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CONSTITUENTS AND BIOLOGICAL ACTIVITIES SOME OF THE SELECTED *Ocimum* SPECIES: A REVIEW

Prof. Abdolhossein Rustaiyan[1*] and Zahra Sadat Aghakhah Razlighi MSc.[2]

[1,2]Department of Chemistry, Faculty of Basic Sciences. Science and Research Branch Islamic Azad University, Tehran, Iran.

***Corresponding Author: Prof. Abdolhossein Rustaiyan**

Department of Chemistry, Faculty of Basic Sciences, Science and Research Branch Islamic Azad University, Tehran, Iran.

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ABSTRACT

The genus *Ocimum* (family Lamiaceae), collectively called basil, consists of about 160 species, and is spread over the tropical, subtropical and warmer parts of the temperate regions of both hemispheres raging from sea level to 1800 ft altitude. Basil has traditionally been used to treat head colds and as a cure for warts and worms, as well as an appetite stimulant, carminative, and diuretic. In addition, it has been used as a mouthwash and astringent to cure inflammations of the mouth and throat. Alcoholic extracts of basil have been used in creams to treat slowly healing wounds. Basil is more widely used as a medicinal herb in the Far East, especially in China and India. It was first described in a major Chinese herbal around A.D 1060 and has since been used in China for spasms of the stomach and kidney ailments, among other applications. It is especially recommended for use before and after parturition to promote blood circulation. The whole herb is also used to treat snakebite and insect bites.

KEY WORDS: *Ocimum*, Lamiaceae, Secondary metabolites, Essential Oils, biological activities, chemical constituents.

INTRODUCTION

The genus *Ocimum* comprises more than 150 species and is considered as one of the largest genera of the Lamiaceae family.[1] The genus *Ocimum* is spread over the tropical, subtropical and warmer parts of the temperate regions of both hemispheres raging from sea level to 1800 ft altitude.[2] [3] Many members of this family are used in traditional, folk medicine, food flavorings, vegetables, and in industry. Leaves are the most used plant parts. Also, they are used as culinary and ornamental plants.[4] Basil has traditionally been used to treat head colds and as a cure for warts and worms, as well as an appetite stimulant, carminative, and diuretic. In addition, it has been used as a mouthwash and astringent to cure inflammations of the mouth and throat.[3] Alcoholic extracts of basil have been used in creams to treat slowly healing wounds.[5] It is especially recommended for use before and after parturition to promote blood circulation. The whole herb is also used to treat snakebite and insect bites.[3] [6]

This family contains a wide variety of chemical compounds such as terpenoids, iridiods, phenolic compounds and flavonoids.[7 - 9] Some of the short chain terpenoids in essential oils are responsible for odor and taste in these plants.[4]

Among the plants known for medicinal value, the plants of genus *Ocimum* are very important for their therapeutic potentials. *Ocimum sanctum* L. (Tulsi), *Ocimum gratissium* (Ram Tulsi), *Ocimum canum* (Dulal Tulsi), *Ocimum basilicum* (Ban Tulsi), *Ocimum kilimandscharicum*, *Ocimum ammericanum*, *Ocimum camphora* and *Ocimum micranthum* are examples of known important species of genus Ocimum which grow in different parts of the world and are known to have medicinal properties.[10-21]

There are many cultivars of basil which vary in their leaf color (green or purple), flower color (white, red, ppurple) and aroma. *Ocimum* spp. contain a wide range of essential oils rich in phenolic compounds and a wide array of other natural products including polyphenols such as flavonoids and anthocyanins.[23] [24]

This plant is used both as a culinary and ornamental herb.[22] [25] [26] The genus *Ocimum* contains between 50 and 150 species of herbs and shrubs found in the tropical regions of Asia, Africa, and Central and South America.[27 -29]

Anti-inflammatory, anti-arthritic, anti-stress and anti-pyretic pharmacological activities of *O. tenuiflorum* have been reported.[30][31] The oil of *O. gratissimum* is used to flavor foods, dental and oral products, in fragrances and aromatherapy, and in traditional rituals and medicines.[3][32]

Basil oil is used for flavor and fragrance in the food, pharmaceutical, cosmetic, and aromatherapy industries. The essential oil possesses antimicrobial[34-37] and insecticidal[38] [39] activity. In addition, basil extract and essential oil have been shown to possess antioxidant activity.[40-44]

***Ocimum Basilicum* L.**

Ocimum basilicum L. (sweet basil) is an annual herb which grows in several regions all over the world. The plant is widely used in food and oral care products. Sweet basil, *Ocimum basilicum*, is the major culinary and essential oil source of this genus.[3] [45]

The essential oil of the plant is also used in food industries and as perfumery, has also been reported to possess antimicrobial properties.[3] [46] [47] As a result of its medicinal properties, the leaves and flowering tops of sweet basil are used as carminative, diuretic, stimulant, galactogogue, stomachic and antispasmodic medicinal plant in folk medicine.[3] [48-50] Antiviral and antimicrobial activities of this plant have also been reported.[51] [52]

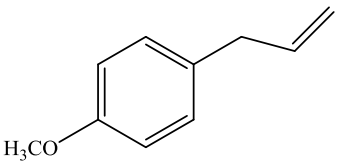
The white, rose and sometimes violet labiate flowers are in 6-blossomed, pedicled, almost sessile axillary false whorls. The calyx is bilabiate, and the corolla is 4-lobed. The lower lip is simple; the 4 stamens lie on it. Among more than 65 species of the genus *Ocimum*, basil is the major essential oil crop which is cultivated commercially in many countries. [24] Basil has a characteristic odor and sharp taste. The plant probably originated in India, Afghanistan, Pakistan, Northern India and Iran, and now is cultivated worldwide. Traditionally, basil has been extensively utilized in food as a flavoring agent, and in perfumery and medical industries.[53] [54]

The chemical composition of basil oil has been the subject of considerable studies. There is extensive diversity in the constituents of the basil oils and several chemo types have been established from various phytochemical investigations. However, methyl chavicol, linalool, methyl cinnamate, methyleugenol, eugenol and geraniol are reported as major components of the oils of different chemotypes of *O. basilicum*.[24] [52] [55] [56]

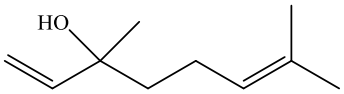
Chemical constituents

The *Ocimum basilicum* essential oils exhibited a wide and varying array of chemical compounds, depending on variations in chemotypes, leaf and flower colors, aroma and origin of the plants.[57] The chemical compositions of the essential oils of *Ocimum basilicum* L. cv. purple and *Ocimum basilicum* L. cv. green cultivated in Iran at full flowering stage were collected from Isfahan in Sep of 2004 at an altitude of 1570m, were investigated by GC-MS. Twenty constituents (98.5% of the total oil) were identified in the volatile oil of *O. basilicum* L. cv. Purple. In the volatile oil of *O. basilicum* L. cv. green, twelve components were characterized representing 99.4% of the total oil. The main constituents found in the oil of *O. basilicum* L. cv. purple were methyl chavicol (52.4%), linalool (20.1%), epi-α-cadinol (5.9%), trans-α-bergamotene (5.2%) and 1,8-cineole (2.4%). In the oil of *O. basilicum* L. cv. green, methyl chavicol (40.5%), geranial (27.6%), neral (18.5%), caryophyllene oxide (5.4%) and humulene epoxide II (1.8%) were the major components.[24]

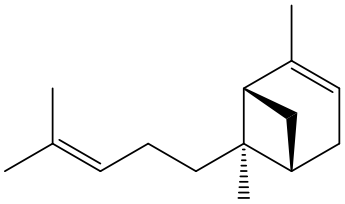
In 2011, a comparison of the chemical composition and antimicrobial activity of the essential oils obtained from the aerial parts of two types of *O. basilicum* L. (green type) and *O. basilicum* (purple type) which collected during the flowering stage from Karaj, just north of Tehran, Iran, in June 2006, were carried out. The oils were obtained by hydrodistillation and were analyzed by GC and GC/MS. The main components of the oil of the *O.basilicum* (green type) were methyl chavicol (62.5%), geranial (12.5%) and neral (9.9%) while in the oil of *O.basilicum* (purple type), trans-a-bergamotene (17.5%), linalool (17.0%) and 1,8-cineole (9.0%) were the prominent components.[3]



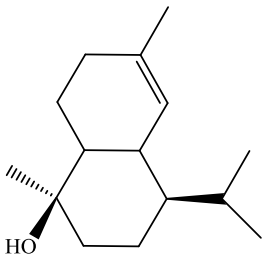
methyl chavicol



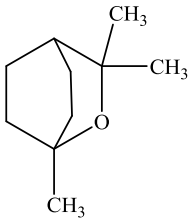
Linalool



trans-a-bergamotene

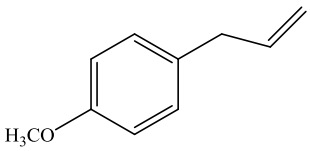


epi-a-cadinol

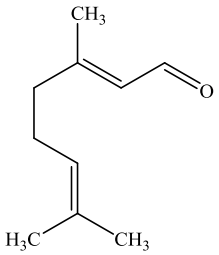


1,8-cineole

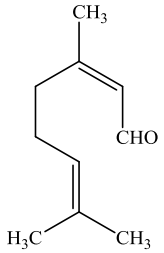
Figure 1: The main constituents found in the oil of O. *basilicum* L. purple from Isfahan and Karaj, Iran.



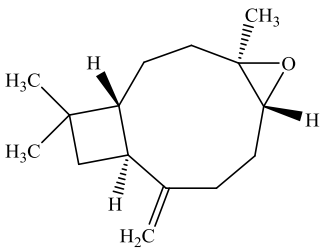
methyl chavicol



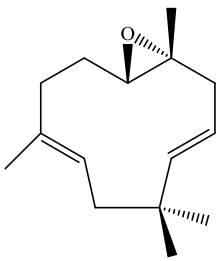
geranial



neral



caryophyllene oxide



humulene epoxide II

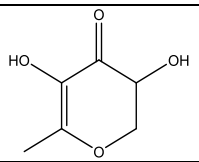
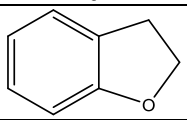
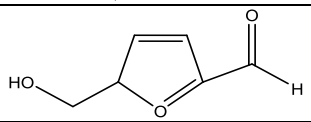
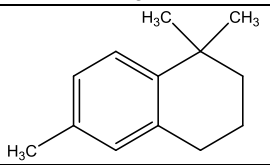
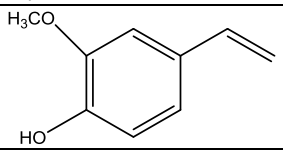
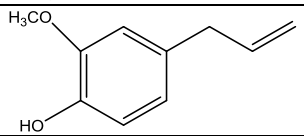
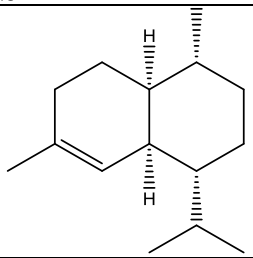
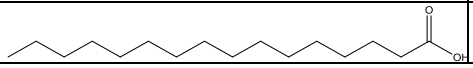
Figure 2: The main constituents found in the oil of *O. basilicum* L. green from Isfahan and Karaj, Iran.

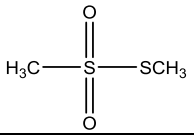
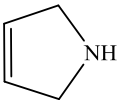
In *O. basilicum* from Bangladesh, linalool and geraniol are reported as the main components.[58] In the oils, obtained from aerial parts of *O. basilicum* grown in Colombia and Bulgaria, linalool and methyl cinnamate are reported as major components of volatile oils respectinely.[59] [60] Linalool and methyl eugenol are the main components of the essential oils of *O. basilicum* cultivated in Mali[56] and Guinea.[61] The observed differences may be probably due to different environmental and genetic factors, different chemotypes and the nutritional status of the plants as well as other factors that can influence the oil composition. Mixture of methyl chavicol and linalool comprise 72.5% of the oil of *O. basilicum* L. cv. purple. The results of the study

indicate that the composition of volatile oil of purple balm cultivated in Iran is similar to those which are reported from Nigeria [62] Benin [63] and Togo. [64] On the other hands, geranial and neral were not detected in the oil of purple balm and the green basil was characterized by high content (46.1%) of citral (geranial and neral). For determination of probable chemotypes further investigations would be required.[24]

In a study, the relative retention time of the ethanol extracts of leaf and leaf callus of *Ocimum basilicum* L. and mass spectra of different constituents were compared using standards from the library. As shown in Table 1, 12 compounds were identified. Results showed that *Ocimum basilicum* L. leaf extracts contained a complex mixture of numerous compounds, many of which were present in trace amounts. 2,3-dihydroxy-3,5-dihydroxy-6-methyl-4H-Pyran-4-one (1), 2,3-dihydro-Benzofuran (2), 5-hydroxymethylfurfural (3), 1,2,3,4-tetrahydro-1,1,6-trimethyl-naphtalene (4), 2-methoxy-4-vinylphenol (5), eugenol (6), γ-muurolene (7), n-hexadecanoic acid (8), phytol (9), and (Z,Z,Z)-9,12,15- octadecatrienoic acid (10) were observed as versatile common constituents of *Ocimum basilicum* L. in vivo leaf (L) extracts. Besides S-methyl methanethiosulphonate (11), 2,5-dihydro-1H-pyrrole (12), and 2,3-dihydro-3,5-dihydroxy- 6-methyl-4H-pyran-4-one (1), 2-methoxy-4-vinylphenol (5) and eugenol (6) were also observed in *Ocimum basilicum* L. in vitro leaf extracts (IL). Additionally, in vitro leaf callus grown in light conditions (CL) presented S-methyl methanethiosulphonate (11), 2,3-dihydro-3,5-dihydroxy-6-methyl-4H-pyran-4-one (1), 2-methoxy-4-vinylphenol (5), n-hexadecanoic acid (8) and (Z,Z,Z)-9,12,15-octadecatrienoic acid (10). In vitro leaf callus grown in dark conditions (CD) revealed the existence of 2,3-dihydro-3,5-dihydroxy- 6-methyl-4H-pyran-4-one (1), 5-hydroxymethylfurfural (3), 2-methoxy-4-vinylphenol (5), n-hexadecanoic acid (8) and (Z, Z, Z)-9,12,15-octadecatrienoic acid (10).

Table 1 Identification of compounds by GC-MS.

Nos.	Name	Structures	Formula
1	2,2-Dihydroxy-3,5-dihydroxy-6-methyl-4H-Pyran-4-one		$C_6H_8O_4$
2	2,2-Dihydro-benzofuran		C_6H_8O
3	5-Hydroxymethylfurfural		$C_6H_6O_3$
4	1,2,3,4-Tetrahydro-1,1,6-trimethyl-naphtalene		$C_{13}H_{18}$
5	2-Methoxy-4-vinylphenol		$C_9H_{10}O_2$
6	Eugenol		$C_{10}H_{12}O_2$
7	γ-Muurolene		$C_{15}H_{24}$
8	n-Hexadecanoic acid		$C_{16}H_{32}O_2$

10	(Z,Z,Z)-9,12,15-Octadecatrienoic acid		$C_{18}H_{30}O_2$
11	S-Methyl methanethiosulfonate		$CH_3SO_2SCH_3$
12	2,5-Dihydro-1H-Pyrrole		C_4H_7N

In one study, chemical composition, antioxidant and antimicrobial activities of the essential oils from aerial parts of basil (*Ocimum basilicum* L.) as affected by four seasonal, namely summer, autumn, winter and spring growing variation were investigated. The hydro-distilled essential oils content ranged from 0.5% to 0.8%, the maximum amounts were observed in winter while minimum in summer. The essential oils consisted of linalool as the most abundant component (56.7-60.6%), followed by epi-α-cadinol (8.6-11.4%), α-bergamotene (7.4-9.2%) and γ-cadinene (3.2-5.4%). Samples collected in winter were found to be richer in oxygenated monoterpenes (68.9%), while those of summer were higher in sesquiterpene hydrocarbons (24.3%). The contents of most of the chemical constituents varied significantly ($p < 0.05$) with different seasons.[65]

In another study, Zheljazkov V.D. and et.al. in 2008, determined that, the main constituent of *Ocimum basilicum* cultivars was (–)-linalool with other constituents being (–)-camphor, α-humulene, eucalyptol, eugenol, (–)-bornyl acetate, Estragole, (–)-trans-caryophyllene, α-trans-bergamotene, and cadinol.[33]

Biological Activities

Traditionally basil has been used as a medicinal plant in the treatment of headaches, coughs, diarrhea, constipation, warts, worms, and kidney malfunctions.[66] Externally, basil can be used as an ointment for insect bites, and its oil is applied directly to the skin to treat acne.[67] The leaves and flowering tops of the plant are perceived as carminative, galactogogue, stomachic and antispasmodic in folk medicine.[24] [65] Natural components from basil have long been used to flavor foods and dental and oral products.[66] [68] Iranian basils are used to treat fevers, throat congestions, and stomachache.[29] [69]

Rosmarinic acid (RA) (R-O-caffeoyl-3-4-dihydroxyphenyllactic acid) is one of the most abundant caffeic acid esters present in *Ocimum* spp.[70] RA and its derivatives have been reported to have antioxidant, anti-HIV,[71] and anti-inflammatory or cyclooxygenase inhibitory activity, comparable to ibuprofen, naproxen, and aspirin.[42] Similar to RA, lithospermic acid B (LAB) is known to be a common phenolic constituent in most members of the Lamiaceae family[72] and exhibits endothelium-dependent vasodilator and hypotensive effects.[73 – 75]

Antimicrobial activity: The basil herb, which is easily cultured worldwide, may be a potentially good candidate to be used as a plant with antibacterial activity. The *O. basilicum* essential oils exhibited a wide and varying array of chemical compounds, depending on variations in chemotypes, leaf and flower colors, aroma and origin of the plants.[57] The chief constituents include chavicol methyl ether or estragole, linalool and eugenol.[65] [76]

The studies in the literature suggest linalool as the main active agent responsible for antibacterial activity[77] and other studies suggest this plant suitable for using as an antibacterial against corrupting and poisoning microbes of food products.[78]

The antibacterial properties of basil essential oil were studied on the standard gram-negative bacteria including *Escherichia coli*, *Pseudomonas aeruginosa*, and gram-positive ones including *Bacillus cereus*, *Staphylococcus aureus*. The results of this study showed the presence of bacteriostatic effects of basil essential oil on all the test bacteria.[54]

In addition, in 2011, the antimicrobial activities of two types of *O. basilicum* oils (green and purple types) were assayed by Rustaiyan A. and et.al. against three Grampositive and one Gram-negative bacteria and one fungus, and were compared with standard antibiotics, such as gentamicine. The results revealed that both oils were active against the Gram-positive bacteria *Listeria monocytogenes* and Gram-negative bacteria *Escherichia coli*.[3]

In another study, the essential oils were individually tested against a set of microorganisms, including two Gram-positive bacteria: *Staphylococcus aureus* (*S. aureus*) ATCC 25923, *Bacillus subtilis* (*B. subtilis*) ATCC 10707, two Gram-negative bacteria: *Escherichia coli* (*E. coli*) ATCC 25922 and *Pasteurella multocida* (*P. multocida*), and five pathogenic fungi: *Aspergillus niger* ATCC 10575 (*A. niger*), *Mucor mucedo* (*M. mucedo*),

Fusarium solani (*F. solani*), *Botryodiplodia theobromae* (*B.theobromae*) and *Rhizopus solani* (*R. solani*).[65]

The antimicrobial activity of *O. basilicum* essential oils and linalool, the most abundant component, against bacterial strains: *Staphylococcus aureus, Escherichia coli, Bacillus subtilis, Pasteurella multocida* and *pathogenic fungi Aspergillus niger, Mucor mucedo, Fusarium solani, Botryodiplodia theobromae, Rhizopus solani* was assessed. The results of antimicrobial assays indicated that all the tested microorganisms were affected. The antimicrobial activities of the oils varied significantly ($p < 0.05$), as seasons changed.[65]

Anti‑inflammatory activity: The anti-inflammatory activity of *Ocimum basilicum* L. was investigated the effect of callus induction and the ethanol extract of *O. basilicum* L. to examine its anti-inflammatory activity. The results showed that *O. basilicum* L. may have potential benefits in preventing pathological inflammation.[79]

***Ocimum sanctum* L.**

Ocimum sanctum L. (Tulsi in Sanskrit or Reyhan-e-Moghaddas in Farsi) belonging to Lamiaceae family, is native to Asia, and Central and western parts of Africa.[80]

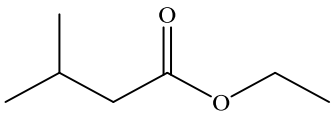
Chemical constituents

In one study, aimed to determine the variations in chemical compositions of the essential oils of *Ocimum sanctum* L. and the experiment was carried out in Agricultural Research Center of Bushehr province, located in nine miles South-east of Borazjan, Iran. *Ocimum sanctum* aerial parts were collected from the cultivated plants at three stages of growth and development during June and July 2012**.** The samples were harvested at vegetative, floral budding (emergence of flower buds) and full flowering stages. A voucher specimen (HSU 24989) is deposited in the herbarium of Shiraz University, Shiraz, Iran. The oils constituents were analyzed by gas chromatography/mass spectrometry (GC/MS). The hydro-distillation of the aerial parts of *O. sanctum* at the vegetative, floral budding, and full flowering stages yielded 0.98%, 0.92% and 1.1% (w/w) essential oils, respectively. The composition of essential oils at different growth stages is shown in Table 2, in the order of their elution from a DB-5 column. A total of 13, 15 and 15 compounds representing 88.44%, 95.09% and 92.21% of the total were detected at vegetative, floral budding and full flowering stages, respectively. GC/MS analyses showed that the main constituents of the essential oil from the vegetative stage were 1, 8-Cineole and β-bisabolen, while eugenol was found as the main compound of floral budding and full flowering developmental stages.

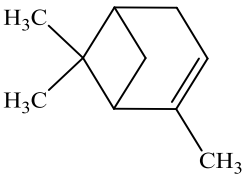
Table 2: Chemical Components of the Essential Oils Distilled from Three Developmental Stages of *Ocimum sanctum*.

Nos.	Compound	Developmental Stages, %			
		RI	Vegetative	Floral Budding	Full Flowering
1	Ethyl Isovalerate	854	-	-	0.83
2	α-Pinene	954	0.76	0.41	0.66
3	Sabinen	985	0.55	0.44	0.49
4	β-Pinene	1010	1.08	1.53	1.73
5	Myrcene	1059	0.53	1.128	0.93
6	1,8-Cineole	1068	20.78	19.41	20.45
7	Linalool	1109	0.22	0.19	0.15
8	Terpinen-4-ol	1184	-	0.28	-
9	α-Terpineol	1211	-	0.37	0.42
10	Estragol	1229	11.49	10.61	11.40
11	Eugenol	1382	15.70	37.15	24.63
12	α-Cis-Bergamotene	1469	3.13	1.30	2.69
13	α-Humulene	1482	2.34	1.29	1.27
14	β-Bisabolen	1542	20.99	13.29	18.76
15	γ-Elemene	1565	10.47	7.7	7.8

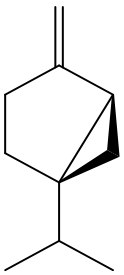
[a] abbreviation: RI, retention index.



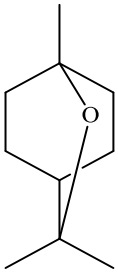
Ethyl Isovalerate



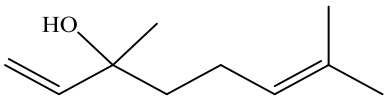
α-Pinene



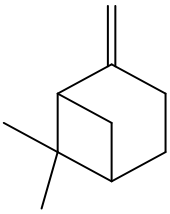
Sabinen



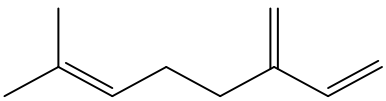
1,8-Cineole



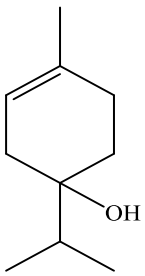
Linalool



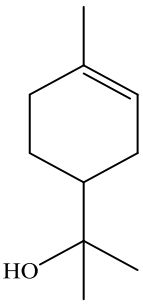
β-Pinene



Myrcene



Terpinen-4-ol



α-Terpineol

Figure 3: Chemical Components of the Essential Oils from *Ocimum sanctum.*

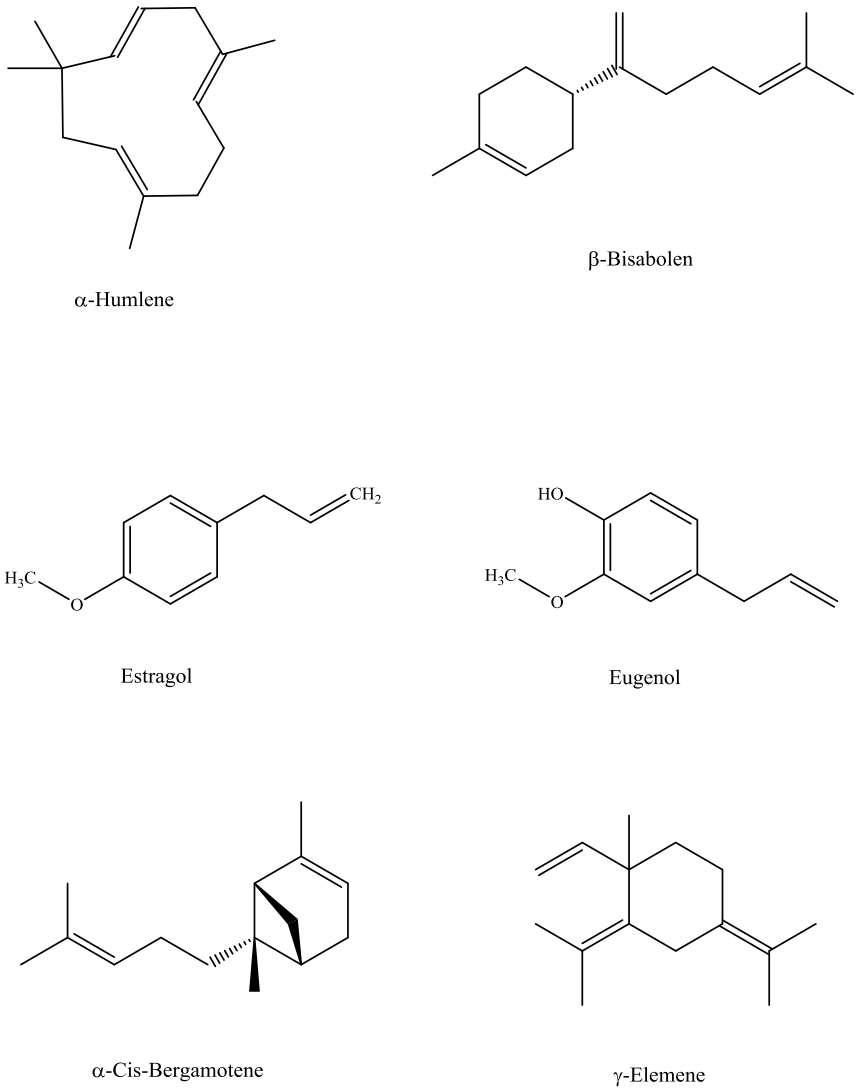


Figure 4: Chemical Components of the Essential Oils from *Ocimum sanctum.*

In one study, the main constituents of *Ocimum sanctum* L. was methyl chavicol, eugenol, and eucalyptol with other constituents being ahumulene, humulene-epoxide II, (–)-trans-caryophyllene, a-trans-bergamotene, and gcadinene.[33]

In addition, *O. sanctum* conducted in Atlantic Canada by Bowes and Zheljazkov (2004). Interestingly, (–)-linalool concentration in both studies was similar; in the study in Atlantic Canada, the (–)-linalool concentration in cv. Mesten oil varied between 38% and 65%, whereas in this study, the (–)-linalool concentration varied between 30% and 65%, indicating a relatively stable range of variation for this trait. However, eugenol accumulation in cv. Mesten in Atlantic Canada was lower than eugenol in cv. Mesten in this study. Regarding cv. Local of holy basil, methyl chavicol and eucalyptol in all locations plus eugenol in Crystal Springs and Verona were the major oil constituents in this study in the United States, whereas the major constituents of this cultivar grown in Atlantic Canada were carene, methyl chavicol, elemene, or a-humulene.[81] [33]

In another research, samples were collected from Shahr-e-Rey, Iran, on August 2013. Main components obtained from hydro-distillation were methyl chavicol (26.86%), linalool (17.76%), epi- α-cadinol (13.12%) in flowers and methyl chavicol (27.64%) , epi- α-cadinol (11.5%) in leaves, and also main components obtained from steam distillation were methyl chavicol (25.2%) , linalool (17.65%), germacrene D (6.87%) in flowers and methyl chavicol (38.96%), linalool (12.13%) in leaves, respectively. Methyl chavicol was the main constituent in all essential oils.[82]

Biological Activities

Pharmacological studies and clinical practices have demonstrated that *Ocimum sanctum* L. possesses anti-oxidative[83][84] and antimicrobial functions including antibacterial,[85] [86] antifungal,[87- 89] antimalarial[85] and anti-helminthic.[90] It has been also recommended to treat diabetes, bronchitis, diarrhea, dysentery, dyslipidemia, hypertension and skin diseases.[80] [85] [91] [92] Tulsi has also been used in treatment of fever, bronchitis, arthritis, convulsions, bronchitis, bronchial asthma, malaria, diarrhea, dysentery, skin diseases, arthritis, painful eye

diseases, insect bite etc. The *O. sanctum* L. has also been suggested to possess antifertility, anticancer, antidiabetic, antifungal, antimicrobial, hepatoprotective, cardioprotective, antiemetic, antispasmodic, analgesic, adaptogenic and diaphoretic actions.[85]

Eugenol (l-hydroxy-2-methoxy-4-allylbenzene), is a phenolic compound and major constituent of essential oils extracted from different parts of Tulsi plant. the active constituent present in *Ocimum sanctum* L., has been found to be largely responsible for the therapeutic potentials of Tulsi.[20] [85]

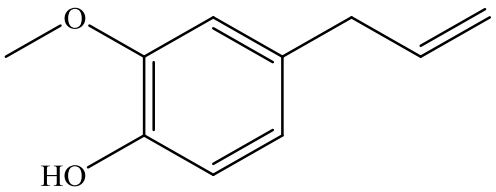


Figure 5: Eugenol (l-hydroxy-2-methoxy-4-allylbenzene).

Aqueous decoction of Tulsi leaves is given to patients suffering from gastric and hepatic disorders.[17][19] Herbal preparations containing *Ocimum sanctum* L. have been suggested to shorten the course of illness, clinical symptoms and biochemical parameters in patients suffering from viral hepatitis.[17] The leaf juice of *Ocimum sanctum* L. along with Triphala is used in Ayurvedic eye drop preparations recommended for glaucoma, cataract, chronic conjunctivitis and other painful eye diseases. The juice of fresh leaves is also given to patients to treat chronic fever, dysentery, hemorrhage and dyspepsia. A decoction of Tulsi leaves is a popular remedy for cold.[17] [19] Tulsi leaves also check vomiting and has been as anthelmintic.[11]

As a prophylactic against malaria, fresh Tulsi leaves are taken with black pepper in the morning. A decoction of the root of Tulsi plant is given as a diaphoretic in malarial fever.[19] As far as its antimalarial effect is concerned Tulsi extracts and essential oil have also been found to possess insecticidal and larvicidal activities against mosquitoes.[17] *Ocimum sanctum* L. also possesses antifungal activity against *Asperigillus niger*. Aqueous extract of Tulsi is found effective in patients suffering from viral encephalitis.[17]

Aqueous decoction of whole plant lowers the blood sugar (glucose) level and is said to control diabetes mellitus.[21] Paste of Tulsi leaves are found effective in the treatment of ring-worm and other skin diseases.[11] [17] [19] Tulsi has been also recommended for use as antidote for dog bite, scorpion bite and insect bite in traditional system of medicine.[11] [17][19] The fresh leaves and flower tops of *Ocimum sanctum* L. have been used as antispasmodic agent (as smooth muscle relaxant).[11] [17] The seeds are mucilaginous and demulcent and are given in disorders of the genitourinary system. [17] The leaves of Tulsi plant have also been shown to possess good anti-stress (adaptogenic), analgesic, anti-hyperlipidemic, antioxidant potentials in experimental animals.[17] [93 – 97] Leaves and seeds of Tulsi plants have been reported to reduce blood and urinary uric acid level in albino rabbits and possess diuretic property.[19] Gastric ulceration and secretion are reported to be inhibited by Tulsi in albino rats.[11]

Anti-microbial activity: Foods provide a suitable media for many microorganisms to grow and produce such as *Staphylococcus aureus* or *Aspergillus* species. On the other hand, certain types of live bacteria such as *Entrobacteriacea* family might be transmitted through eating contaminated foods and cause food-borne infection. Contaminated foods are among the main concerns of the public health policy makers and food industries.[98 – 101] It is observed that many of plants and their aromatic products have potential antimicrobial activities.[102-105] The anti-microbial activity of *O. sanctum* against some microorganisms has been investigated in some previous studies. Agarwal and et.al. in an experimental study demonstrated that *O. sanctum* extract was effective against *Streptococcus mutans*.[86] Others showed antimicrobial properties of the extract of this plant against *S. aureus* and enteric bacteria.[106] In another study, its efficacy against multi-resistant strains of *Neisseria gonorrhea* was demonstrated.[107]

Antifungal activities of the *O. sanctum* against *Candida* spp. and dermatophytes were previously indicated.[88] [89] [104] In the current study, the developmental growth stages of the Essential oils, in particular full flowering stage, exhibited significant fungistatic and fungicidal activities against *Aspergillus* species. These results support the previously reported data, [87] and suggest that the essential oil of *O. sanctum* has the potential to be used in the food industries as preservative to prevent the growth of aflatoxicogenic fungi.[80]

The results showed anti-bacterial and anti-fungal characteristics of a traditional plant called *O.sanctum* on food-borne Gram-positive, Gram-negative bacteria and *Aspergillus* species. The compositions of essential oils might be affected by the developmental stage of the plant.[104] [108] Although some authors reported Methyl Chavicol[88] as the major compounds of the essential oil, others reported eugenol as the main constituent of the essential oil.[87] [90] In the study, β-bisabolen was the dominant compound of the oil at the vegetative stage which declined gradually from 20.99% to 13.29% at the floral budding stage. Eugenol which reached its maximum level at the floral budding stage was identified as the main compounds of both floral budding and full flowering stages. The lower concentration of eugenol in this study, compared with that of some previous reports,[87] may reflect variations due to geographical location. During the various developmental stages of *O.*

sanctum, the concentration of 1, 8-Cineole gradually declined from 20.78% to 20.45%.[80]

Antibacterial activity: In a study was carried out to observe the antibacterial activity of aqueous extract, chloroform extract, alcohol extract and oil obtained from leaves of *Ocimum sanctum* against the selected bacteria i.e., *E. coli, P. aeruginosa, S. typhimurium* and *S. aureus*. This investigation reveals that *Ocimum sanctum* may be a better alternative as a preservative in Food Industries since it is equally effective against pathogenic gram positive and gram negative bacteria.[109]

Anthelmintic activity: The essential oil of *Ocimum sanctum* and eugenol, tested in vitro, showed potent anthelmintic activity in the *Caenorhabditis elegans* model. The essential oil of *O. sanctum* and eugenol showed potent anthelmintic activity. These results may lend support for the traditional use of the plant as an anthelmintic. Furthermore, eugenol, as its main and active constituent, could be the putative anthelmintic principle in the essential oil.[90]

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