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REVIEW ARTICLE

NATURAL ANTIOXIDANTS AND ANTIMICROBIALS FROM VARIOUS SOURCES AS MEAT PRESERVERS

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ABSTRACT

In this paper, the utilization and potential effect of natural medicinal plants as antioxidant and antimicrobial in meat is reviewed. Lipid oxidation and microbial are well-known as the main causes of quality loss in meat and its products. Lipid oxidation occurs due to generation of free radicals reactive oxygen species (ROS) and reactive nitrogen species (RNS) from fractions of both lipid and protein. However, different bacteria such as mesophile, psychrotrophic, psychrophile and thermophile are the most types that able to survive under various processing conditions of meat and its products causing spoilage of these products. The presence of natural antioxidants and antimicrobials in some medicinal plants are considered as the major constituents that could be used successfully in meat and its products to inhibit both oxidation and microbial deterioration leading to safer meat with better shelf life.

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INTRODUCTION

Meat is considered as a nutritive source of food with high content and quality of proteins, minerals and vitamins. It recognized as highly perishable product due to its biological composition. Many interrelated factors influence the shelf life and freshness of meat such as atmospheric oxygen (O_2), moisture, light, endogenous enzymes, holding temperature and most importantly, micro-organisms. Oxidation of lipids in meat resulting in production of free radicals which cause deterioration and off-flavour development (Faseseas *et al*., 2007). Lahucky *et al*., 2010) claimed that antioxidants are those chemical compounds that are capable of donating hydrogen to the free radicals to minimize rancidity and retard lipid peroxidation without any damage to the sensory or nutritional properties of meat products. Many synthetic antioxidants such as tertiary butyl hydroquinone, hydroxytoluene and hydroxyanisole have been used as meat preservers (Faseseas *et al*., 2007). With the increased demand for safety, fresh appearance, high quality, convenience and an extended shelf life in meat, alternative non-synergistic preservers are highly recommended. Natural meat preservers are preferred to synergistic ones because the later contained many issues that have been questioned by researchers such as carcinogenic, pathogenicity and toxicity effects on humans (Hayes*et al*., 2010). This review article investigates the effect of phenolic compounds from several natural sources as meat preservers. The information given in this investigation could be of useful particularly for those who deal with meat safety.

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Deterioration of meat with lipid and protein oxidation

Oxidation is recognized as one of the major causes of in meat quality deterioration. Many researcher have reported the effect of lipid oxidation in meat (Rock *et al*., 2009; Minka and Ayo, 2009; Muchenje *et al*., 2009; Cataldi, 2010; Archile-Contreras and Purslow, 2011; Zhang *et al*., 2011; Bernevic *et al*., 2011; Promeyrata *et al*., 2011; Fayemi and Muchenje, 2012; Chulayo *et al*., 2012; Fayemi and Muchenje, 2013; Chulayo and Muchenje, 2013; Piccione *et al*., 2013; Sample, 2013). This is due to oxidative deterioration which meat becomes susceptible to it because of its high concentrations of unsaturated lipids, a range of oxidizing agents in the muscle tissue, metal catalysts and heme pigments. Contini *et al*. (2014) and Palmieri and Sblendorio (2007) reported that oxidative deterioration of meat resulted in poor shelf life, formation of toxic compounds, nutrient and drip losses and development of off flavour. Generation of Free radicals could be possible under normal physiologic conditions because molecular oxygen in the oxidative meat undergoes a series of reactions. During the metabolic reaction, a small portion (about 2–5%) of free

radicals is converted in the a form of reactive oxygen species (ROS). When These free radicals particularly reactive nitrogen species (RNS) and reactive oxygen species (ROS) cause several homeostatic processes when interact with nucleic acids proteins and fatty acids mainly in essential oxidation–reduction reactions (Moylan *et al*., 2014).

Many researchers reported oxidative stress which caused by animbalance between the production of ROS and antioxidant defense mechanisms in multicellular organism (Power and Jackson, 2008; da Silva *et al*., 2010; Barbieri and Sestili, 2012; Alfadda and Sallam, 2012; Gutierrez and Elkind, 2012 and Sung *et al*., 2013). According to Kolakowska and Bratosz (2010), it was found that high concentration of ROS could reduce meat quality and sensory evaluation as well. This could lead to loss of protein functionality (Hassan, 2012; Lund *et al*., 2011) and depletion of essential amino acids such as trypotophan and phenylalanine (Ganhao *et al*., 2010). Suman and Joseph, (2013) reported that lipid oxidation of meat could cause fractions of meat lipids, degradation of unsaponifiable and polyunsaturated fatty acid and conversion of oxymyoglobin [oxyMb (Fe2+)] to metmyoglobin [MetMb(Fe3+)] pigment resulting in generation of free radicals and lead to deterioration of meat protein.

Protein oxidation is consider as one of the most important issues when meat qualityis evaluated. Many studies was conducted with the objectives of investigating protein oxidation Ventanasa and Cava, 2006; Estevez *et al.,* 2008; Stadtman, 1990; Estevez et al., 2009; Levine *et al*., 1990; Estevez, Xiong, 2000; Mapiye *et al*., 2012; Lund *et al*., 2011 and Udenogwe and Howard 2013). This is due to effects on nutritional, physicochemical and sensory properties of meat and meat products. Protein oxidation is described as thecovalent modification of a protein induced ROS or by reacting withsecondary by-products of oxidative stress (Shacter (2000). According to Lund *et al*. (2011) this phenomenon occurs through a chain reaction of free radicals like oxidation of lipids in animalmuscle. The initial phase started with the initiation processes ofabstracting hydrogen atoms from protein (PH) via ROS to form a proteincarbon-centered radical (P•) which is consequently converted into analkylproxyl radical (POO•) in the presence of oxygenand then converted to an alkyl peroxide (POOH) by abstracting hydrogenatoms from another susceptible molecule (Lund *et al*., 2011). Subsequent reactions with ROS, such as HO2 or with reduced forms of transition metals such as Fe2+ or Cu1+, lead to the production of alkoxyl radical (PO•) and its hydroxyl derivative (POH). The oxidationof protein occurs due to the interaction between proteins, especiallythe nitrogen or sulfur centers of reactive amino acid residues of protein (PH) and lipid hydro peroxide (ROOH) or secondary lipid oxidation products, such as aldhehydes or reducing sugar (Viljanen, 2005 and Baron, 2010).

Some microorganisms that cause spoilage of meat

The microorganisms that commonly and mostly involved in meat spoilage are *Enterobacteriaceae* family and *Pseudomonas* spp., *Brochothrixthermosphacta* and lactic acid bacteria. There are many factors that are considered speed up meat spoilage and greatly affect shelf life. These factors include intrinsic factors (pH value, water activity, the and the nutritional content and initial number of psychrotrophs present on the meat surface) and extrinsic factors such as oxygen availability and storage temperature. Bruckner *et al*. (2012) reported that *P. putida* accounting on both fresh pork and poultry meat under aerobic conditions were around 90% of *Pseudomonas* spp.), with less occurring frequentlyof *P. fluorescens*. They claimed that the populationof pseudomonades attained values of 9 – 10 log10 CFU.g^{-1} after several days dependingon the storage temperature. *P. putida* and *P. fragi*were observed as the principal species in minced beef and a population of pseudomonades of 107 – 108 CFU.g^{-1} could cause bad smell to appear as well slime layer to form on meat (Doulgeraki and Nychas (2013). It was demonstrated that these phenomenon appear when pseudomonades exhaust glucose and lactic acid in meat and begin to metabolise nitrogenous compounds particularly amino acids (Nychas *et al*., 2008). Meat also could become contaminated at slaughterhouse with clostridia. Particles of soil that remain attached to the skin or excrement are main sources of this contamination. Clostridia get onto the surface of carcasses by means of indirect and direct contact. Psychrotrophic clostridia present in environment of slaughterhouse and on meat surface in the form of spores. According to Clemens *et al*. (2010), even a single spore may cause BPS-type spoilage (Blown-Pack Spoilage). Therefore, It is necessity to observe strict meat hygiene in slaughterhouses. It was reportedthat clostridia can growth on meat even when refrigeration temperatures are maintained, even at the most extreme temperature used for storing meat in a chilled state such as at –1.5°C (Adam *et al*., 2011).

Table 1.Food pathogens associated with spoilage and poisoning of raw meats and its products (adapted from Fernandes, 2009)

S. No.	Organism	Gram reaction cell morphology	Food poisoning
1	*Listeria monocytogenes*.	G+ve rod	Infection
2	*Escherichia coli*	G-ve rod	Infection
3	*Bacillus cereus*	G+vesporing rod	Intoxication
4	*Salmonella* spp.	G-ve rod	Infection
5	*Staphylococcus aureus*	G+ve cocci	Intoxication
6	*Aeromonashydrophilla*	G-ve rod	Infection
7	*Yersinia enterocolitica*	G-ve rod	Infection
8	*Campylobacter* spp.	G-ve spiral rod	Infection

Utilization of natural products as meat antioxidants

Recently, special attention has been paid to several medicinal plants that could be potentially used as sources of meat preservation and as well as improvement of meat nutritional quality. This is because most of these plants (spices and herbs) had relatively highchemical components such as protein, carbohydrate and fat) and mineral such as (phosphorus, calcium, iron and potassium). Besides, it was reported that natural antioxidant extracts could possibly increase tenderness of meat (Contini *et al*., 2014). It was found there natural plants possess high concentration of antioxidant-compounds (Martin and Appel, 2010, Shahidi and Zhong, 2010, Moyo *et al*., 2012, Karre *et al*., 2013 and Nkukwana *et al*., 2014). The natural antioxidants had great ability to reduce protein and lipid oxidation, discolouration in meat (Fasseas *et al*., 2007; Camo *et al*., 2008; Zinoviadou *et al*., 2009, Pennington and Fisher, 2009). The use of natural antioxidants in muscle food could

play anantimicrobial, antioxidative and preservative duringboth storage processing. The addition of these natural antioxidants inhibits the formation of cholesterol oxidized products, stabilize cholesterol levels and reduces the formation and absorption of malondialdehydeand heterocyclic amine (HCA) in cooked meat (Valenzuela *et al*., 2003; Lobo *et al*. (2010); Megan-Tempest, 2012; El Sohaimy, 2012; Duthie *et al*., 2013 and Kobus-Cisowska *et al*., 2014).

Table 2. Selected natural products used as meat preservers

S. No.	Natural product used	Type of meat used in the treatment	Reference
1	Lychee (Litchi chinensis Sonn.) seed.	Fresh lean pork and lard	Qi *et al*., 2015
2	leafy green vegetable extracts	Beef Patties	Kim *et al*., 2013a
3	Pomegranate fruit juice	Chicken meat (dipping method)	Vaithiyanathan *et al*., 2011
4	Kinnow rind powder	Cooked goat meat patties	Devatkal *et al*., 2010
5	Garlic powders	Pork loin	Park *et al*., 2008
6	Sage	Minced chicken meat	Mariutti *et al*., 2008
7	Grape seed extract	Cooked Ground beef	Ahn *et al*., 2007
8	Cranberry extract	Cooked pork	Lee *et al*., 2006

Utilization of natural products as meat antimicrobials

The effectiveness of medicinal plants such as Oleoresin rosemary, Origanum vulgare, Fatsia spp., Saturejahorvatii, Syzygiumaromaticum and Artemisia absinthium, had been reported in several studies (Kim *et al*., 2013a; Kim *et al*., 2013b; Kurcubic *et al*., 2014; Sanchez-Muniz *et al*., 2012, Krishnan *et al*. 2014). Sharma *et al*. (2012) reported that the presence and level of concentration of different phytochemical compounds such as flavonoid, phenolic, alkaloids, tannins, saponins, carvacrol, thymol and terpenes have been recognized as the potential source of antimicrobial activities in plant materials.Microbial growth caused meat wastages and spoilage with the consequence of economic loss, foodborne illnesses and food insecurity. Theuse of natural compounds such as organic acids and essential oilshas been identified for decontamination of poultry, beef and pork and products against Salmonella (Mani-López *et al*., 2012; Sant'Ana *et al*., 2014). The utilization of natural compounds against food-related pathogenic microorganismshas taken place because of concern over the negative consumer perception to chemical preservatives (Nostro *et al*., 2002 and Gutierrez *et al*., 2009). Radha Krishnan *et al*. (2014) investigated effects of different spice extracts as antioxidant antimicrobial in raw chicken meat during storage for 15 days at 4°C. The raw chicken meat samples were treated with extracts of Brassica nigra (BN), Cinnmomum cassia (CC), Origanum vulgare (OV) and Syzygiumaromaticum (SA). The spices were extracted in water in the ratio of 1:10 (w/v). The results showed that the spice extracts used had very effective and gave significant positive results against lipid oxidation and microbial growth and they approved potential effect as a natural antioxidant in raw chicken meats. For instance when essential oils used as antimicrobials in comparison with synthetic antimicrobials essential oils were found more effective against bacteria in vitro that when added to meat. Naveena (2006) claimed that this reduction in efficacy might represent a limitation to the use of the synthetic antimicrobials agents in foods, since the addition of high concentrations is likely to impart a certain flavor to meat. de Oliveira *et al*. (2010) investigated the occurrence of an enhancing inhibitory effect of the combined application of carvacrol and thymol with acetic and lactic acid in concentration of 0.6 and 1.25 µL/mL, respectively against Staphylococcus aureus using the determination of Fractional Inhibitory Concentration (FIC) index and kill-time assay in meat broth and in meat aa a food model. They found that the treated sample either alone or in mixture provided smaller ant staphylococcal effect in meat broth than in meat model. This results could arise as an interesting approach for the improvement of meat preservation using more natural procedures, considering the current demand of consumer and sensory quality of meat.

Conclusion

The use of natural medicinal plants in meat approved great antioxidants and antimicrobials effects due to their potential bioactive compounds. They could be use successfully for preserving meat from deterioration and prolonging its shelf life. There is a need to explore this area of research in order to protect meat from quality losses due to oxidation and microbial spoilage and infection.

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