Application of essential oil and supercritical fluid extracts in meat processing

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Abstract. The meat industry is demanding antioxidants from natural sources to replace synthetic antioxidants because of their potential negative health consequences. These compounds are classified as generally recognized as safe (GRAS), and their application alone or combined with essential oils, ingredients or preservation technologies have beneficial effects on meat products. Although steam distillation is the most common industrial technique for essential oil extraction, novel technologies such as supercritical fluid extraction have emerged to address the drawbacks of the traditional extraction method and to obtain high-quality essential oils. Numerous studies have demonstrated the efficacy of essential oil obtained using the traditional or a novel extraction technique as natural antioxidants and antimicrobial agents in meat products. Based on this literature review, it can be concluded that essential oil addition in fresh and processed meat and meat products can delay, retard, or prevent lipid oxidation, retard development of off-flavors (rancidity), improve microbiological quality and extend shelf-life.

1. Introduction

Meat and meat products are predisposed to quality deterioration due to their complex nutritional composition that consists of different saturated and unsaturated lipids, proteins, carbohydrates, vitamins and pigments [1,2]. The quality deterioration is due to chemical degradation and microbial growth. The most common reason for chemical degradation is lipid oxidation. Lipid oxidation leads to rancidity, discoloration and accumulation of potentially toxic compounds that are harmful to human health. Hence, suppressing lipid oxidation and preventing bacterial growth are major means of extending the shelf life of meat and meat products [3,4]. Beside packaging, one of the main strategies to suppress lipid oxidation and inhibit microbial growth is the application of synthetic antioxidants and antimicrobial agents [5]. However, these compounds are potentially unhealthy due to their toxic, mutagenic and carcinogenic properties [6-8].

Consequently, in the past decade, the interest of researchers has been focused on finding alternatives for these additives from natural resources [9-17]. It is well known that plant essential oils (EOs) and extracts exhibit strong antioxidative and antimicrobial activities and possess anticarcinogenic and antimutagenic properties. Hence, the addition of plant EOs and/or plant extracts could be a good solution to improve the health image of different types of meat products [6-9].

EOs are volatile, oily extracts obtained from aromatic and medicinal plant materials, including flowers, buds, roots, bark, and leaves by means of expression, fermentation, extraction or steam
distillation, and have strong antioxidant and antimicrobial activities [18]. Approximately 300 EOs are commercially important in the fragrance markets. Due to their biological properties and flavor characteristics, these oils have been extensively used for centuries in food products. Regarding meat and meat products, EOs from oregano, rosemary, thyme, clove, balm, ginger, basilica, coriander, marjoram and basil have shown great potential to be used as antioxidants and antimicrobial agents [2,18,19].

2. Essential oil extraction technique
EOs and extracts from different plant materials can be obtained using different extraction techniques. Hydrodistillation and supercritical fluid extraction (SFE) have been frequently used for EO recovery, while diverse emerging techniques such as microwave-assisted, ultrasound-assisted and subcritical water extraction have been used for isolation of the polyphenolic fraction [20,21,22].

Conventionally used techniques for EO recovery such as hydrodistillation and extraction with organic solvents are accompanied by certain disadvantages. High temperatures during hydrodistillation can lead to decomposition of thermo-labile compounds, which results in variation of chemical shape in the EO obtained. Moreover, the hydrodistillation technique demands enormous energy consumption. In the case of EO extraction with organic solvents, toxicity of the solvent residue and its poor selectivity are the main drawbacks. Therefore, new trends of “green” chemistry demand application of “green” extraction techniques. Additionally, it has been noticed that green extraction methods, such as SFE techniques, provided certain advantages in relation to chemical shape and selectivity comparing to conventional recovery of EO [5,20,21,22].

2.1. Supercritical fluid extraction
SFE is marked as an advanced and environmentally friendly alternative to conventional solid–liquid or liquid–liquid solvent extraction both for analytical sample preparation and for production-scale applications, mainly when a clean solvent, such as carbon dioxide, is used instead of toxic organic solvents. The advantages of SFE are the possibility of tuning the solvent power of the fluid by changes in pressure and temperature, while simultaneously modifying other physico-chemical properties such as density, viscosity and diffusivity. In general, transport properties are favored under supercritical conditions, and therefore, extraction processes are faster and provide higher extraction yields [20-22].

Yousefi et al. [22] concluded that the resulting supercritical fluid extracts are clean and pure, possess high quality, and their aromas have great similarity to the aromas of the original plants before the extraction process. The temperatures used in the extraction (around 35°C) allow this processs to be used for thermally and chemically sensitive compounds, maintaining the quality of the final product.

3. Application of essential oils and supercritical fluid extracts in meat and meat products
In the past decade, many studies examined the application of EOs as antioxidant and antimicrobial agents in meat products. These natural antioxidants were obtained from different herbs and spices (rosemary, oregano, sage, thyme, basil, winter savory and others) and their potential for decreasing lipid oxidation and microbial growth in meat and meat products was investigated [3-9,23-31].

Rosemary EO as a natural antioxidant was used in several studies [19,23,24]. This EO had a good antioxidant potential in fresh sausages [23] and cooked pork sausages [19,24].

Oregano EO’s role as a natural antioxidant was confirmed in different types of meat products. Fasseas et al. [25] suggested this EO was suitable for use in raw and cooked porcine and bovine ground meat. Oregano EO at concentration of 3% w/w produced a significant decrease of the oxidation reactions in analyzed meat samples. Also, Viuda-Martos et al. [19,26] determined that oregano EO decreased lipid oxidation and microbial growth in meat products.

Sage EO was also evaluated in other studies [3,27,28]. Estévez et al. [27] suggested that sage EO (0.1%) had a good antioxidative potential in liver pâté during 90 days of storage.

Thyme EO was used as a natural food preservative in different meat products. This EO effectively delays lipid oxidation in minced beef [29], chicken breast [30] and fresh pork sausages [8].
Basil EO was also used as a natural antioxidant in a meat processing [9,31]. The effect of different concentrations of basil EO (0.062, 0.125, and 0.25%) on the lipid oxidative stability of burger was assessed during 12 days of refrigerated storage at 4°C [31]. Basil EO reduced lipid oxidation of beef burger and its efficiency was not dependent upon the EO concentration. Also, in our previous study [9], we determined that basil EO at lower concentrations (0.1-1.0 µL/g) had positive effects on the oxidative and microbial stability of cooked pork sausages during 30 days of refrigerated storage.

It is well known that SFE has been utilized for extraction of EOs (producing SFE-EOs), due to its advantages over the conventional hydrodistillation technique [20-22]. Hence, in our previous studies we examined the effects of sage and winter savory EOs obtained by conventional hydrodistillation and SFE as potential antioxidants and antimicrobial agents in fresh pork sausages [4,5,28]. Conventional EO and SFE-EO obtained from sage herbal dust were added at three concentrations (0.050, 0.075 and 0.100 µL/g) to fresh pork sausage mixture (Petrovská klobása sausages) [4,28]. Sage SFE-EO at concentrations of 0.075 and 0.100 µL/g was the most effective against microbial growth [28]. This study demonstrated the good antioxidative potential of sage EO and especially of sage SFE-EO, which produced the greatest inhibitory potential against lipid oxidation at a concentration of 0.100 µL/g [28].

Antioxidant effects of EOs could be achieved through scavenging free radicals, the inhibition of lipid peroxidation, and the chelating of transition metal ions [1,2,28]. Besides monoterpenic hydrocarbons, diterpene polyphenols were designated as the major subgroup of sage bioactive compounds responsible for high antioxidant potential. The higher antioxidant activity of sage SFE-EO could be potentially explained by the synergistic effects of terpenoids and other lipids which are simultaneously extracted by SFE [28]. Moreover, sage SFE-EO provided better sensory properties of fresh pork sausages, another advantage of this novel extraction technique [28]. Yet another aspect which should be considered is utilization of sage herbal dust as raw material for EO recovery and utilization in food products. Valorization of by-products such as this would lead towards more sustainable and more economically efficient production of natural extracts [4,28]. The overall results show that sage EO and especially sage SFE-EO, as natural antioxidant and antimicrobial agents, could be successfully applied in meat processing [28].

In the case of winter savory, EO and SFE-EO were added at concentrations of 0.075 and 0.150 µL/g in basic formulations for fresh pork sausage. Winter savory EO and SFE-EO improved the oxidative stability of fresh pork sausages. The measured good antioxidant activity of winter savory lipid extract obtained by SFE could be attributed to its major monoterpenic phenolics, particularly carvacrol and thymol. Winter savory EO and SFE-EO at 0.150 µL/g both reduced the Enterobacteriaceae count in sausages to under 3 log cfu/g. However, sausages produced with winter savory SFE-EO achieved higher scores for odor, flavor and overall acceptance than did sausages with winter savory EO. Therefore, this study revealed the significant antioxidative and antimicrobial activity of winter savory SFE-EO, and consequently its potential for utilization in meat industry [5].

4. Conclusions
Meat and meat products are highly susceptible to lipid oxidation and microbial deterioration, which ultimately lead to safety and quality issues. EOs could be used in meat and meat products as natural alternatives to synthetic food additives, particularly as effective antioxidant and antimicrobial agents. However, EOs can negatively modify the sensory properties of the final product due to their strong aromas. The novel extraction technique, SFE, should be optimized to achieve optimal composition of EOs regarding antioxidant and antimicrobial activity as well as sensory quality of meat products.

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