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Review paper

Essential oils as emerging ingredients in processing of minced meat products

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ABSTRACT

Essential oils (EOs) are volatile complex molecules of different aromatic and medicinal herbs which contain organic compounds (e.g., phenolics, aldehydes, terpenoids, carotenoids) with strong antioxidative and antimicrobial capacity. EOs can be isolated using different methods, including conventional hydrodistillation (HD) and non-conventional supercritical fluid extraction (SFE). Minced meat products are one of the most dominant products from the meat industry worldwide. These products are susceptible to chemical and microbial deterioration due to their high water, protein, and fat content. In order to enhance the quality and shelf-life of minced meat products, using EOs isolated from different herbs as natural ingredients could be a good solution. Therefore, this review aimed to illustrate the positive aspects of EOs with preservative roles in meat products while, at the same time, underlining the prospective risks influenced by these compounds.

1. Introduction

Burgers, meatballs, and fresh sausages are among the most abundant minced meat products worldwide. These meat products have a substantial nutritive value, extraordinary sensory quality, high availability, and relatively low cost (*Salter*, 2018). Minced meat products are manufactured by grinding and mixing meat (e.g., pork, beef, poultry) and fatty tissue with table salt, spices, or spice mixtures (*Regulation RS 50*, 2019). Also, it should be noted that minced meat products in Serbia are manufactured without the usage of preservatives and synthetic antioxidants, or any thermal treatments. Hence, these products are very susceptible to chemical and microbial deterioration, which leads to a relatively short shelf-life of final products (*Schilling et al.*, 2018; *Bantawa et al.*, 2018). Lipid and protein oxidation are the chief reasons for chemical deterioration and reduced shelf-life for minced meat products (*Šojić et al.*, 2014; *Domínguez et al.*, 2019; *Lorenzo et al.*, 2018). In order to enhance the quality and safety of different types of fresh or processed meat products, different natural ingredients can be used (*Lorenzo et al.*, 2018; *Munekata et al.*, 2020). Regarding their recognised levels of phenolics, terpenoids, carotenoids, and other bioactive compounds with significant antioxidative and antimicrobial potential, essential oils (EOs) isolated from different herbs could be applied as natural ingredients and quality enhancers for minced meat products (*Šuput et al.*, 2012; *da Silveira et al.*, 2014; *Kocić-Tanackov et al.*, 2017; *Tomović et al.*, 2017; *Araujo et al.*, 2018; *Falowo et al.*, 2019; *Danilović et al.*, 2021; *Pateiro et al.*, 2021; *Šojić et al.*, 2023a).

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2.1. Recovery and characterization of EOs

EOs are volatile complex molecules of aromatic plants obtained by hydrodistillation methods or by cold pressing from citrus fruit peel. Terpenoids, aldehydes, ketones, esters, alcohol, and acids are the main constituents of EOs (85%), while trace elements constitute the rest (15%). The chemical profile of EOs is related to climate, geographical origin, development stage, plant cultivar, post-harvest processing and methods used for EO extraction (*Oliveira et al*., 2006; *Pavlić et al*., 2015).

Terpenoids (monoterpenes, sesquiterpenes, and diterpenes) are the principal organic compounds contained in EOs. Carvacrol, linalool, thymol and menthol, as the main terpenoids in EOs, manifest their antioxidative and antimicrobial activities owing to an aromatic structure with extremely potent functional groups. Thymol and carvacrol, as the most frequently phenolic-terpenoids, possess important radical scavenging activity towards hydroxyl radicals. The antibacterial potential of EOs depends on their chemical shape. It is well-known that terpenoids, thymol and carvacrol change cell-membrane permeability, decreasing synthesis of adenosine triphosphate and, lastly, decreasing the viability of microbial cells (Šojić et al., 2023b).

Moreover, terpenoids can affect the aroma and flavour of beverages (e.g., from juniper in gin) and of food aromas. Also, EOs and their constituents are considered as GRAS compounds (generally recognized as safe) in the US, and are indicated as flavouring agents by their food associations, according to the US Food and Drug Administration. Also, they can be applied as quality enhancers in food packaging in the EU. The separation methods for EOs might affect their chemical profile, so finding the optimum extraction methods to deliver enhanced quality and satisfactory yields is crucial (*Becerril et al*., 2020).

Hydrodistillation (HD) is a simple method used to extract pure EO comprised only of volatile compounds. HD is based on interactions among dry herbs, boiling water and steam (*Šojić et al*., 2023b). The vapor given off is additionally chilled, and EO and water are generally collected as a two-phase liquid system, which can be separated. HD is considered as a simple and economical method for EOs recovery. However, it is well known that high temperatures during HD allow hydrolysis and thermal degradation of bioactive compounds (e.g., terpenoids, phenolics, carotenoids), which could reduce the quality of EOs. Furthermore, HD is a highly energy-consuming procedure, including heating and cooling down the vapour. These drawbacks were the core causes for an innovative approach in the progress of novel eco-friendly methods which could diminish solvent, processing times and energy used, and enhance the quality of the obtained EOs (*Burger et al*., 2019).

SFE (Supercritical fluid extraction) is an eco-friendly method for recovering lipophilic extracts, including EOs, from different parts of herbs. In comparison with HD, SFE reduces solvent consumption and extraction time, advances selectivity and extraction yield, saves energy, and preserves target compounds (e.g., terpenoids, phenolics, carotenoids) from decomposition generated by high temperature. The main principle of SFE is the usage of supercritical fluids, which leads to better dispersion into plant material pores and quicker release of target compounds. Carbon dioxide (CO_2) has been primarily used as the solvent for SFEs, because its possesses several attributes required for the extraction: inert and GRAS gas, non-flammable, available, economical, and non-explosive in a high-purity state (*Essien et al*., 2020). Our previous studies determined that using SFE with CO_2 (100 bar at 40°C; 350 bar at 40°C) leads to the isolation of high-quality lipid extracts from sage and winter savory with strong preservative effects in ground meat products (*Šojić et al*., 2018; *Šojić et al*., 2019).

SFE has wide-reaching usage, particularly in producing food ingredients (vitamin-rich extracts and aromas, colorants, etc.) and nutraceuticals. The primary limiting factor for SFE usage in the food sector is the equipment cost, which is above $US 1,150,000 for a high-pressure processing plant with two extractors of 500 L (*Prado et al*., 2012).

2.2. Application of EOs in minced meat products

EOs isolated from different herbs (*Ocimum basilicum* L., *Coriandrum sativum* L., *Allium sativum* L., *Salvia officinalis* L., *Origanum vulgare* L., *Satureja hortensis* L., *Satureja montana* L., *Origanum majorana* L. *Laurus nobilis, Satureja montana* L.) were used as natural ingredients with preservative potential in minced meat products processing (Table 1).

Falowo et al. (2019) determined that EO isolated from *Ocimum basilicum* L. and used at the level of 2% and 4% enhanced the color and reduced lipid

oxidation in minced beef subjected to aerobic conditions and stored (4 ± 1°C) for seven days. Also, a group of researchers (*González-Alonso et al*., 2020) examined the impact of EO isolated from *Coriandrum sativum* L. addition (0.02%) on the microbiological profile of minced beef subjected to cold storage. *González-Alonso et al*. (2020) noted that this EO reduced the growth of *Enterobacteriaceae* in fresh meat products and prolonged their shelf-life. The protective effects of diverse antimicrobial compounds in EO isolated from *Allium sativum* L. on the quality and safety of fresh sausages inoculated with *Escherichia coli* were evaluated by *Araújo et al*. (2018). These scientists indicated that this EO successfully decreased the growth of *E. coli*, as one of the main pathogenic bacteria, and conserved the red colour of final products during cold storage.

In the case of *Salvia officinalis* L., it was noted that EO isolated from this aromatic plant efficiently preserved the quality and prolonged the shelf-life of fresh sausages and minced beef subjected to cold storage (*Šojić et al*., 2018; *Danilović et al*., 2021). Moreover, *Origanum vulgare* L. EO showed a similar protective effect and reduced lipid oxidation and microbiological growth in black wildebeest meat (*Shange et al*., 2019). Our previous study determined that EOs obtained from *Origanum majorana* L., *Satureja hortensis* L., and *Satureja montana* L. possessed strong antimicrobial effects in fresh turkey sausages (*Šojić et al*., 2023a). Also, these EOs, alone and in combinations, reduced biogenic amine formation in final products (*Šojić et al*., 2023a). EO obtained from *Satureja montana* L. also prolongs the shelf-life of pre-cooked pork chops (*Jokanović et al*., 2020). Finally, *da Silveira et al*. (2014) determined that EO obtained from *Laurus nobilis* provides a powerful antimicrobial effect in fresh Tuscan sausages subjected to cold storage.

Also, it should be noted that several studies confirmed the better preservative effect for EOs

Table 1. Application of EOs in minced meat products subjected to cold storage

Herb	Type of extraction	Dose of extract	Minced meat product	Effect	Reference
Ocimum basilicum L.	HD	2–6%	Minced beef	RLO	*Falowo et al*. (2019)
Coriandrum sativum L.	HD	0.02%	Minced chicken	DMG	*González-Alonso et al*. (2020)
Allium sativum L.	HD	125 µL/kg	Fresh sausages	DMG	*Araújo et al*. (2018)
Salvia officinalis L.	HD, SFE	0.05–0.1 µL/g	Fresh sausage	RLO, DMG	*Šojić et al*. (2018)
	HD, SFE	0.2–0.6 µL/mL	Minced pork	DMG	*Danilović et al*. (2021)
Origanum vulgare L.	HD	1% (v/v)	Black wildebeest meat	DMG	*Shange et al*. (2019)
Satureja hortensis L.	HD	0.150 µL/g	Fresh turkey sausages	DMG	*Šojić et al*. (2023a)
Satureja montana L.	HD	0.150 µL/g	Fresh turkey sausages	DMG	
Origanum majorana L.	HD	0.150 µL/g	Fresh turkey sausages	DMG	
Laurus nobilis	HD	0.05 g/100 or 0.10 g/100g	Fresh Tuscan sausage	DMG	*da Silveira et al*. (2014)
Satureja montana L.	HD, SFE	0.075–0.150 µL/g	Fresh sausage	RLO, DMG	*Šojić et al*. (2019)
	HD, SFE	0.200 µL/g	Precooked pork chops	RLO	*Jokanović et al*. (2020)

Legend: HD – hydrodistillation; SFE – supercritical fluid extract; RLO – reduction of lipid oxidation; DMG – decrease of microbiological growth

obtained by SFE than EOs obtained by conventional HD. This could be the result of higher selectivity and solubility of supercritical fluids, which promote isolation of coextracted lipids, which possess a solid antioxidative and antimicrobial activity in meat products (*Šojić et al*., 2018; *Šojić et al*., 2019; *Jokanović et al*., 2020).

Although EOs obtained by HD and SFE had a strong preservative potential, there are a few restrictions concerning the usage of these natural compounds in the meat industry. Primarily, it is well known that some herbs and their EOs might not be harmless to humans (e.g., thujones should not be ≥ 0.5 mg/kg). Therefore, in our prior investigation (*Šojić et al*., 2018), we restricted the addition of sage EOs to under 0.15 μL/g in fresh pork sausages. Also, the high levels of EOs, provide atypical sensory properties of final meat products.

Therefore, it is critical to find a balance among effective doses of EOs and the safety and sensory tolerability of the flavoured meat products. Hence, in our earlier investigations (*Šojić et al*., 2018; *Šojić et al*., 2019), we determined the borderline for sensory appropriateness of sage and winter savory EOs (≤0.150 μL/g) in fresh pork sausages.

3. Conclusion

This review reveals that the use of EOs isolated from diverse herbs (*Ocimum basilicum* L., *Coriandrum sativum* L., *Allium sativum* L., *Salvia officinalis* L., *Origanum vulgare* L., *Satureja hortensis* L., *Satureja montana* L., *Origanum majorana* L. *Laurus nobilis, Satureja montana* L.) can prolong the shelf life of minced meat products and enhanced the quality of final products, in some cases. Also, EOs comprise various bioactive compounds with substantial health benefits for humans. HD, as the conventional method for EO recovery, can negatively affect the thermosensitive compounds (e.g., cause decomposition of phenolics, terpenoids, carotenoids) and can have harmful environmental implications. Therefore, the requirements to discover more sustainable extraction methods for EOs have led scientists to advance novel methods allowing "green" extraction, including SFE.

It should be concluded that before adding EOs to meat batters, it is necessary to define the optimum EO doses and estimate the harmfulness of EOs and their bioavailability for the consumers. Finally, applying these extracts in active packaging is advisable and might find huge interest in the future.

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