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A COMPREHENSIVE REVIEW OF MEDICINAL AND THERAPEUTIC USES OF *MENTHA PIPERITA*

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Abstract: The new trend in food science is to replace the synthetic preservatives with natural vegetable sources. As mentioned by a large scientific literature, due to their rich chemical composition in bioactive compounds, essential oils could be a novelty in this research area. Thanks to the main components of *Mentha piperita* species, such as menthol and menthone, peppermint oil represent a new possibility to prevent and maintain the appearance of food borne pathogens. Also, peppermint oil could be successfully used to treat different human diseases, having medicinal and therapeutic effects.
Keywords: *Mentha piperita*, bioactive compounds, antimicrobial activity, medicinal, therapeutic.

Introduction

Botanical description of *Mentha piperita* L.

Peppermint, which is botanically named *Mentha piperita* L. *(M. piperita*), belongs to the family of *Lamiaceae* and it is known as mint, spearmint, and peppermint. The aerial parts of the plant contains essential oil rich in numerous aroma compounds such as: menthol, menthone, isomenthone, menthofuran, carvone, linalool, linalyl acetate and piperitenone oxide (Verma *et al.*, 2010).

This species is mainly cultivated as a source of essential oil, as a condiment in different industries (pastry and confectionary, meat and non-alcoholic beverages, candies, ice-creams), and for pharmaceutical purposes (Areias *et al.*, 2001).

Mentha genus belongs to the *Lamiaceae* family and has about 25 species and some hybrids. *M. piperita* is according to Tsai, Wu, Lin, Lin & Huang (2013) a hybrid of spearmint (*M. spicata* L.) and water mint (*M.*

aquatica L.), (Figure 1) which grows in different areas with soils characterized by high water-holding capacity. Being a hybrid can propagates through rhizomes (P. Kumar, Mishra, Malik, & Satya, 2011).

M. piperita is a perennial herbaceous plant which might reach 100 cm in height. The leaves are short (2,5 -5 cm long), stalked opposite and toothed and the flowers pinkish or purplish, with an irregular shapes (Bupesh, Amutha, Nandagopal, & Ganeshkumar, 2007), appearing in the summer months. Due to its network of runners, mint could reach long surfaces being fast growing and showing tolerance to different agro-climatic conditions (D. K. Verma & Srivastav, 2017).

It is cultivated almost in all over the world such as India, China, Europe, America, Australia, South Africa, United States, Canada and some other countries, being the world most important commercial herb from the point of view of cultivated area for oil distillation. In our country, according to Rodica Vârban, Stoie & Bogdan (2018), mint was between the first cultivated aromatic and medicinal plants, able to growth in our country climate.

From the plant, the leaves and the flowers are collected and dried in order to be used in different purposes (Shah & Mello, 2004). The peppermint oil world production is about 8000 tons per year (Shah & Mello, 2004).

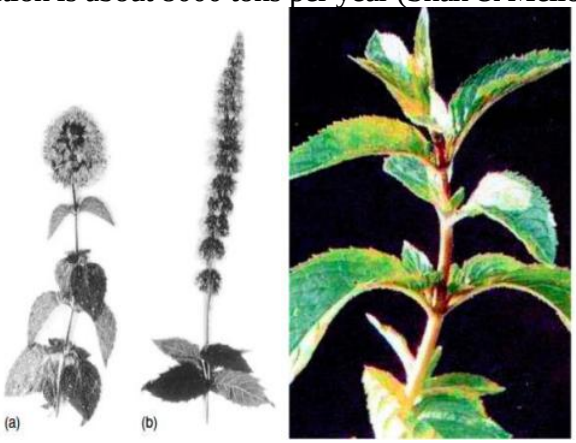

Fig.1. a) *Mentha aquatica; b) Mentha spicata c) Mentha piperita*
(Source: Kokkini, Karousou and Hanlidou, 2003; Shah & Mello, 2004)

Historical, popular and medicinal uses

Since ancient times, medicinal plants have been used in traditional medicine due to their therapeutic effects. *Mentha piperita* has been exploited by man for more than 250 years (Saharkhiz *et al.*, 2012) and it is recognized as being GRAS (generally recognized as safe) by Food and Drug Administration (FDA), as reported by Gardiner (2000).

The Latin name *Mentha piperita* comes from Greek *Mintha* which means the name of a mythical nymph thought to have metamorphosed into the plant and from the Latin word *piper* which means pepper. Due to its essential oils it has been used for decades as a medicinal and fragrant plant with uses in pharmaceutical, food and cosmetic industries. Peppermint oil is according to Gardiner (2000) the most extensively used oils among all the volatile ones.

Is one of the oldest medicinal plants being used by Egyptian, Roman, Greek cultures as a herb in cooking and medicine and nowadays it is named as the most economically aromatic and medicinal plant produced in the United States (Gardiner, 2000). Chinese traditional medicine mentioned the herb for the first time and its dried leaves has been found in Egyptian pyramids (Beigi, Torki-Harchegani & Pirbalouti, 2018). The medicinal use of mint date to ancient times and included analgesic, anti-inflammatory, antiemetic, stimulant, anticatarrhal, emmenagogue apllications (Kalp, Ne & As, 2002).

Mint is also mentioned in the Icelandic Pharmacopoeias of the thirteenth century, but *Mentha piperita* was recognized as a distinct species only in seventeenth century, by the botanist John Ray, according to P. Kumar *et al.* (2011).

The peppermint tea has been traditionally used for the treatment of colic in infants, indigestion, anorexia, and to reduce gas and cramping. This is in line with other findings (Alves, C, Brito & Cavalcanti, 2012), who proved the effectiveness of *Mentha piperita* on colic infants, through clinical trial studies. On the other side, the oil it was successfully used in rheumatism, muscular pains, toothache and menstrual cramps.

M. piperita could be also successfully used for the treatment of fever, bronchitis, nausea, common cold having carminative, anti-spasmodic, and anthelmintic effects (Benzaid, Tichati, Djeribi & Rouabhia, 2019). According to Shah & Mello (2004), the peppermint oil is used nowadays as an inhalant for respiratory problems and peppermint tea is reported as a solution for in the treatment of coughs, in the inflammation of the oral mucosa and throat. More than that, *M. piperita* is used nowadays in the treatment of irritable bowel syndrome, biliary tract disorders, ulcerative colitis and Crohn's disease.

M. piperita essential oils, according to Kalp *et al.* (2002) might also have externally uses such us antiseptic, astringent, rubefacient, antipruritic and could be involved in treatment of neuralgia, myalgia, migraines and headaches. Saharkhiz *et al.* (2012) reported that mint essential oils have antiviral, antibacterial, antibiofilm formation, antiodema, radioprotective and antioxidant activities. More than that *M. piperita* essential oil could have inhibitory effects against *Aspergillus* species and their aflatoxin production. The world oil peppermint production is about 8000 tons per year, being the most used oil from the volatiles ones, according to Balakrishnan (2015).

Today, the research attention is focused on the development of natural food preservatives based on mint essential oils, in order to prolong the shelf life of the final products, aiming to reduce the food waste and its impact environment.

Chemical composition of *M. piperita* essential oil and antimicrobial activity

Essential oils are defined as valuable natural products which can be used as o source of raw materials in different areas such as perfumery, aromatherapy, cosmetics, phototherapy, spices and food (nutrition) (Saharkhiz *et al.*, 2012). They are extracted from aromatic and medicinal plants through steam distillation or solvent extraction (Tsai *et al.*, 2013). The chemical composition of essential oil is strictly correlated with the interaction between the genotype and the environment, climatic conditions, method of distillation and time of harvest, according to Verma *et al.* (2010).

M. piperita oil has a rich chemical composition with 85 constituents identified and 40 unidentified, mostly made up from menthol (50%), menthone (10 to 30%), methyl esters (10%) and monoterpene derivate such us: piperitone, menthofurane and pulegone (Kizil & Ha, 2010). Peppermint oil is described as having a clear to a pale yellow colour, with a fresh and menthol smell and watery in viscosity (Balakrishnan, 2015).

The major chemical bioactive compound is menthol strictly related with neomenthol and isomenthol (Shah & Mello, 2004). Menthol is a crystalline and waxy substance involved in medical purposes such as fever, nasal congestion, skin irritation compared to menthone which is mainly used in perfumery and as a flavour agent (P. Kumar *et al.*, 2011).

Similar chemical composition was reported by Saharkhiz *et al.* (2012): menthol (53.28%) was the primary component from the *Mentha piperita* essential oil, followed by menthyl acetate (15.10%), menthofuran (11.18%) and 1.8 cineole (6.69%). Also, Balakrishnan (2015) reported that menthol is the main component of peppermint oil, being responsible for the anti-spasmolytic effects, having a total amount of 55.0%, followed by menthone (14.0-32.0%). Also, limonene (1.0-5.0%), cineole (3.5-14.0%), menthofuran (1.0-9.0%), isomenthone (1.5-10.0%), methyl acetate (2.8-10%), pulegone (4.0%) and carvone (max.1.0%) were reported as components of peppermint essential oil.

In a study reported by Benzaid *et al.* (2019), 30 chemicals volatile components were present in the essential oil, as showed in Figure 2. The major component was menthol (32.9%), menthone (24.4%), 8.1% *cis*-caran and 7.9% eucalyptol (1-8-cineole). Also, the antioxidant activity of *Mentha*

piperita essential oil is high, reaching a value of 60% RSA (radical scavenging activity) and may be correlated with the presence of menthol, menthone, cis-caran and eucalyptol. This high antioxidant activity might be involved in the reduction of free radical chain reaction, with influence in cancer prevention. This result is in line with the value reported by Kizil & Ha (2010), who showed an antioxidant activity of 60.41% RSA (radical scavenging activity) of *Mentha piperita* essential oil and with Sun, Wang, Wang, Zhou, & Yang (2014) who showed an antioxidant activity of 55% RSA (radical scavenging activity).

More than that (Baliga *et al.*, 2010) showed that *Mentha piperita* could have radioprotective effect in the cancer treatment with radiotherapy. The study has been made on mice, and demonstrated that mint could be useful in the prevention of the toxic effects appearance of ionizing radiation. Also, they reported an anti-inflammatory activity of *Mentha piperita*, due to the presence of terpenoid oxide 1,8-Cineole.

Mentha piperita essential oil has cardiovascular, pulmonary, gastrointestinal benefits and positive effects on skin and mucous membrane, dental health, immune modulation, neuro-psychiatric and antimicrobial effects (Balakrishnan, 2015). Cardiovascular benefits could be explained by the vasodilating properties, having impact on the diminution of hearth rate and systolic pressure. The pulmonary properties of this essential oil are due to the increment of the nasal air force and therefore, the air quantity into the lungs is improving.

Due to its antimicrobial effect, peppermint oil could have positive influence on dental health by creating an un-favourable bacteria environment and providing freshness in breath. Peppermint oil it is also involved in endocrine effects, increasing the secretion of endocrine hormones, according to Balakrishnan (2015).

Compound	Apex RT	RI	% Area
1- Butanol, 3-methyl	2 .50	726	0.2
α-Thujene	6.00	927	0.1
α-Pinene	6.27	939	0.9
β-Pinene	7.77	980	1.5
β-Myrcene	8.22	988	0.1
(+)-2-Carene	9.26	1004	0.2
1,8-Cineole	10.35	1030	7.9
trans-β-Ocimene	10.42	1036	0.3
γ-Terpinene	11.28	1049	0.3
(Z)-β-Terpineol	11.69	1150	0.1
Menthone	17.93	1160	24.4
Isopulegone	18.05	1169	1.0
Menthol	20.47	1186	32.9
Pulegone	22.61	1216	1.5
Isopiperitenone	23.47	1245	1.2
trans-Carane	24.38	1264	0.5
cis-Carane	25.95	1293	8.1
Menthyl acetate	26.36	1304	0.5
β-Bourbonene	30.45	1382	0.7
β-Elemene	30.90	1388	0.3
δ-Elemene	31.87	1417	0.1
β-Caryophyllene	32.64	1430	2.9
epi-bicyclosesquiphellandrene	32.95	1450	0.1
cis,cis,cis-1,1,4,8-Tetramethyl-4,7,10-cycloundecatriene	34.29	1472	0.1
2-Isopropyl-5-methyl-9-methylene-bicyclo[4.4.0] dec-1-ene	35.02	1480	0.2
Germacrene D	36.08	1496	1.2
δ-Cadinene	38.40	1525	0.2
Spathulenol	40.71	1564	0.2
Caryophyllene oxide	40.86	1576	0.3
γ-Selinene	41.24	1589	0.5
Sum			88.5

RI: Retention index
RT: Retention time (min)

Fig.2. Chemical composition of *Mentha piperita* essential oil (Source: Benzaid *et al.*, 2019)

Regarding the chemical composition of *Mentha piperita*, the polyphenolic compounds should be mentioned, because their many biological properties (Areias *et al.*, 2001). The most important phenolics compounds (Areias *et al.*, 2001) are eriocitrin and rosmarinic acid, having a total amount from the total phenolics of 59 to 67%, respectively (Figure 3).

No.	Compound	RT (min s) gradient No. 1	RT (min s) gradient No. 2
a	Eriodictyol 7-*O*-heteroside	09.22	–
1	Eriodictyol 7-*O*-rutinoside	–	12.05
2	Eriodictyol 7-*O*-glucoside	–	14.19
b	Luteolin 7-*O*-heteroside	22.43	–
3	Luteolin 7-*O*-rutinoside	–	18.02
4	Luteolin 7-*O*-glucoside	–	20.08
5	Hesperetin 7-*O*-rutinoside	–	23.46
c	Apigenin 7-*O*-heteroside	26.48	–
6	Apigenin 7-*O*-rutinoside	–	25.22
7	Rosmarinic acid	24.53	28.10
8	5,6-OH-7,8,3′,4′-OMe-flavone	54.38	52.29
9	Pebrellin (5,6-dihydroxy-7,8,4′trimethoxyflavone)	56.14	55.55
10	Gardenin B (5-hydroxy-6,7,8,4′-tetramethoxyflavone)	60.29	62.19

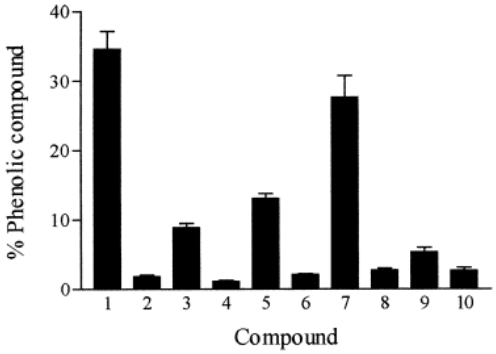

Fig.3. Peppermint phenolic compounds
(Source: Areias *et al.*, 2001).

Also, *Mentha piperita* has a chemical composition rich in minerals, such as calcium, magnesium, zinc, manganese, iron, phosphorus ranged from 12150 mg/kg Ca, 3602 mg/kg Mg, 12.64 mg/kg Zn, 70.82 mg/kg Mn, 531.5 mg/kg Fe, to 1102 mg/kg P, as reported by Kizil & Ha (2010).

Regarding the antimicrobial activity of *Mentha piperita* essential oil (Benzaid *et al.*, 2019) tested the growth of different microoganisms using solid agar. As showed in Figure 4, the essential oil from *Mentha piperita* could have antimicrobial activities against gram-positive and gram-negative bacteria, significantly decreasing their growth and biofilm development.

Microorganism	Inhibition zone (mm)		The minimal inhibitory concentrations (MIC)
	EO	Antibiotic	
Pseudomonas aeruginosa	16	18	4
Pseudomonas aeruginosa ATCC 27853	11	09	4
Klebsiella pneumoniae	46	R	8
Klebsiella pneumoniae E47	25	R	2
Klebsiella oxytica	32	06	1
Escherichia coli ATCC 25922	15	R	0.5
Escherichia coli BMR	20	R	0.5
Enterobacter sakazakii	20	10	0.25
Enterobacter cloacae	32	20	1
Proteus mirabilis	38	R	1
Proteus vulgaris	50	32	4
Citrobacter koseri	45	51	4
Citrus frendii	50	42	1
Acinetobacter baumannii	25	R	2
Salmonella entertidis	24	R	2
Serratia marcescens	60	R	1
Stenotrophomonas maltophilia	20	R	4
Morganella morganii	23	R	4
Pasteurella multocida	35	R	0.5
Staphylococcus aureus ATCC 25923	R	R	-
Staphylococcus aureus ATCC 29213	R	R	-
Staphylococcus aureus	30	R	0.5
Staphylococcus hominis	43	R	0.25
Enterococcus faecalis	45	30	1
Candida albicans	++++++	13	0.25
Candida albicans ATCC	++++++	18	0.25

(R) = resistant

Fig.4. Antimicrobial activities of the *Mentha piperita* essential oil (Source: Benzaid *et al.*, 2019)

Peppermint oil has antibacterial and bacteriostatic effects on gram-positive and gram negative bacteria such as S*treptococcus pyrogens*, S*treptococcus aureus*, *Streptococcus pyrogens*, *Serratia marcescens*, *E.coli* and *Mycobacterium avium* but also antimicrobial activity against pathogenic bacteria such as *Bacillus substillus*, *Pseudomonas aureus*, *Pseudomonas aerogenosa* (Bupesh *et al.*, 2007). Also, Kizil & Ha (2010) reported that the essential oil of *M. piperita* could have strong antimicrobial activity against *C. albicans.*

In a study realized by Saharkhiz *et al.* (2012), was also showed the antimicrobial properties of *M. piperita* essential oil which was involved in the maintenance and extension of the shelf life of the final products, proving that this essential oil could be a new raw material in the development of a new range of products for controlling the growth fungal infections.

Tsai *et al.* (2013) showed that *Staphylococus aureus* and *Pseudomonas acnes,* two Gram-positive bacteria were more sensitive to the *Mentha piperita* essential oil, compared to *Escherichia coli* and *Pseudomonas aeruginosa* which were more resistant. Also, Mahboubi & Kazempour (2014), reported that menthol and menthone, the main components from peppermint oil have high antimicrobial activity against gram positive and negative bacteria, yeast and fungi (*Candida albicans*). They also mentioned that the combination of peppermint essential oil with antibiotics could reduce the antibiotics dose and its side effects.

The idea that by using peppermint oil as vapour can reduce the appearance of foodborne pathogens and spoilage microorganisms is supported also by A. Kumar & Malik (2011), who tested the antibacterial effect of *Mentha piperita* oil vapour and concluded that it could be used as a potential agent for preventing the appearance of food spoilage.

The combination of different essential oils such as *Zataria multiflora, Carum carvi* and *Mentha piperita* showed bacteriostatic effect of *Escherichia Coli O157:H7* in prepared commercial chiken soup. A percentaje of 0.6% *Mentha piperita* oil combined with 1% *Zataria multiflora* was proved to be enough for the bacteriostatic effect on *Escherichia Coli O157:H7* (Fazlara *et al.*, 2008).

Also, Henri *et al.* (2010) showed that the combination oils between *Lippia multifloram* Moldenke, *Mentha piperita* L. and *Ocimum basilicum* L. is useful against *Staphylococus aureus* due to the bioactive compounds such as carvacrol, linalool, menthol.

Kalp *et al.* (2002) showed that due to rich the chemical composition of *Mentha piperita* oil in menthol and menthone, this oil could be active against *Klebsiella pneumoniae, Proteus Vulgaris, Pseudomonas aeruginosa, Salmonella pullorum, Staphylococcus aureus, Streptococcus faecalis, and Comamonas terrigena.*

Recently, the innovations in food packaging industry are focused on the uses of natural antimicrobial sources such as the essential oils. The incorporation of the essential oils in the polymer matrices for food packaging aims to prolong the final products shelf life. *Mentha piperita* essential oils has been already used in the encapsulation of chitosan-cinnamic acid nanogels and proved to have antimicrobial activity (Ribeiro-Santos and Andrade, 2017).

CONCLUSIONS

To conclude, it can be said that *Mentha piperita* has potential active antimicrobial properties and could be successfully used in order to extend or

to maintain the shelf life of the final products. Also, the essential oil could be a possible raw material in the development of products for controlling fungal infections. More than that, *Mentha piperita* essential oil has medicinal and therapeutic effects on human beings.

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