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REVIEW

Phytochemical Constituents and Pharmacological Activities of Sweet Basil-*Ocimum basilicum* L. (Lamiaceae)

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Ocimum basilicum L. (sweet basil) belongs to family Lamiaceae. The family Lamiaceae comprises the most employed medicinal plants as a worldwide source of spices and also as a consolidated source of extracts. The chemical composition of sweet basil essential oil has been investigated and by now more than 200 chemical components have been reported from many regions of the world. The chemical constituents showed the presence of monoterpene hydrocarbons, oxygenated monoterpene, sesquiterpene hydrocarbons, oxygenated sesquiterpene, triterpene, flavanoids, aromatic compounds, *etc*. The compounds have been reported to exhibit antibacterial and antifungal, antiproliferative/anticancer, antidyspepsia, antigiardial, antiinflammatory, antioxidant, antiulcer, antiviral, insecticidal and wound-healing activities. They also showed antiwormal response, cardiac stimulant, effects on CNS, hypoglycaemic and hypolipidemic effects and inhibitory effect on platelet aggregation. Various parts of the plant of *O. basilicum* (sweet basil) have been widely used in traditional medicine. Leaves and flowering parts of *O. basilicum* are traditionally used as antispasmodic, aromatic, carminative, digestive, galactogogue, stomachic and tonic agent. They have also been used as a folk remedy to treat various ailments such as feverish illness, poor digestion, nausea, abdominal cramps, gastro-enteritis, migraine, insomnia, depression, gonorrhea, dysentery and chronic diarrhea exhaustion. Externally, they have been applied for the treatment of acne, loss of smell, insect stings, snake bites and skin infections.

Key Words: *Ocimum basilicum*, **Phytochemical constituents, Terpenes.**

INTRODUCTION

Basil (*Ocimum basilicum* L.) is one of the most famous, annual or perennial herb belonging to the family Lamiaccae[1]. Physically, basil is characterized by square, branching stems, opposite leaves, verticillaster inflorescence, calyx and corolla bilabiate, brown or black seeds (also called nutlets)[2]. It is a native of Africa, India and Asia, cultivated in temperate climate throughout the world[1]. There is some confusion in the literature about the exact number of species of the genus Ocimum. Therefore, the genus is still being studied by researchers[3]. According to Tchoumbougnang *et al.*[4], the genus Ocimum (basil) was known to comprise at least 200 species and numerous varieties which have been recently reclassified into 64 species. Generally, the species of Ocimum are both cultivated herbs and shrubs and wild growing.

There are many opinions on the origin of the word basil. Some say the word basil is an abbreviated form of the Greek: Basilikon phuton, meaning royal herb. Others hold that the name *Ocimum basilicum* derives from the Greek: okimon, smell and basilikon, royal[5].

Many beliefs and rituals are associated with Basil. In Italy it is a symbol of Love, in France it is called as a herb of royal and during Victorian time it was used as a sign of good wishes. Jewish people used it to get strength during fasting while an African legend claims that basil protects against Scorpio. However, a group of European thinks that it is a symbol of Satan[1].

Basil was once credited for growing a scorpion in a man's brain after he had sniffed the herb every day. Other tales include the breeding of poisonous beasts if sweet basil was left to rot in horse dung[6].

The strong aromatic scent of the leaves is very much like cloves. Every good Hindu goes to his rest with a Basil leaf on his breast. This is his passport to Paradise[7].

Sweet basil (*O. basilicum*) attracted great attention in ancient systems (Ayurvedic and Unani) of Indian medicine for its use in the treatment of various ailments[8,9]. Basil is used in traditional medicines, as a culinary herb and a well-known source of flavoring principles[10]. It is a popular herb in the US and Mediterranean diets[11]. The cosmetic industries use basil in soap, shampoos, lotions, oils and perfumes. Its oil has many aroma therapies uses and as a medicine for stress, migraine, cold and hay fever. Basil tea is good for digestion, to expel gases, stomach cramps, constipation, diarrhoea and vomiting. It is used to treat mental fatigue, nervous conditions and hyssop for cough.

Leaves and flowering parts of *O. basilicum* are of great importance for medicinal use as antispasmodic, aromatic, carminative, digestive, galactogogue, stomachic and tonic agent. Externally, they have been applied for the treatment of acne, loss of smell, insect stings, snake bites and skin infections[12].

Essential oil of *O. basilicum* has been used as folk medicine to treat various diseases. For example, the aerial part of the plant is traditionally used as antispasmodic, aromatic, carminative, digestive, stomachic and tonic agents[13].

Basil has a long and interesting history steeped in legend[3]. It, originally native to Iran, India and other tropical regions of Asia, has been in cultivation for over 5,000 years[8]. It is thought to have been brought to ancient Greece by Alexander the Great (356-323 B.C.E.), to have made its way to England from India in the mid 1500s and arrived in the US in the early 1600s. It was grown in medieval gardens and is mentioned in many classic herbals, including those of Culpeper, Gerard, Parkinson and Dioscorides[3].

In Roman times, the use of sweet basil for healing was disputed by Greek healers, Galen and Dioscorides who thought it should not be taken internally. Pliny, the Roman scholar and author on the other hand, defended its use and it has since been used to lower blood pressure, cleanse the blood, lower blood sugar levels and cholesterol and as a general detoxifier[14]. Gerard praised basil as a remedy for melancholy but also repeated Dioscorides' warning that too much basil "dulleth the sight and is of a hard digestion"[3].

Chemical constituents: The chemical composition of basil essential oil has been investigated since the 1930s[15] and by now more than 200 chemical components have been identified which revealed a huge diversity in the constituents of its oil from many regions of the world[16]. Detail of the chemical constituents is presented in Table-1 and analysis of nutrients of *Ocimum basilicum* fresh leaves is given in Table-2.

Pharmacological activies: *Ocimum basilicum* L. (sweet basil) has been studied in different parts of the world. It has been reported to exhibit antibacterial and antifungal, antiproliferative/anticancer, antidyspepsia, antigiardial, anti-inflammatory, antioxidant, antiulcer, antiviral, insecticidal and wound-healing activities. It also showed antiwormal response, cardiac stimulant, effects on CNS, hypoglycaemic and hypolipidemic effects and inhibitory effect on platelet aggregation.

Antibacterial and antifungal activities: *Ocimum basilicum* possesses considerable antimicrobial activities as studied by various research groups. Its essential oils and their principal constituents were found to exhibit antimicrobial activity against a wide range of gram-negative and gram-positive bacteria, yeast and mold[17].

In one study ethanol, methanol and hexane extracts from *O. basilicum* were investigated for their *in vitro* antimicrobial properties. All three extracts were different in terms of their antibacterial activities. The ethanol extract exhibited an antimicrobial effect against 9 strains in the genera *Acinetobacter*, *Bacillus*, *Escherichia* and *Staphylococcus*, making 6 % of the total 146 bacterial strains tested. On the other hand, the methanol and hexane extracts of *O. basilicum* showed antibacterial activities against 11 and 13 strains in six bacterial genera *viz.*, *Acinetobacter*, *Bacillus*, *Brucella*, *Escherichia*, *Micrococcus* and *Staphylococcus* forming 9 and 10 % of the 146 bacterial strains tested, respectively. The methanol and hexane extracts also inhibited three isolates of *Candida albicans*[13,14].

According to Budka and Khan[18] essential oils from *O. basilicum* (basil), *Thymus vulgaris* (thyme), *Origanum vulgare* (oregano) exhibited bactericidal properties against *Bacillus cereus* in rice-based foods. In a similar study, only methanol extracts among various extracts of *O. basilucum* showed the antimicrobial activity against *Pseudomonas aeruginosa*, *Shigella* sp., *Listeria monocytogenes*, *Staphylococcus aureus* and two different strains of *Escherichia coli*.

In another study, the antimicrobial activities of the volatile oils of *O. basilicum* and *O. gratissimum* L. were studied *via* separate incorporation of the volatile oils into tooth pastes (2 and 5 %). The volatile oils showed antibacterial activities comparable to a commercial tooth paste (which contains *O. basilicum* 0.01 % among others) against most resistant organisms. As components of mouth washes, the volatile oils completely inhibited the growth of organisms at a concentration of 0.5 %[19]. Essential oils from *O. basilicum* originating from Turkey exhibited antibacterial activity ranging from 1.25-10 μL disc(-1) against the test organisms with inhibition zones of 9.5-39.0 mm and minimal inhibitory concentrations values in the range 0.5- > or =1 μL/L[20].

According to Kristinsson *et al.*[21], the treatment with oil of basil or essential oil components cured or healed 56-81 % of rats infected with *Haemophilus influenzae* and 6-75 % of rats infected with Pneumococci, compared with 5.6-6 % of rats in the placebo group.

The vapours of peppermint oil and two of its major constituents (menthol and menthone) and sweet basil oil and two of its major constituents (linalool and eugenol), were tested against *Sclerotinia sclerotiorum* (Lib.) and *Rhizopus stolonifer* (Ehrenb. ex Fr.) by Edris and Farrag *et al.*[22]. The constituents of basil oil, *i.e.*, linalool alone showed a moderate antifungal activity while eugenol showed no activity at all.

In one study the essential oil of the aerial parts of *Ocimum basilicum*, was obtained by hydrodistillation and analyzed by GC-MS. Fifteen compounds, representing 74.19 % of the total oil were identified showing significant antifungal activity against some plant pathogenic fungi[23].

Antiproliferative/anticancer activity: A study on the antiproliferative activity of essential oil from 17 Thai medicinal plants on human mouth epidermal carcinoma (KB) and murine leukemia (P388) cell lines. In the KB cell line, sweet basil

TABLE-1
CHEMICAL COMPOSITION OF ESSENTIAL OILS OF *Ocimum bsilicum* L. REPORTED FROM LITERATURES.

Compound	m.f.	m.w.	Part	Reference
Monoterpenes				
Monoterpene hydrocarbons				
α-Phellandrene	$C_{10}H_{16}$	136	Aerial parts	42, 43
α-Pinene	$C_{10}H_{16}$	136	Aerial parts	34,42 - 46
α-Terpinene	$C_{10}H_{16}$	136	Inflor., leaves	42, 45 - 47
α-Terpinolene	$C_{10}H_{16}$	136	Leaves	42
α-Myrcene	$C_{10}H_{16}$	136	Leaves	16,42,48
β-Phellandrene	$C_{10}H_{16}$	136	Aerial parts	43
β-Pinene	$C_{10}H_{16}$	136	Inflor., leaves	34,42 - 48
Camphene	$C_{10}H_{16}$	136	Inflor., leaves	34,42, 45 - 46
cis-β-Ocimene.0	$C_{10}H_{16}$	136	Aerial parts	44, 49
cis-Ocimene	$C_{10}H_{16}$	136	Leaves	42
δ-3-Carene	$C_{10}H_{16}$	136	Leaves	42
β-Ocimene	$C_{10}H_{16}$	136	Leaves	48
(E)-β-Ocimene	$C_{10}H_{16}$	136	Aerial parts	16, 43, 45, 46
Limonene	$C_{10}H_{16}$	136	Aerial parts	16, 43-49
Myrcene	$C_{10}H_{16}$	136	Aerial parts	43-46
p-Cymene	$C_{10}H_{14}$	134	Aerial parts	43, 47
Sabinene	$C_{10}H_{16}$	136	Aerial parts	42-46
Terpinolene	$C_{10}H_{16}$	136	Inflor., leaves	43, 45, 46
Thujene	$C_{10}H_{16}$	136	Leaves	42
γ-Terpinene	$C_{10}H_{16}$	136	Aerial parts	43, 45, 46, 47
Oxygenated monoterpene				
α-Citral	$C_{10}H_{16}O$	152	Leaves	47
α-Fenchyl acetate	$C_{12}H_{20}O_2$	196	Aerial parts	43
α-Terpineol	$C_{10}H_{18}O$	154	Aerial parts	43, 44, 47, 48
Borneol	$C_{10}H_{18}O$	154	Aerial parts	43, 44, 47
Bornyl acetate	$C_{12}H_{20}O_2$	196	Aerial parts	43, 47, 49
Camphor	$C_{10}H_{16}O$	152	Aerial parts	34, 42, 44-48, 50
Carvacrol	$C_{10}H_{14}O$	150	Aerial parts	43
Carvone	$C_{10}H_{14}O$	150	Aerial parts	43
1,8-Cineole	$C_{10}H_{18}O$	154	Aerial parts	34, 42, 44-51
cis-Linalool oxide	$C_{10}H_{18}O_2$	170	Aerial parts	43
cis-Rose oxide	$C_{10}H_{18}O$	154	Aerial parts	44
Citronellol	$C_{10}H_{20}O$	156	Aerial parts	49
Endo-Fenchol	$C_{10}H_{18}O$	154	Aerial parts	43
Estragol	$C_{10}H_{12}O_2$	174	Aerial parts	44, 51
Eugenol	$C_{10}H_{12}O_2$	174	Leaves	44, 45, 46, 51, 48
Exo-2-hydroxycineole-acetate	$C_{12}H_{20}O_3$	212	Leaves	47
Fenchone	$C_{10}H_{16}O$	152	Aerial parts	43-46, 48-50
Geranial	$C_{10}H_{16}O$	152	Aerial parts	43, 50
Geraniol	$C_{10}H_{18}O$	154	Aerial parts	43-48
Geranyl acetate	$C_{12}H_{20}O_2$	196	Aerial parts	43, 47
Hotrienol	$C_{10}H_{16}O$	152	Leaves	47
iso-Neomenthol	$C_{10}H_{20}O$	156	Aerial parts	44
iso-Pinocamphone	$C_{10}H_{16}O$	152	Aerial parts	43
trans-Pinocamphone	$C_{10}H_{16}O$	152	Aerial parts	43
L-Camphor	$C_{10}H_{16}O$	152	Leaves	51
L-Carvone	$C_{10}H_{14}O$	150	Leaves	47
Lavandulol	$C_{10}H_{18}O$	154	Leaves	47
Linalool	$C_{10}H_{18}O$	154	Aerial parts	34, 42-48, 50, 51
Linalool *cis*-furanoid	–	–	Leaves	47
Linalool *trans*-furenoid	–	–	Leaves	49
Linalyl acetate	$C_{12}H_{20}O_2$	196	Leaves	43, 47, 49
Menthol	$C_{10}H_{20}O$	156	Aerial parts	48
Menthone	$C_{-?}H_{18}O$	154	Aerial parts	48
Methyl chavicol	$C_{10}H_{12}O$	148	Aerial parts	43, 45, 46, 50, 51
Myrtenal	$C_{10}H_{12}O$	148	Leaves	43, 50
Myrtenol	$C_{10}H_{16}O$	152	Aerial parts	34, 43
Neral	$C_{10}H_{14}O$	152	Aerial parts	43, 50
Nerol	$C_{10}H_{18}O$	154	Leaves	42, 43, 47
Ocimene oxide	$C_{10}H_{16}O$	152	Leaves	47
Pinocarvone	$C_{10}H_{14}O$	150	Aerial parts	43

P-menth-1,8-dien-4-ol	$C_{10}H_{16}O$	152	Leaves	47
Piperitone	$C_{10}H_{16}O$	152	Aerial parts	48
Pulegone	$C_{10}H_{12}O_2$	174	Aerial parts	49
Terpinen-4-ol	$C_{10}H_{18}O$	154	Aerial parts	42-45, 46, 50
Terpinyl formate	$C1_1H_{18}O_2$	182	Leaves	47
trans-Linalool oxide	$C_{10}H_{18}O_2$	170	Aerial parts	43
trans-Myroxide	$C_{10}H_{16}O$	152	Aerial parts	43
trans-Sabinene hydrate	$C_{10}H_{18}O$	154	Leaves	47
trans-*p*-Menth-2-en-1-ol	$C_{10}H_{18}O$	154	Leaves	47
Thymol	$C_{10}H_{16}O$	152	Leaves	33
Verbenone	$C_{10}H_{14}O$	150	Leaves	47
(Z)-Sabinene hydrate	$C_{10}H_{18}O$	154	Inflor., leaves	45,46
Sesquimonoterpenes				
Sesquiterpene hydrocarbons				
Cyclohexane, 2,4-diisopropenyl-1-methyl-1-vinyl	$C_{15}H_{24}$	204	Aerial parts	23
1,4,7-Cycloundecatriene,1,5,9,9-tetramethyl	$C_{15}H_{24}$	204	Aerial parts	23
α-Acoradiene	$C_{15}H_{24}$	204	Aerial parts	43
α-Amorphene	$C_{15}H_{24}$	204	Aerial parts	47, 48
α-Bulnesene	$C_{15}H_{24}$	204	Essential oil	16, 44
α-Cadinene	$C_{15}H_{24}$	204	Inflor., leaves	44-46
α-Cedrene	$C_{15}H_{24}$	204	Inflor., leaves	44-46
α-Copaene	$C_{15}H_{24}$	204	Inflor., leaves	43-49
α-Cubebene	$C_{15}H_{24}$	204	Aerial parts	34, 44-46
α-Guaiene	$C_{15}H_{24}$	204	Aerial parts	43-46, 48
α-Gurjunene	$C_{15}H_{24}$	204	Aerial parts	43
γ-Gurjunene	$C_{15}H_{24}$	204	Aerial parts	43
α-7-epi-Selinene	$C_{15}H_{24}$	204	Aerial parts	43
α-Humulene	$C_{15}H_{24}$	204	Aerial parts	43, 48-51
Aromadendrene	$C_{15}H_{24}$	204	Inflor., leaves	45 - 46
α-(Z)-Bergamotene	$C_{15}H_{24}$	204	Inflor., leaves	45-46
α-Zingiberene	$C_{15}H_{24}$	204	Inflor., leaves	45-46
β-Acoradiene	$C_{15}H_{24}$	204	Aerial parts	43
β-Bourbonene	$C_{15}H_{24}$	204	Aerial parts	43-46
β-Caryophyllene	$C_{15}H_{24}$	204	Aerial parts	43, 49, 51
β-Cedrene	$C_{15}H_{24}$	204	Aerial parts	43
β-Copaene	$C_{15}H_{24}$	204	Aerial parts	2, 49
β-Cubebene	$C_{15}H_{24}$	204	Aerial parts	23, 43-49, 51
β-Elemene	$C_{15}H_{24}$	204	Leaves	43, 48, 51
β-Guaiene	$C_{15}H_{24}$	204	Aerial parts	23
β-Ocimene	$C_{15}H_{24}$	204	Aerial parts	48
β-Selinene	$C_{15}H_{24}$	204	Aerial parts	45-47, 49
Bicycloelemene	$C_{15}H_{24}$	204	Aerial parts	43
Bicyclogermacrene	$C_{15}H_{24}$	204	Aerial parts	43-51
Cadinene	$C_{15}H_{24}$	204	Aerial parts	23
Cadina-3,5-diene	$C_{15}H_{24}$	204	Aerial parts	43
cis-Calamene	$C_{15}H_{24}$	204	Aerial parts	48
cis-Muurola-4(14),5-diene	$C_{15}H_{24}$	204	Aerial parts	42, 43
(E)-β-Farnesene	$C_{15}H_{24}$	204	Inflor., leaves	45, 46
(E)-Caryophyllene	$C_{15}H_{24}$	204	Inflor., leaves	45, 46
1-Epibicyclosesqui-phellandrene	$C_{14}H_{22}O$	204	Roots, seeds	33
Epsilon-muurolene	$C_{15}H_{24}$	204	Leaves	42
Dehydroaromadendrene	$C_{15}H_{22}$	204	Leaves	47
Germacrene-A	$C_{15}H_{24}$	204	Aerial parts	437, 48-50
Germacrene-B	$C_{15}H_{24}$	204	Leaves	48
Germacrene-D	$C_{15}H_{24}$	204	Aerial parts	42-48, 49-51
Guaia-1(10),11-diene	$C_{15}H_{24}$	204	Aerial parts	23
Iso-caryophyllene	$C_{15}H_{24}$	204	Aerial parts	34
Isoledene	$C_{15}H_{24}$	204	Aerial parts	43
Longifolene	$C_{15}H_{24}$	204	Aerial parts	43
δ-Selinene	$C_{15}H_{24}$	204	Leaves	47
St α-ylangene	$C_{15}H_{24}$	204	Leaves	42
trans-α-Bisabolene	$C_{15}H_{24}$	204	Aerial parts	43, 50
trans-α-Bergamotene	$C_{15}H_{24}$	204	Aerial parts	42, 43, 48-50
trans-β-Farnesene	$C_{15}H_2$	204	Inflor., leaves	49
trans-β-Ocimene	$C_{15}H_{24}$	204	Aerial parts	34

trans-Caryophyllene	$C_{15}H_{24}$	204	Aerial parts	43, 50
Valencene	$C_{15}H_{24}$	204	Leaves	47
γ-Cadinene	$C_{15}H_{24}$	204	Inflor., leaves	45, 46, 49, 50
γ-Terpin	$C_{15}H_{24}$	204	Aerial parts	34
δ-Cadinene	$C_{15}H_{24}$	204	Inflor., leaves	45-47
γ-Muurolene	$C_{15}H_{24}$	204	Aerial parts	49
(Z)-Calamenene	$C_{15}H_{24}$	204	Inflor., leaves	45, 46
Oxygenated sesquiterpenes				
α-Cadinol	$C_{15}H_{26}O$	222	Aerial parts	23, 45-49
α-Humulene oxide	$C_{15}H_{24}O$	220	Leaves	47
Alloaromadendrene	$C_{15}H_{24}O$	220	Inflor., leaves	45,46
β-Basibolol	$C_{15}H_{26}O$	222	Inflor., leaves	45-47, 49
β-Basibolol isomer	$C_{15}H_{26}O$	222	Leaves	47
β-Eudesmol	$C_{15}H_{26}O$	222	Aerial parts	45-50
Cubenol	$C_{15}H_{26}O$	222	Oil	16
Caryophyllene oxide	$C_{15}H_{24}O$	220	Aerial parts	43-47, 49, 50
1,10-di-epi-cubenol	$C_{15}H_{26}O$	222	Aerial parts	43, 50
Dihydroactinidiolide	$C_{11}H_{16}O_2$	180	Leaves	47
Isospathulenol	$C_{15}H_{24}O$	220	Leaves	47
Muurolol	$C_{15}H_{26}O$	222	Aerial parts	49
Spathulenol	$C_{15}H_{24}O$	220	Aerial parts	43-50
T-cadinol	$C_{15}H_{26}O$	222	Roots, seeds	33
Viridiflorol	$C_{15}H_{26}O$	222	Aerial parts	49
(Z)-Nerolidol	$C_{15}H_{26}O$	222	Inflor., leaves	45, 46
Triterpene				
Alphitolic acid	$C_{30}H_{48}O_4$	472	Roots, seeds	33, 52
Betulin	$C_{30}H_{50}O_2$	442	Roots, seeds	33, 52
Betulinic acid	$C_{30}H_{48}O_3$	456	Roots, seeds	33, 52, 53
3-Epimaslinic acid			Root	52
Euscaphic acids	$C_{30}H_{48}O_5$	488	Root	52
Oleonolic acid	$C_{30}H_{48}O_3$	456	Rts,Sds,Lf,Fl.	33, 52, 53
Pomolic acid	$C_{30}H_{48}O_4$	472	Roots, Seeds	33
Ursolic acid	$C_{30}H_{48}O_3$	456	Rts,Sds,Lf,Fl.	33, 52
Basilol	$C_{37}H_{52}O_4$	460	Leaves, Flower	53
Ocimol	$C_{39}H_{56}O_6$	620	Leaves, Flower	53
Aliphatic alcohol				
Cyclohexanol	$C_6H_{12}O$	100	Leaves	47
Hexanol	$C_6H_{14}O$	102	Leaves	47
Octanol	$C_8H_{18}O$	130	Leaves	47
3-Octanol	$C_8H_{18}O$	130	Leaves	47, 50
1-Octen-3-ol	$C_8H_{16}O$	128	Leaves	47
1-Penten-3-ol	$C_5H_{10}O$	86	Leaves	47
(Z)-2-pentenol	$C_5H_{10}O$	86	Leaves	47
(Z)-3-hexanol	$C_6H_{14}O$	102	Leaves	47
Aliphatic aldehyde				
(E)-3-hexenal	$C_6H_{10}O$	98	Leaves	47
(E,Z)-2,4-heptadienal	$C_7H_{10}O$	110	Leaves	47
Hexanal	$C_6H_{12}O$	100	Leaves	47
Aliphatic ester				
(Z)-3-hexenyl acetate	$C_8H_{14}O_2$	142	Leaves	47
Aliphatic ketones				
β-Ionone	$C_{13}H_{20}O$	192	Leaves	47
cis-Jasmone	$C_{11}H_{16}O$	164	Leaves	47
3-Hydroxy-2-butanone	$C_4H_8O_2$	88	Leaves	47
6-Methyl-5-heptenone	$C_8H_{14}O$	126	Leaves	47, 50
6-Methyl-(E,E)-3,5-heptadien-2-one	$C_8H_{14}O$	126	Leaves	47
trans-β-Ionone-5,6-epoxide			Leaves	47
Aromatic Compounds				
4-Allylphenol	$C_9H_{10}O$	134	Leaves	47
Anethole	$C_{10}H_{12}O$	148	Leaves	47
Anisaldehyde	$C_8H_8O_2$	136	Leaves	47
Benzyl alcohol	C_7H_8O	108	Leaves	47
Cuminaldehyde	$C_{10}H_{12}O$	148	Leaves	47
Estragole	$C_{10}H_{12}O$	148	Leaves	47
Ethyl cinnamate	$C_{11}H_{12}O_2$	176	Leaves	47
Methyl benzoate	$C_8H_8O_2$	136	Leaves	47

Methyl cinnamate	$C_{10}H_{10}O_2$	162	Leaves	34, 47
Methyl eugenol	$C_{11}H_{14}O_2$	178	Leaves	3, 44 -47, 51
Methyl salicylate	$C_8H_8O_3$	152	Leaves	47
p-Methoxycinnamaldehyde	$C_{10}H_{10}O_2$	162	Leaves	47
Phenethyl alcohol	$C_8H_{10}O$	122	Leaves	47
Phenyl acetaldehyde	C_8H_8O	120	Leaves	47
Safrole	$C_{10}H_{10}O_2$	162	Leaves	47
Benzaldehyde	C_7H_6O	106	Leaves	42
cis-hex-3-enyl acetate	$C_8H_{14}O_2$	142	Leaves	42
Flavonoids				
Quercetin	$C_{15}H_{10}O_7$	302	Leaves	33
Quercetin-3-O-diglycoside			Leaves	33
Quercetin-3-O-B-D-Galactoside	$C_{21}H_{20}O_{12}$	466	Whole plant	33
Quercetin-3-O-B-D-glucoside	$C_{21}H_{22}O_{12}$	468	Whole plant	33
Quercetin-3-O-B-D-glucoside-2”-gallate	$C_{21}H_{22}O_{11}$	452	Whole plant	33
Quercetin-3-O-(2”-O-galloyl)- rutinoside	$C_{27}H_{30}O_{16}$	610	Whole plant	33
Quercetin-3-O-a-L-rhamnoside	$C_{21}H_{20}O_{11}$	448	Whole plant	33
Isoquercetrin	$C_{21}H_{20}O_{12}$	468	Leaves	33
Kaempferol	$C_{15}H_{10}O_6$	286	Leaves	33
Kaempferol-3-O-rotinoside	$C_{22}H_{30}O_{15}$	534	Leaves	33
Kaempferol-3-O-B-D-glucoside	$C_{21}H_{22}O_{11}$	450	Whole plant	33
Rutin	$C_{22}H_{30}O_{16}$	550	Leaves	33
3,5-Pyridinedicarboxylic acid, 2,6-dimethyldiethyl ester	$C_{13}H_{17}NO_4$	251	Aerial parts	23
Monosaccharide				
L-Arabinose	$C_5H_{10}O_5$	150	Seeds	33
L-Rhamnose	$C_6H_{12}O_5$	154	Seeds	33
D-Xylose	$C_5H_{10}O_5$	150	Seeds	33
Coumarin				
Coumarin	$C_{10}H_8O_4$	192	Whole plant	33
Aesculetin	$C_9H_6O_4$	178	Leaves	33
p-Coumaric acid	$C_9H_8O_3$	164	Leaves	33
Cinnamates				
(1). 4'-carbomethoxy-2'-hydroxy phenyl ferulate	–	–	Essential oil	54
(2). (E)-3'-hydroxy-4'-(1"-hydroxyethyl)-phenyl-4- methoxycinnamate	–	–	Essential oil	54
Caeffic acid	$C_9H_8O_4$	180	Leaves	33
Caftaric acid (caffeoyl-tartaric acid)	$C_{13}H_{12}O_9$	312	Leaves	42, 6
Polyphenols				
Rosmarinic acid	$C_{18}H_{16}O_8$	360	Whole plant	33
chicoric acid (dicaffeoyltartaric acid)	$C_{22}H_{18}O_{12}$	474	Leaves	6
Phenylpropene				
Estragole	$C_{10}H_{12}O$	148	Aerial parts	16, 44, 49, 51
Glycoside				
Esculin	$C_9H_8O_6$	212	Leaves	33
Syringin	$C_{17}H_{24}O_9$	372	Whole plant	33
Steroids:				
Basilimoside	$C_{36}H_{60}O_6$	588	Aerial parts	53
Daucosterol	$C_{35}H_{60}O_6$	576	Whole plant	33
B-Sitosterol	$C_{29}H_{50}O$	414	Leaves, flower	33
Stigmasterol	$C_{29}H_{48}O$	412		
Stigmasterol-3-O-B-D-glucoside	$C_{35}H_{58}O_6$	574	Whole plant	33
Miscellaneous compounds				
Dihydroactinidiolide				
2,6-Dimethylpyrazine	$C_6H_8N_2$	94	Leaves	47
Myristicin	$C_{11}H_{12}O_3$	192	Leaves	47
γ-Butyrolactone	$C_4H_6O_2$	86	Leaves	47
Cyclohexene	C_6H_{10}	82	Aerial parts	23
2-Pentanone,4-hydroxy-4-methyl	$C_6H_{12}O_2$	116	Aerial parts	23

TABLE-2
ANALYSIS OF NUTRIENTS: *Ocimum basilicum*, FRESH LEAVES, NUTRITIVE VALUE PER 100 g

Principle	Nutrient value	Percentage of RDA (recommended dietary) (%)
Energy	23 Kcal	1
Carbohydrates	2.65 g	2
Protein	3.15 g	6
Total fat	0.64 g	2
Cholesterol	0 mg	0
Dietary fiber	1.60 g	4
Vitamins		
Folates	68 mcg	17
Niacin	0.902 mg	6
Pantothenic acid	0.209 mg	4
Pyridoxine	0.155 mg	12
Riboflavin	0.076 mg	6
Thiamin	0.034 mg	2.5
Vitamin A	5275 IU	175
Vitamin C	18 mg	30
Vitamin E	0.80 mg	5
Vitamin K	414.8 mcg	345
Electrolytes		
Sodium	4 mg	0
Potassium	295 mg	6
Minerals		
Calcium	177 mg	18
Copper	385 mg	43
Iron	3.17 mg	40
Magnesium	64 mg	16
Manganese	1.15 mg	57
Phyto-nutrients		
Carotene-β	3142 mcg	–
Crypto-xanthin-β	46 mcg	
Lutein-zeaxanthin	5650 mcg	–

Source: USDA National nutrient data base[55].

(*Ocimum basilicum*) oil showed the highest antiproliferative activity in the P388 cell line. The results suggested the potential of Thai medicinal plants for cancer treatment[24].

Anti-dyspepsia: A double-blind placebo-controlled study showed *Ocimum basilicum* seems to relieve functional dyspepsia in female and young patients with dysmotility[25].

Antigiardial activity: In one study, Almeida *et al.*[26], reported the antigiardial activity of the essential oil (2 mg/mL) and its purified substances. Pretreatment of peritoneal mouse macrophages with 2 mg/mL essential oil dilution reduced in 79 % the association index between these macrophages and *Giardia lamblia*, with a concomitant increase by 153 % on nitric oxide production by the *G. lamblia*-ingested macrophages. The protein profiles and proteolitic activity of these parasite trophozoites, previously treated or not with 2 mg/mL essential oil or with the purified fractions, were also determined. Besides, the proteolitic activity, mainly of cysteine proteases, was clearly inhibited by the essential oil (2 mg/mL) and the purified linalool (300 µg/mL).

Antiinflammatory: Study of *Ocimum basilicum* crude methanolic extracts exhibited antiinflammatory activity as evidenced by the inhibition of the key proinflammatory cytokines and mediators[5].

Antioxidant activities: Polyphenols of *Ocium basilicum* were known for their antioxidant activity. In one study, polyphenols of *O. basilicum* were isolated from methanol extract and were examined for antioxidant activities, which exhibited best antioxidant activity as well as excellent synergistic effect against α-tocopherol[27].

Kin *et al.*[28] identified two phenolic compounds, rosmarinic and caffeic acids as strong antioxidant constituents of sweet basil.

Jayasinghe *et al.*[29] have reported the antioxidant capacity of essential oils obtained by steam hydrodistillation from five species of the genus *Ocimum*, namely *O. basilicum*, *O. basilicum var. purpurascens*, *O. gratissimum*, *O. micranthum* and *O. tenuiflorum* (syn. *O. sanctum*). In the hypoxanthine/xanthine oxidase assay, strong antioxidant capacity was evident in all the oils but the greater was shown by that obtained from *O. tenuiflorum* (IC_{50} = 0.46 µL/mL) compared to *O. basilicum* var. *purpurascens* (IC_{50} = 1.84 µL/mL). The antioxidant activity of a methanolic extract of *O. basilicum* was examined using different *in vitro* assay model systems. The DPPH scavenging assay system and the oxidation of the soy phosphotidylcholine liposome model system were used to evaluate the antioxidant activity of each fraction. Fraction IV showed the strongest activity followed by fractions V and VI. Phenolic compounds responsible for the antioxidative activity of the fractions were characterized by atmospheric pressure, chemical ionization liquid chromatography-mass spectrometry. Moreover, the native of antioxidant activity of rosmarinic acid in the liposome system was examined. The results showed that one rosmarinic acid can capture 1.52 radicals and furthermore, the existence of a synergistic effect between α-tocopherol and rosmarinic acid was revealed.

According to Gulcin *et al.*[30], the possible radical scavenging and antioxidant activity of the water and ethanol extracts of basil was investigated using different antioxidant methodologies: 1,1-diphenyl-2-picryl-hydrazyl (DPPH) free radical scavenging, scavenging of superoxide anion radical-generated non-enzymatic system, ferric thiocyanate method, reducing power, hydrogen peroxide scavenging and metal chelating activities. Experiments revealed that water and ethanol extracts of basil have an antioxidant effects which are concentration-dependent. The total antioxidant activity was performed according to the ferric thiocyanate method. Additionally, these antioxidant activities were compared with BHA, BHT and α-tocopherol as reference antioxidants. The additional total phenolic content of these basil extracts was determined as the gallic acid equivalent and were found to be equivalent.

Antiulcer: Study showed the seed extracts of *O. basilicum* to possess significant antiulcer activity against ethanol-induced ulceration in animal models[31].

Antiviral: Study of crude aqueous and ethanolic extracts yielded apigenin, linalool and ursolic acid, exhibiting a broad spectrum of antiviral activities, especially against coxsackie virus B1 and enterovirus 71[32].

Antiwormal response: In one study the volatile oil of *O. basilicum* was analyzed through fractional distillation and chromatography and found that 2 fractions showed maximum antiwormal response under the test conditions. The results in all probabilities supported the use of fresh extract of plant as "Nasal drops" which have been successfully employed in Peennaswara infections in India[33].

TABLE-3
BIOLOGICAL ACTIVITIES OF VARIOUS CHEMICAL CONSTITUENTS OF *Ocimum basilicum*

Organism	Constituents	References
Antibacterial activities		
Staphylococcus aureus, Salmonella enteritidis, Escherichia coli	Essential oil	41
Bacillus cereus	Essential oil	18
Pseudomonas aeruginosa, *Listeria monocytogenes*, *Shigella* sp., *Staphylococcus aureus*	Methanol extract	2
Two different strains of *Escherichia coli*.	Methanol extract	2
Haemophilus influenzae and *Pneumococci*	Essential oil	21
Staphylococcus aureus	Essential oil	56
Staphylococcus, Enterococcus and *Pseudomonas*	Linalool, methylchavikol,methyl cinnamat and linolen	57
Escheriachia coli, Pseudomonas aeruginosa, Salmonella typhi, and Staphylococcus aureus.	Extract	58
Staphylococcus aureus, Escherichia coli, Bacillus subtilis,Pasteurella multocida and pathogenic fungi Aspergillus niger, Mucor mucedo, Fusarium solani, Micrococcus, G-negative and G-positive bacteria	Essential oil	17
Giardia lamblia	Linalool	26
Pseudomonas aernuginosa	Rosmarinic acid	59
9 strains of 4 genera (*Acinetobacter, Bacillus*, *Escherichia, Staphylococcus*)	Ethanol extract	13
11 strains of 6 genera (*Acinetobacter, Bacillus, Brucella*, *Escherichia, Micrococcus* and *Staphylococcus*)	Methanol extract	13
13 strains of 6 genera (*Acinetobacter*, *Bacillus*, *Brucella*, *Escherichia*, *Micrococcus*, *Staphylococcus*)	Hexane extract	13
Bacillus cereus, *B. subtilis*, *B. megaterium*, *Escherichia coli*, *Staphylococcus aureus*, *Listeria monocytogenes*, *Shigella boydii*, *S. dysenteriae*,*Vibrio mimicus*, *V. parahaemolyticus*, and *Salmonella typhi*	Essential oils, methanol extract	60
S. dysenteria	–	48
Antifungal activity		
Sclerotinia sclerotiorum (Lib.), *Rhizopus stolonifer* (*Ehrenb*. exFr.) Vuill, *Mucor* sp. (Fisher)	Linalool and eugenol	22
Alternaria alternate (Fries : Fries) von Keissler *Fulvia fulva* (Cooke) Ciferri *Fusarium solani* var. *coeruleum* Glomerella cingulata(Stonem.) Spauld. etSchren	Essential oil	23
Fusarium oxysporum f. sp. *vasinfectum* and *Rhizopus nigricans*,	Cineol, linalool, methylchavicol and eugeno	61
Three isolates of *Candida albicans*	Methanol and hexane extract	13
Candida albicans,Penicillium notatum, *Microsporeum gyseum*	Essential oil	41
Yeast and mold.	Essential oil	17
Aureobasidium pullulans, Debaryomyces hansenii, Penicillium simplicissimum, P. citrinum, P. expansum, P. aurantiogriseum	Essential oil	43
Antiseptic activity		
Proteus vulgaris, Bacillus substilis, Salmonella paratyph	Essential oil	41
Antiviral activity		
Herpes viruses, Adenoviruses, hepatitis B virus and coxsackie virus B1 and enterovirus 71	Apigenin, linalool and	
Insecticidal activity		
Spodoptera littoralis (Egyptian cottonworm)	Extract	62
Tribolium castaneum, Sitophilus oryzae, Stagobiom paniceum, Bruchus chinensis (stored grain insects)	Ocimene, cineole, linalool, methyl cinnamate, methyl chavicol	33
Ceratitis capitata, Bactrocera dorsalis, B.cucurbitae	Basil oil and *trans*-anethole, estragole, linalool	38
Repellent activity		
Culex pipiens	Essential oils	62
Mosquito	Essential oils	63
Trypanocidal activity		
Epimastigotes and trypomastigotes forms	Essential oil eugenoland linalool	64

Cardiac stimulant: The study evaluated the cardiac effects of extracts derived from the aerial parts of *Ocimum basilicum*. Results showed the alcoholic extracts exhibited a cardiotonic effect and the aqueous extract produced a B-adrenergic effect[4].

Effects on CNS: The essential oil of *Ocimum basilicum* was screened some CNS activities (*viz*., sedative, hypnotic, anticonvulsant, local anesthetic). When tested in mice, *Ocimum basilicum* essential oil had no effect on motor activity up to a dose of 1.2 mL kg^{-1} at 90 min postadministration. However, higher doses produced motor impairment at all time intervals. Pentobarbitone sleeping time tested in mice was significantly increased by all doses of the essential oil higher than 0.2 mL kg^{-1}. Intraperitoneal administration of *Ocimum basilicum* essential oil significantly increased in a dose-dependent manner the latency of convulsion and per cent of animals exhibiting clonic seizures. Likewise, it reduced lethality in response to different convulsive stimulus used in this study. The ED_{50} values of the essential oil of *Ocimum basilicum* were 0.61, 0.43 and 1.27 mL kg^{-1}, against convulsions induced by pentylenetetrazole, picrotoxin and strychnine, respectively. A study of the local anesthetic activity of the *Ocimum basilicum* essential oil by using a nerve block model employing in frog revealed that it had no local anesthetic effect. The LD_{50} of the essential oil was 3.64 mL kg^{-1} [correlation coefficient r = 0.961 and linear regression y = 147 ln(x) - 141.7]. The observed anticonvulsant and hypnotic activities in this study could be related to the presence of a variety of terpenes in the essential oil[34].

Hypoglycaemic effect: According to Zeggwagh *et al*.[35], the aqueous extract of *Ocimum basilicum* whole plant showed hypoglycaemic effect in normal and streptozotocin diabetic rats. After a single oral administration, *Ocimum basilicum* significantly reduced blood glucose levels in normal ($p < 0.01$) and diabetic rats ($p < 0.001$). After 15 days of repeated oral administration, *Ocimum basilicum* produced a potent reduction on blood glucose levels ($p < 0.001$) in diabetic rats and a less reduction in normal rats ($p < 0.05$). In addition, plasma insulin levels and body weight remained unchanged over 15 days of oral administration in normal and diabetic rats.

Hypolipidemic effects: *O. basilicum* contain polar products are possibly able to lower plasma lipid concentrations and might be beneficial in preventing hyperlipidemia and related cardiovascular diseases. Hicham Harnafia *et al*.[36], has reported the hypocholesterolemic and hypotriglyceridemic activities of aqueous extract of basil in hyperlipemic rats, which were induced by high fat diet. Sweet basil showed significant decrease in plasma and liver total cholesterol ($p < 0.02$ and $p < 0.05$, respectively) and triglyceride ($p < 0.02$ and $p < 0.01$, respectively). Similar result was also observed on plasma LDL-cholesterol concentrations ($p < 0.02$). In a similar study, hypolipidemic effects of the aqueous extract of *Ocimum basilicum* whole plant significantly reduced the cholesterol and triglycerides levels after repeated oral administration in diabetic rats ($p < 0.001$) and ($p < 0.05$), respectively.

Inhibitory effect on platelet aggregation: In one study *O. basilicum* showed an inhibitory effect on platelet aggregation induced by ADP and thrombin revealing its potential as an antithrombotic profile *in vivo*[37].

Insecticidal activity: Basil oil and its three major active constituents (*trans*-anethole, estragole and linalool) were tested on three tephritid fruit fly species, *Ceratitis capitata* (Wiedemann), *Bactrocera dorsalis* (Hendel) and *B. cucurbitae* (Coquillett) for insecticidal activity. All test chemicals acted fast and showed a steep dose-response relationship. The lethal times for 90 % mortality/knockdown (LT_{90}) of the three fly species to 10 % of the test chemicals were between 8 and 38 min. The toxic action of basil oil in *C. capitata* occurred significantly faster than in *B. cucurbitae* but slightly faster than in *B. dorsalis*. Estragole acted faster in *B. dorsalis* than in *C. capitata* and *B. cucurbitae*. Linalool action was faster in *B. dorsalis* and *C. capitata* than in *B. cucurbitae trans*-Anethole action was similar to all three species. Methyl eugenol acted faster in *C. capitata* and *B. cucurbitae* than in *B. dorsalis*. When linalool was mixed with cuelure (attractant to *B. cucurbitae* male), its potency to the three fly species decreased as the concentration of cuelure increased. This was due to linalool hydrolysis catalyzed by acetic acid from cuelure degradation, which was confirmed by chemical analysis. When methyl eugenol (*B. dorsalis* male attractant) was mixed with basil oil, *trans*-anethole, estragole or linalool, it did not affect the toxicity of basil oil and linalool to *B. dorsalis*, but it did significantly decrease the toxicity of *trans*-anethole and estragole. Structural similarity between methyl eugenol and *trans*-anethole and estragole suggests that methyl eugenol might act at a site similar to that of trans-anethole and estragole and serve as an antagonist if an action site exists. Methyl eugenol also may play a physiological role on the toxicity reduction[38].

Wound-healing activity: Wound healing activities of sweet basil was studies on cutaneous excision wounds in rats. Wounds treated with honey in combination with *Ocimum basilicum* alcoholic leaf extract and solcoseryl-jelly showed accelerated wound healing compared to honey alone[39].

Effects and use as a culinary herb: Ocimum species are used in traditional Iranian medicine, as a culinary herb and as a well-known source of flavouring principles. Horticultural characteristics, including quantitative and qualitative traits along with the chemical variation of phenolic acids, of 23 accessions of basil (*O. basilicum*) from Iran were studied. Morphological studies of accessions showed a high level of variability in recorded traits. Quantification of phenolic acids was determined using high-performance liquid chromatography and showed drastic variations between accessions. Chemical studies revealed that rosmarinic acid is the predominant phenolic acid present in both flower and leaf tissues. Unusual basil accessions were identified that can serve as genetic sources of phenolic acids for crop improvement[40].

Toxicity: There is little available literature on the toxicity of *Ocimum* spp. However, *O. basilicum*, the species that appears to be used the most medicinally and the one for which the most analysis has been done, contains several potentially dangerous compounds. Some of these compounds are: safrole, rutin, caffeic acid, tryptophan and quercetin.

P-Coumaric acid and caffeic acid (phenolic acids) can inhibit digestion of plant cell walls in ruminants, because of their antimicrobial activity. When these phenolic acids are metabolized by rumen microbes, benzoic acid, 3-phenyl-propionic acid and cinnamic acid may be formed. When these compounds are detoxified, hippuric acid is formed. 3-Phenyl-propionic acid can decrease metabolic efficiency. Detoxifying the compounds costs the animal nitrogen, which also can decrease productivity.

Quercetin (a flavanoid) may be a cocarcinogen in bracken fern (*Pteridium aquilinum*). It has been suggested that it may interact with Bovine papilloma virus type 4, leading to malignant epithelial papillomas in the upper alimentary tract. Adverse effects from quercetin in *Ocimum* spp., when used to treat animals, is not known.

Safrole, which was used to flavor sodas, was banned as a food additive in the US. It has been shown to cause cancer in rats. Oil of Ocimum also contains *d*-limonene, which has anticarcinogenic properties[41].

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