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Plant extracts as natural antioxidants in meat processing

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Abstract

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In response to recent claims that synthetic antioxidants have the potential to cause toxicological effects and consumers' increased interest in purchasing natural products, the meat industry has been seeking sources of natural antioxidants. Due to their high phenolic compound content, medicinal plants, spices and other plant materials provide a good alternative to conventional antioxidants. Numerous studies have demonstrated the efficacy of plant essential oil and plant extracts when used in meat products. Generally, essential oil and plant extracts, as natural antioxidants are added to fresh and processed meat and meat products to delay, or prevent lipid oxidation, rancidity, decrease microbial growth, improve colour stability and extend shelf-life, without any damage to the sensory or nutritional properties**.**

Keywords: natural antioxidants; lipid oxidation; meat products

Introduction

Meat products charachterised relatively high content of lipids. Lipids is responsible for various properties of meat and meat products. From a physiological point of view, lipids acts as a source of essential fatty acids and fat soluble vitamins and constitutes the most concentrated source of energy in a diet (9 kcal/g). Furthermore, lipids affects flavor, texture, mouth feel, juiciness and overall sensation of lubricity of the product (Hansen et al., 2004; Zhao et al., 2011; Šojić et al., 2014). At the same time, meat products are susceptible to lipid oxidation that can deteriorate their sensorial properties by generating degradation compounds, which are associated to rancid taste and odour.

Material and Methods

Lipid oxidation in meat products

Lipolysis is the first step in the process of auto-oxidation of free fatty acids. Moreover, the oxidative degradation of lipids of meat and meat products involves the oxidation of unsaturated fatty acids, especially polyunsaturated fatty acids and cholesterol (Šojić et al., 2014). Polyunsaturated fatty acids having three or more double bonds are primarily tied to phospholipids and are important for the development of the characteristic flavor state of food. The free radicals formed in lipid oxidation (R•) react with oxygen producing peroxy radicals (ROO•). In this initial process ROO• react with several RH resulting in lipid hydroperoxides (ROOH), which are the main primary products of oxidation (Gandemer, 2002; Šojić et al., 2014). These are primary products of lipid oxidation and are relatively stable at moderate reaction conditions (low temperature/absence of prooxidative metal ions). However, because of the adverse conditions present in the muscle foods, the hydroperoxides become susceptible to further free radical chain reactions, such as isomerization and decomposition. This produces secondary products, including pentanal, hexanal, 4-hydroxynonenal and malondialdehyde. The last stage is known as termination reaction,

during which the free radicals react in various combinations to form stable products. Other unstable compounds are also formed during the termination reaction, which also affect the quality of meat products and give rise to an unpleasant flavour (taste and odour). Many compounds formed during lipid oxidation (aldehydes, ketones) contribute off-odours that are perceptible at very low concentrations (Šojić et al., 2014; Šojić et al., 2015).

Lipid oxidation also increases the rate of metmyoglobin formation; metmyoglobin acts as a catalyst for lipid oxidation, which further increases the rate of lipid oxidation and deterioration of product colour and flavour occurs (Šojić et al., 2014; Tomović et al., 2017).

Thus, lipid oxidation is responsible for development of primary and secondary oxidation products, reduction in nutritional quality, as well as changes in flavour and colour, which can precipitate health hazards and economic losses in terms of inferior product quality.

Natural antioxidants

Antioxidants are chemical substances that at very low level retard the oxidation of easily oxidizable biomolecules (lipids and proteins) in different type of meat products, thus extend shelf life of products by protecting them against deterioration caused by oxidation. The addition of antioxidants in food is controlled by regulatory country laws or international standards. Although there are many compounds that have been proposed to possess antioxidant potential to inhibit oxidative deterioration, just a few can be used in food products (Karre et al., 2013; Kumar et al., 2015).

From a chemical standpoint, antioxidants are compounds or systems that delay process of autoxidation by: inhibiting formation of free radicals or interrupting propagation of the free radical by one (or more) of several mechanisms: (1) scavenging species that initiate peroxidation, (2) chelating metal ions such that they are unable to generate reactive species or decompose lipid peroxides, (3) quenching $^{\cdot}O_2^-$, so preventing formation of peroxides, (4) breaking the autoxidative chain reaction and/or (5) reducing localized O_2 concentrations (Tomović et al., 2017).

In the food industry, antioxidants can be divided into natural and synthetic antioxidants. BHA (butylated hydroxyanisole), BHT (butylated hydroxytoluene), PG (propyl gallate) and TBHQ (tert-butylhydroquinone) are the most common synthetic antioxidant in food (Šojić et al., 2015). Ingredients isolated from natural sources which exhibit antioxidative potential in a food model system are considered as natural antioxidants and these compounds play an important role in the food industry (Tomović et al., 2017). However, in past decade synthetic antioxidants have been identified as toxicological and carcinogenic agents (Georgantelis et al., 2007; Šojić et al., 2015; Šojić et al., 2017; Šojić et al., 2018; Zeng et al., 2016). For these reasons, some synthetic antioxidants (BHA, BHT, PG and EDTA) are regulated by the law as direct food additives. Thus, the food industry now chooses natural products over synthetic ones. Consequently, the food market is demanding natural antioxidants, free of synthetic additives and still capable of diminishing oxidation processes in high-fat meat and meat products (Kumar et al., 2015).

The plant kingdom is one of the most abundant source of natural antioxidants, which are abundantly present in spices (seeds), herbs and essential oils used in meat products for sensory enhancement (Tomović et al., 2017).

Plants are persistently the generous source to supply man with valuable bioactive substances and thus different plant products are being evaluated as natural antioxidants to preserve and improve the overall quality of meat and meat products. These natural antioxidants isolated from plants, in the form of extracts, have been obtained from different sources such as fruits (grapes, date, pomegranate, quinoa), vegetables, (broccoli, drumstick, potato, curry, pumpkin, nettle), spices and herbs (tea, rosemary, oregano, cinnamon, sage, thyme, mint, ginger, clove) and investigated to decrease process of lipid oxidation (Hromiš et al., 2013; Krkić et al., 2013; Shah et al., 2014; Tomović et al., 2017).

Antioxidant and flavour components of herbs and spices can be removed or concentrated as: extracts, essential oils or resins. Extracts are soluble fractions and that can be removed from plans by solubilizing the components of interest in an aqueous, alcohol, lipid, solvent or supercritical CO_2 phase, then removing it. Essential oils represent the volatile oils and often contain isoprenoid compounds. Chemically, essential oils are extremely complex mixtures containing compounds of every major functional group class. Plants also contain resins that are non-volatile, high molecular weight, amorphous solids, or semisolids that flow when subjected to heat or stress (Brewer, 2011; Tomović et al., 2017). Most resins are bicyclic terpenes (alpha and beta-pinene, delta-3 carene and sabinene), monocyclic terpenes (limonene and terpinolene) and tricyclic sesquiterpenes (longifolene, caryophyllene and delta-cadinene). They are soluble in most organic solvents but not in water. Resins can contain small amounts of volatile phenolic compounds (Tomović et al., 2017).

Use of essential oil and plant extracts as natural antioxidants in meat processing

The demonstrated efficacy of essential oils and plant extracts as natural antioxidants to retard lipid oxidation, colour and flavour deterioration in meat products has stimulated a broad interest within the meat industry to explore non-traditional food

Table 1. Natural antioxidants used to inhibit oxidation in processed meat products

Antioxidant category	Meat/Meat products	Reference
Caraway essential oil	Dry fermented sausage	Hromiš et al., 2013
Caraway essential oil	Dry fermented sausage	Krkić et al., 2013
Echinacea angustifolia extracts	Cooked chicken meat	Gallo et al., 2012
Grape seed extract	Ground chicken thigh meat	Brannan, 2008
Juniperus communis L.	Cooked sausages	Šojić et al., 2017
Laurus nobilis essential oil Mushroom extract	Fresh sausage Beef and fish meat	da Silveira et al., 2017 Bao et al., 2008
Nutmeg	Cooked sausage	Šojić et al., 2015
Oregano and sage essential oils	Ground meat	Fasseas et al., 2008
Oregano extract	Fresh beef steaks	Camo et al., 2011
Sage essential oil	Fresh pork sausages	Šojić et al., 2018

ingredient strategies (Bao et al., 2008; Brannan, 2008; Camo et al., 2011; Gallo et al., 2012; Fasseas et al., 2008; Šojić et al., 2018; da Silveira et al., 2017; Tomović et al., 2017). Effects of essential oils and plant extracts on lipid oxidation, development of rancidity and off-flavours and colour stability have been demonstrated in numerous studies (Table 1).

Finally, when used as antioxidants for product quality preservation, these natural compounds can also be regarded as nutraceutical ingredients or supplements for health promotion. Indeed, plant-derived antioxidants provide meat processors with the flexibility to develop novel products with enhanced nutritional value and health benefits and an attractive overall quality profile (Tomović et al., 2017).

Conclusions

In the past years, there has been a huge demand for natural antioxidants, mainly because of adverse toxicological reports on many synthetic compounds.

Natural antioxidants (essential oil and plant extracts) used in meat products for their flavour, often contain high concentrations of phenolic compounds (phenolic acids, phenolic diterpenes, flavonoids and volatile oils). Different solvents and methods can be utilized to prepare the plant extracts and the properties of an extract will depend on the method and solvent used for extraction. The fact that they are natural and have antioxidative and antimicrobial activity that is as good as or better than the synthetic antioxidants makes them particularly attractive for meat processors because of consumer demand for natural ingredients.

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