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Original Article

Evaluating antioxidant and antimicrobial activities of essential oils extracted from six plants: Caraway, mint, onion, parsley, fennel, and watercress

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Abstract

Background

Essential oils extracted from mint, parsley, caraway, onion, fennel, and watercress contain compounds that have different effects on the growth of some microbial strains. These volatile oils can also be used to flavor some foods and preserve foods to extend their shelf life.

Aim

To identify the composition of extracted volatile oils and know their effect on the growth of some microbial strains.

Materials and methods

Commercial samples of six plants (caraway, mint, onion, parsley, fennel, and watercress) were purchased from the local market. Extractions of essential oils from the sample as well as gas chromatography/mass spectrometry analysis were performed. Antimicrobial activity holes (1 cm diameter) were made in the center of Petri dishes containing nutrient agar with 1 ml suspension of the tested microorganisms using a flamed cork borer. Each hole was filled with tested essential oils.

Results

The results showed that the major components of essential oils of caraway were carvone and limonene (53.69 and 45.23%, respectively), the major components of essential oils of mint were isomenthone and menthol (42.55 and 28.29%, respectively), the major components of essential oils of fennel were estragole and limonene (89.12 and 09.50%, respectively), the major components of essential oils of parsley were valencene, limonene, and pulegone (46.97, 23.09, and 10.56%, respectively), the major components of essential oils of onion were o-cymene and thymoquinone (23.69 and 22.72%, respectively), the major components of essential oils of watercress were estragole (100%). The study investigated the antimicrobial activities of essential oils of mint and parsley to be the best for inhibition of the growth of most tested bacteria, whereas essential oils (50 µl) extracted from caraway, fennel, onion, and watercress did not inhibit the growth of tested bacteria. Essential oils extracted from mint and parsley were tested for antibacterial activity against *Salmonella* sp., *Staphylococcus aureus*, *Enterococcus*, and *Citrobacter*. The results showed that tested oils of mint and parsley exhibited an inhibitory effect on the growth of the microorganisms *Salmonella sp.*, *S. aureus*, and *Enterococcus*. At 200 µl, essential oils extracted from mint did not show inhibition of the growth of *Citrobacter* and *Escherichia coli*. However, parsley did not show inhibition of growth of the *E. coli* at 100, 200, and 300 µl.

Conclusion

Some of the essential oils (mint and parsley) showed antibacterial activity against *Salmonella* sp., *S. aureus*, *Enterococcus*, and *Citrobacter.* Some oils did not show inhibition of the growth of *Citrobacter and E. coli.* These volatile oils can be used to flavor some food and preserve it by extending the shelf life.

Keywords: Antimicrobial activity, caraway, essential oils, fennel, watercress, mint, onion, parsley

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Introduction

Numerous food products require protection against microbial spoilage during their shelf life. The growing demand of consumers for safe and natural products without chemical preservatives has resulted in assessing the feasibility of mild preservation techniques and improving the microbial quality and safety of products while maintaining their good nutritional and organoleptic properties. Spices are one of the important food commodities that are used mainly for their flavoring properties. The volatile essential oils present in spices are responsible for their typical aroma. Spices are prone to microbial contamination during storage and transportation [1].

Essential oils are volatile oily liquids obtained from different plant parts and widely used as food flavoring agents [2] and recognized for their antibacterial, antifungal, antiviral, insecticidal, and antioxidant properties [3,4]. As essential oils are generally recognized, their natural antimicrobial effects by the addition of small amounts of other natural preservatives may be a way of attaining a balance between sensory acceptability and antimicrobial efficiency. Essential oils of herbs and their components, products from the secondary metabolism of plants, have many applications in ethnomedicine, food flavoring, and preservation, as well as in the fragrance and pharmaceutical industries.

The antimicrobial and antioxidant properties of essential oils have been known for a long time, and a number of investigations have been conducted on their antimicrobial activities using various bacteria, viruses, and fungi. A common feature of plant volatiles is their hydrophobic nature, and studies addressing the mode of antimicrobial action of such compounds generally point to the cell membrane as the primary target. Recent studies showed that essential oils of oregano, thyme, clove, and cinnamon are among the most active in this respect. Chemical analysis of these oils has shown the constituents to be principally carvacrol, thymol, and eugenol and their precursors, although the composition of essential oils from a particular spice of plant can differ according to the geographical sources [5]. Eugenol (4-ally 1-2- methoxyphenyl), a major component of clove and cinnamon oils, is also generally recognized as a safe material by the Food and Drug Administration. It is commonly used as a flavoring agent in cosmetics and food products, particularly as a dental material. Eugenol is active against many pathogenic bacteria such as *Escherichia coli*, *Listeria monocytogenes*, *Campylobacter jejuni*, *Salmonella enterica*, *Staphylococcus aureus*, *Lactobacillus sakei*, and *Helicobacter pylori* [6,7] and against fungi and viruses. Cinnamon and clove oils are commonly used in the food industry because of their special aroma [8].

Aim

The aim was to identify the composition of the extracted volatile oils of six plants (caraway, mint, onion, parsley, fennel, and watercress) and know their effect on the growth of some types of microbes.

Materials and methods

Materials

Commercial samples of six plants (caraway, mint, fennel, parsley, onion, and watercress) were purchased from the local market and then packed in polyethylene bags (500 ± 2 g).

Methods

Extraction of essential oils from samples

The essential oils were obtained by steam distillation according to the method described in the British pharmacopeia [9] by using the Clevenger apparatus for the determination of essential oils lighter than water.

Gas chromatography/mass spectrometry analysis

Gas chromatography/mass spectrometry (GC/MC) analysis was done in a Thermo scientific Model ITQ900 GC system mass spectrometer with a built-in autosampler, with the use of the HP-88 capillary column (30 m × 0.25 mm × 0.25 mm). For GC/MS detection, an electron ionization system with ionization energy of 70 ev was used. Helium was the transporter gas at a flow rate of 0.6 ml/min. The column temperature program was the same as defined before. In splitless gas chromatography, the sample, diluted with hexane (200 mg/2 ml Hexan), was transferred to the column. Identification of the oil components was successfully done by comparison of their mass spectral fragmentation model with the available mass library of National Institute of Standards and Technology.

Antimicrobial activity

The diffusion phase technique described by Aboaba *et al.* [10] was used to evaluate the antimicrobial activities of the studied essential oils. It could be illustrated in the following: holes (1 cm diameter) were made in the center of Petri dishes containing nutrient agar with 1 ml suspension of the tested microorganisms using a flamed cock borer. Each hole was filled with the tested essential oils. The plates were incubated at 37°C for 2 days. The zone of inhibition was obtained by measuring the underside of the plate in two planes with a ruler calibrated in millimeters.

Results and discussion

In general, the total phenols and antioxidant activity of mint leaves were higher than in coriander and parsley. This may also be owing to the difference in families of these herbs, as coriander and parsley belong to Apiaceae, whereas mint is included in Lamiaceae. Juhaimi and Ghafoor [11] studied the extracts of different parts of three different herbs for their phenolic and antioxidant activities. Leaves of mint and parsley showed the maximum total phenols and antioxidant activity than those of their stem.

Antimicrobial activities of many species and herbs are owing to their essential oil fractions. The composition, structure, as well as functional groups of the oils play an important role in determining their antimicrobial activity [12,13]. The main volatile components of crude essential oils are recovered by GC-MS, as shown in Tables 1 and 2. Plant essential oils are a complex mixtures of volatile organic compounds, which play indispensable roles in the environment, for the plant itself as well as for humans. The potential biological information stored in essential oil composition data can provide an insight into the silent language of plants and the roles of these chemical emissions in defense communication and pollinator attraction [14].

The compounds identified from caraway, mint, onion, parsley, fennel, and watercress are shown in Tables 1 and 2. The main components of caraway volatile oil were carvone (53.69%) and limonene (45.23%); the main components of mint volatile oil were isomenthone (42.55%) and menthol (28.29%); the main components of onion volatile oil were 5-cymene (23.69%) and thymoquinone (27.72%); the main components of parsley volatile oil were valencene (46.97%) and limonene (23.09%); the main components of fennel volatile oil were estragole (89.12%) and limonene (09.50%); and the main component of watercress volatile oil was estragole (100%).

Effect of volatile oils extracted from caraway, onion, parsley, mint, fennel, and watercress: the results showed that the samples of mint and parsley had higher effects on the bacteria compared with other samples (Table 3).

Table 3 shows the antibacterial activity of essential oil extracted from caraway, onion, parsley, mint, fennel, and watercress on the same foodborne bacteria. The data illustrated that the mint sample was effective against all of the tested bacteria strains and exhibited inhibition zone diameters of 14, 10, 13, and 30 mm for *E. coli*, *Salmonella*, *Enterococcus*, and *Citrobacter*, respectively, but the parsley sample was effective against the bacteria strains *Salmonella*, *S. aureus*, and *Enterococcus* (15.5, 17.0, and 11.0 mm, respectively). These results are in agreement with those obtained by Omidbeyg *et al*. [12] and YesilCeliktas *et al.* [13], who found that the composition structures, as well as functional groups of the oils, play an important role in determining their antimicrobial activity.

Table 1: Constituent volatile compounds of caraway, mint, and onion

Constituent volatile compounds of caraway oil		Constituent volatile compounds of mint oil		Constituent volatile compounds of onion oil	
Components	**Constituents of caraway oil**	**Component**	**Constituents of mint oil**	**Component**	**Constituents of onion oil**
3-carene	00.01	Camphene	01.19	5-cymene	23.69
Pinene	00.13	Pinene	00.70	Selinene	06.57
Limonene	45.23	Limonene	02.09	Limonene	08.66
Limonene oxide	00.16	Ocimene	01.00	Copaene	13.02
Elemence	00.06	Isomenthone	42.55	Aromadendrene	05.31
Caryophyllene	00.14	Monthly a catate	03.62	Caryophyllene	05.18
Verbenol	00.14	Isopulegol	00.99	Curcumene	02.35
Cubebene	00.07	p. menthone	14.55	Carvone	12.50
Carvone	53.69	Menthol	28.29	Thymoquinone	27.72
Caryophyllene oxide	00.02	Terpineol	00.74	–	–
Apiol	00.34	Pulegone	02.37	–	–
–	–	Piperitone	01.91	–	–

Table 2: Constituent volatile compounds of parsley, fennel, and watercress

Constituent volatile compounds of parsley		Constituent volatile compounds of fennel		Constituent volatile compounds of watercress oil	
Components	**Constituents parsley oil**	**Component**	**Constituents fennel oil**	**Component**	**Constituents watercress oil**
3-carene	00.74	Limonene	09.50	Estragole	100
Pinene	00.64	L-fenchone	01.04	–	–
Limonene	23.09	Estragole	89.12	–	–
Myrtenol	00.53	Carvon	00.06	–	–
Farnesene	00.04	Apiol	00.28	–	–
Caryophyllene	00.95	–	–	–	–
p-menthene	00.09	–	–	–	–
Cyclocitral	01.22	–	–	–	–
Cadinene	01.92	–	–	–	–
Arislolene	01.61	–	–	–	–
Alloaromadendrene	04.22	–	–	–	–
Valencene	46.97	–	–	–	–
Guaiene	07.52	–	–	–	–
Pulegone	10.56	–	–	–	–
Selinene	00.04	–	–	–	–
Elemene	00.03	–	–	–	–

Table 3: Antimicrobial activities of essential oil from caraway, mint, onion, parsley, fennel, and watercress (50 μl)

Bacteria	Caraway			Onion			Parsley			Mint			Fennel			Watercress		
	1	2	M	1	2	M	1	2	M	1	2	M	1	2	M	1	2	M
Escherichia coli	–	–	–	–	–	–	–	–	–	15	14	14.5	–	–	–	–	–	–
Salmonella	–	–	–	14	14	14	11	10	10.5	10	10	10	–	–	–	–	–	–
Staphylococcus aureus	–	–	–	–	–	–	17	17	17	–	–	–	–	–	–	–	–	–
Enterococcus	–	–	–	–	–	–	11	11	11	13	13	13	–	–	–	–	–	–
Citrobacter	–	–	–	–	–	–	–	–	–	30	30	30	–	–	–	–	–	---

M, mean.

Antibacterial activity of essential oils extracted from mint on some foodborne bacteria is shown in Table 4. The data illustrated that the samples l00, 200, and 300 were effective against the three tested bacteria (*Salmonella and Enterococcus*) and exhibited inhibition zone diameters, but essential oils extracted from mint were not effective against *E. coli.* These results are in agreement with those obtained by Mashareg *et al.* [15], who found that the essential oil of spearmint was a more effective antioxidant than those of fennel and anise.

Table 5 shows the antibacterial activity of essential oils extracted from parsley on some bacteria. The data illustrated that the samples were used at three different concentrations (l00, 200, and 300 µl) and were effective against two tested bacteria (*Salmonella* and *Enterococcus*) and exhibited inhibition zone diameters. However, essential oils extracted from parsley at concentrations of 200 and 300 µl were not effective against *S. aureus* and Citrobacter, whereas essential oils extracted from parsley at concentrations of 100, 200 µl, and 300 ml were not effective against *E. coli*. On the contrary, all of the essential oils showed antioxidant properties with different degrees of scavenging activity; shallot and leek oils were the strongest antioxidants. In the antimicrobial activity tests, all the essential oils inhibited a good range of gram-positive and gram-negative bacteria, whereas garlic, onion, and Chinese chive were among the strongest. These activities are mainly attributed to the presence of the sulfur compounds in their compositions; moreover, the variability in the composition structure and concentration of the different sulfides present in the essential oils play an important role in the determination of their antimicrobial and antioxidant activities. This result is in accordance with those obtained by DimaMnayer *et al*. [16].

Table 4: Antimicrobial activities of essential oil extracted from mint (100 μl, 200 μl, and 300 μl)

Bacteria	100 μl			200 μl			300 μl		
	1	2	M	1	2	M	1	2	M
Escherichia coli	–	–	–	–	–	–	–	–	–
Salmonella	55	30	42.5	55	70	62.5	55	40	47.5
Staphylococcus aureus	–	–	–	30	20	25	17	20	18.5
Enterococcus	35	45	40	25	50	37.5	12	10	11
Citrobacter	–	–	–	–	–	–	–	–	–

M, mean.

Table 5: Antimicrobial activities of essential oil extracted from parsley (100 μl, 200 μl, and 300 μl)

Bacteria	100 μl			200 μl			300 μl		
	1	2	M	1	2	M	1	2	M
Escherichia coli	–	–	–	–	–	–	–	–	–
Salmonella	24	30	27	55	80	67.5	25	30	27.5
Staphylococcus aureus	15	17	16	–	–	–	–	–	–
Enterococcus	13	14	13.5	11	12	11.5	6	12	9
Citrobacter	15	10	12.5	–	–	–	17	20	18.5

M, mean.

Conclusion and recommendations

Some of the essential oils of mint and parsley showed antibacterial activity against *Salmonella* sp., *S. aureus*, *Enterococcus*, and *Citrobacter*. Some of the oils did not inhibit the growth of *Citrobacter* and *E. coli*. These volatile oils can be used to flavor some foods and preserve them by extending their shelf life. So, this study recommends using extracted oils from mint and parsley in preserving some processed foods.

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Conflicts of interest

There are no conflicts of interest.

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