDICINAL PLANTS IN MEAT AND MEAT PRODUCTS

The use of medicinal plants, which have an important antioxidative effect on meat and meat products, is increasing. The most studied medicinal plants for use in meat and meat products are thyme, thyme, rosemary, liquorice and green tea. For instance, thyme was detected as effective on inhibition of oxidation, keeping flavor and safety of meat [30].

The effects of these plants on the quality of meat products vary depending on the usage dose and their original color and flavor.Results of the studies on the use of medicinal plants in meat and meat products depending storage conditions and doses are given in Table 2.

Table2. *Application of medicinal plants in meat and meat products*

Medicinal Plant	Meat/Meat Product Storage Period	Results	References
Oregano Thyme (%5)	Ground beef patties Storage at 4 °C for 12 days.	Oregano showed higher antioxidant activity than Thyme Reduced TBARS.	[38]
Urtica dioica (250 ppm 500 ppm)	Meatball Storage at 4 °C for 9 days.	The color properties of the meatballs were not affected. Reduced TBARS.	[39]
Licorice	Pork Meat	Licorice extract was an	[40]

Rosemary extract (0%, 0.02%, 0.05%,0.1%)	Storage at 2 °C for 7 and 14 days and at -20 °C for 6 months.	effective antioxidant in precooked pork patties capable of inhibiting lipid oxidation. Licorice extract was more effective than rosemary extract	
Oregano and sage leaves (0.2% w/w each)	Cooked chicken meat Storage at 4 °C for 96 h	The samples with added herbs presented lower TBARS values than those of the control and BHT samples	[41]
Rosemary extracts (250, 500, 750 mg/kg)	Porcine liver patties Storage at -21 °C for 2 days	Rosemary extracts reduced lipid oxidation and it had no effect on colour stability.	[42]
Marjoram, rosemary, sage (%0.4)	Ground beef Storage at 5 °C for 41 and 48 days	Marjoram, rosemary and sage had antioxidant effects. They could be used at level of 0.04% of sample (v/w) to minimize lipid oxidation and improve color. Marjoram showed the highest antioxidant effect.	[43]
Annatto Seeds (%0,1) Coriander Leaves (%0,5)	Fish meatballs Storage at -18°C for 120 days	Combined usage of these spices had higher antioxidant activity.	[44]
Nettle extract (200, 500 ppm)	Ground Beef Storage at 2 °C for 14 days	500 ppm showed highest antioxidant effect.	[45]
Ginkgo biloba leaf extract (%0.05)	Meat dumplings/ Meatballs Storage at -18°C for 180 days	There is nonegative changes in the sensorial properties Significantly decreased lipid oxidation	[46]
Carob fruit extracts (Liposterine and Exxenterol) (30g/1kg)	Cooked pork Storage at -18°C for 6 months and at 3°C for 20 days.	Reduced TBARS valuesand decreased oxidation products	[47]
Myrtle extract(%10) Rosemary extract(%10) Nettle extract(%10) Lemon balm extract(%10)	Beef patties Storage at -20 ± 2C for 120 days.	Myrtle and rosemary extracts showed the highest antioxidant effects, than other extracts.	[48]
Thym braspicata (oil) (300ppm)	Dry fermented Turkish sausage Ripening period for 15 days	Sensorial properties improved Decreased TBARS, putrescine, histamine, tyramine formation	[49]
Green tea extract (300 ppm and 150 ppm)	Dry fermented Turkish sausage Ripening period for 15 days	Green tea was more effective than BHT. Decreased TBARS formation. pH, colour, and overall sensory quality were not affected by the addition of green tea.	[50]

6. CONCLUSION

Medicinal plants are traditionally used in folk medicine as natural healing remedies with therapeutic effects. The application of different kinds of medicinal plants as antioxidants have been studied in meat and meat products and these studies show promising results. These medicinal plants inhibited lipid oxidationand degradation of meat pigments thus stabilized the color and helped to delay the rancid flavors in meat and meat products. Further research is needed to determine their safe limits and toxicological effects in meat and meat products as the extraction or processing conditions may alter their properties.

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