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Review Article

CHEMICAL COMPOSITION OF ESSENTIAL OIL OF *OCIMUM BASILICUM*L. (BASIL) AND ITS BIOLOGICAL ACTIVITIES–AN OVERVIEW

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ABSTRACT

Essential oils are complex mixtures of biological active substances used for fragrance and traditional medicine since long back. It contains mainly triterpenes and aromatic compounds, the chemical composition of the essential oils vary with seasonal, geographical and climatic conditions. Recently there are more researches focused on their chemical profiles and its medicinal properties. Due to their antimicrobial, antifungal, insecticidal, larvicidal and antioxidant properties, they are used as alternatives for synthetic chemical products to reduce cost and side effects. The genus *Ocimum* comprising of more than 150 species grows widely throughout the world. This review focused mainly on the chemical composition of *Ocimum basilicum* essential oil and its biological activities.

Keywords: *Ocimum basilicum*, Lamiaceae, Linalool, Methyl cinnamate, Methyl chavicol, Eugenol

INTRODUCTION

The importance of essential oils increases in recent years due to their availability and biological properties. The genus *Ocimum* L., comprising of more than 150 species grows widely throughout temperate regions of the world [1-3]. Among the plants known for medicinal value, the members of genus *Ocimum* (family Lamiaceae) are very important for their therapeutic potentials. *Ocimum sanctum* L., *Ocimum gratissimum* L., *Ocimum canum* Sims, *Ocimum basilicum* L., *Ocimum kilimandscharicum* Guerke, *Ocimumamericanum* L., and *Ocimum micranthum* Willd are examples of important species of genus *Ocimum* [4-5]. *Ocimum basilicum* L. commonly called as Sweet Basil which belongs to family Lamiaceae is native plant of Indo-Malayan region. It is called the "king of herbs" which contains plenty of phytochemicals with significant nutritional as well as antioxidant capabilities and health benefits [6]. In India *Ocimum basilicum* are cultivated from ancient times for their strong religious and spiritual associations, and people believe that it spreads positive energy to the houses. In Vedic times the sweet basil was used to control appetite by Saints and is used as an ingredient of dental and oral health care products and also in fragrances [7]. It grows in several regions all over the world. Basil is an erect branching herb that grows 0.3 to 1.3m high, with light green silky leaves. Its leaves are simple, opposite, 3 to 11 cm long, 1 to 6 cm wide, ovate, acute and usually toothed containing numerous oil glands which store essential oils. The flowers of sweet basil are white to purple in color and arranged in a terminal spike. It has long been utilized traditionally for curing a lot of troubles, such as anxiousness, stings, sickness, strong aching, gripe, pyrexia, platonic transmissions, infective diseases, headaches, coughs, acne, diarrhea, constipation, warts, worms and kidney malfunction [8-10]. Sweet basil is cultivated for the production of essential oils, dry leaves as a culinary herb, condiment/spice or as an ornamental plant. It is used as an ingredient in various dishes and food preparations, especially in the Mediterranean cuisine [11]. Basil essential oils contain a broad array of chemical compounds depending on variations in chemo types, flower and leaf colors, aroma and particularly the origin of the plant. Moreover, the aromatic and morphological character of plants is greatly influenced by environmental conditions and agronomic techniques [12, 13]. The chemical composition of essential oils of Ocimum species has been well studied. Basil essential oils contained monoterpenes derivatives (camphor, limonene, 1, 8-cineole, linalool, geraniol) and phenyl propanoid derivatives (eugenol, methyleugenol, chavicol, estragole, methyl-cinnamate) [14-15]. Different chemotypes of basil have been recognized based on the predominant essential oil constituents (e. g. linalool, methyl chavicol, methyl cinnamate, methyl eugenol, eugenol) [15, 16]. Basil essential oil has been reported to contain various biological activities with beneficial to humans. This review emphasizes the chemical composition of various samples of basil oils from different geographical regions and its traditional use as well as clinical potentials.

Chemical compostion of basil essential oil

The chemical composition of *O. basilicum* essential oil has been carried out in various parts of the world. Many authors isolated the essential oil from *O. basilicum* and reported that numerous volatile constituents in *O. basilicum.* The main constituents are Linalool, 1,8, cineol, eugenol, methyl cinnamate, camphor, methyl eugenol, methyl chavicol, β-elemene, β-ocimene, camphene, carvacrol, α-bergamotene, α-cadinol and geranial. Some of the important constituents were given in the table 1.

The composition of 18 Turkish basil essential oils was analyzed by GC and GC/MS [73]. Variation of essential oils in the landraces was subjected to cluster analysis, and seven different chemotypes were identified. They were (1) linalool, (2) methyl cinnamate, (3) methyl cinnamate/linalool, (4) methyl eugenol, (5) citral, (6) methyl chavicol (estragol), and (7) methyl chavicol/citral. Methyl chavicol with high citral contents (methyl chavicol/citral) can be considered as a ''new chemo type'' in the Turkish basils. Methyl eugenol and methyl chavicol have a structural resemblance to carcinogenic phenylpropanoids, Chemo types having high linalool, methyl cinnamate or citral contents and a mixture of these is suitable to cultivate for use in industry. The content of methyl chavicol was 74.7%, followed by linalool 14.3% were detected as major compounds in India [74]. The chemical variation of phenolic acids of 23 accessions of *O. basilicum* L. were studied in Iran [75]. Morphological studies of accessions showed a high level of variability in recorded traits and showed drastic variations between accessions.

Pharmacological studies of essential oil of *o. basilicum* l.

Antibacterial activity

Even though plenty of antimicrobial agents are commercially available due to their discriminate use in the day to day life, numerous new plant based antibiotics are emerging. In this series *Ocimum* species have excellent antimicrobial properties. To overcome the increasing resistance of disease causing bacterial strains, more effective antimicrobial agents with novel mode of action must be developed with cost effective manner. Essential oils derived from several Ocimum species have been reported to be active against several Gram-positive and Gram-negative bacteria due to their terpenic constituents. In recent years essential oils and plant crude extracts are of certain plants have been shown to have antimicrobial effects. Antibacterial activity of essential oil of *O. basilicum* with gram positive and gram negative bacteria investigated by various authors in different countries were given in table (2).

Table 1: Investigation of chemical composition of *O. basilicum e*ssential oil in various parts of the world

S. No.	Major constituents(%)	Place	Reference
1.	Methyl chavicol (70.00), Linalool (25.00), Eugenol (5.00).	Um Ruaba	[17]
2.	Linalool (4-47.39), Methyl cinnamate (35.16-84.53), methyl chavicol (8.92), unidentified (8-11).	India	[18]
3.	Linalool (45.70), Eugenol (13.40), Methyl eugenol (9.57), Fenchyl alcohol (3.64).	Turkey	[8]
4.	Linalool (7-59), methyl chavicol (5-12), eugenol (2-12).	Indiana	[9]
5.	Linalool, methyl chavicol, eugenol, gerniol	U. K	[16]
6.	Limonene (10.40), Linalool (50.80).	Cameroon	[19]
7.	Linalool (69.0), eubenol (10.0), t-α-bergamotene (3.1), thymol (2.2).	Republic of Guinea	[20]
8.	E-Methyl cinnamate (34.49), Linalool (28.4), camphor (13.84), Z-Methyl cinnamate (6.90), geraniol (3.84).	India	[2]
9.	β-Caryophyllene (2.40), α-Pinene (1.00), β-Pinene (0.80),	Pakistan	[21]
10.	Linalool (36.0) camphor (1.10), β-elemene (1.1), eugenol (18.20), germacrene D (5.33).	Alexandria	[22]
11.	Linalool (10.8), methyl chavicol (60.3), Z-Methyl cinnamate (6.3), 1, 8, cineole (3.1), β-pinene (2.1), α-pinene (2.7).	Nigeria	[23]
12.	Linalool (39.8), estragole (20.5), Methyl cinnamate (12.9), 1, 8, cineole (2.9), eugenol (9.1), α-terpineol (1.1).	Korea	[24]
13.	Camphor (42.1), limonene (7.6), β-selinene (4.3), myrtrnol (3.3), β–caryophyllene (3.3).	Assam, India	[25]
14.	1, 8-cineole (2.4), linalool (20.1), geraniol (27.6), α-trans-bergamotene (5.2), epi-α-cadinol (5.9), methyl chavicol (40-52.4), nerol (18.5), trans caryophyllene (1.2-1.6).	Iran	[26]
15.	Linalool (43-69.33), camphor (0.74-1.24), terpin-4-ol (1.01-5.35), eugenol (9.49-41.20), β-elemene (0.88-1.38), α-trans bergamotene (2.59-7.75), α-cadinol (3.03-13.06), β-Z-ocimene (0.73-2.78).	Brazil	[27]
16.	Trans-β-ocimene (1.61), linalool (44.18), 1,8 cineole (13.65) eugenol (8.59) Methyl cinnamate (4.26), α-cubebene (4.97), Iso caryophyllene (3.10) Germacrene B (1.62).	Egypit	[28]
17.	Linalool (28.6), estragole (21.7), Z-Methyl cinnamate (1.6), 1, 8, cineole (4.0), eugenol (5.9), α-terpineol (1.0). E-Methyl cinnamate (14.3), α-cadinol (7.1), α-amorphene (1.0), bergamotene (2.2).	Croatia	[29]
18.	Linalool(69.2), estragole(2.4), δ–guainene(2.1), α–selinene(1.67), δ-cadinene(1.13), β-selinene(1.04), α–bergamotene(1.02), β-elemene(0.8), eugenol (1.4), geraniol (1.90), α–terpineol (0.7).	Serbia	[30]
19.	Estragole (52.6-58.2), Limonene (13.64-19.41), p-cymene (0.38-2.32), Dill apiole (50.07).	France	[31]
20.	Linalool (6.0), nerol (3.3), neral (36.1), geranial (44.5), trans-iso citral (1.3), β-caryophyllene (1.4), α-farnescene (1.4), cis-α-bisabolene (3.8).	Papua new Guinea	[32]
21.	Linalool (56.7-60.6), Epi-α-cadinol (8.6-11.4), α–bergamotene (7.4-9.2) γ-cadinene (3.2-5.4).	Pakistan	[12]
22.	Linalool (19.93-40.41), 1,8 cineole (19.1-10.52), methyl chavicol(28.92-46.48), eugenol(4.08), γ-elemene (4.18-3.22) α–trans-bergamotene (2.52-4.57), germacrene D (4.04), t-cadinol (4.17-10.9).	Egiypt	[33]
23.	Estragole (85.5), linalool (1.7).	Togo	[34]
24.	Linalool (29.68), Z-cinnamic acid methyl ester (21.49), E-cinnamic acid methyl ester (1.36), α-cadinol (3.99), β-cubebene (1.97), cyclohexane (4.41).	China	[35]
25.	Linalool (6-24), cis-ocimene (22.17) β-pinene (2.46), α-pinene (1.48), Methyl eugenol (22.17), 1, 8, cineole (22.20), eugenol (9.1), β-bisabolene (1.02), t-β-farnesene (3.27), camphor (2.25), germacrene–D(1.53), myrecene (1.69).	UK	[36]
26.	Linalool (57.08), camphor (0.43-1.88), eucalyptol 2.92-6.29), γ-terpinene (1.30-1.97), eugenol (0.43-1.88), α-bergamotene (2.27-3.70), germacrene D (3.89-4.40), Naphthalene (11-14.6).	Turkey	[37]
27.	Methyl chavicol (80.95), β-ocimene (2.7-0.88), Linalool (1.02), camphor (1.09), β–caryophyllene (1.88), α-humulene (0.56-2.24), α-amorphene (1.05-3.49).	malaysia	[38]
28.	Linalool (46.95), 1, 8-cineole (1.20), β-elemene (7.84), cis-caryophyllene (2.49), farnesene (6.86-11.04), α-guaine (1.44), δ-guaine (5.26), γ-cadinene (3.36-5.88), epi-bicyclo sesquiphellandrene (5.92-18.58).	Romania	[39]
29.	Limonene(1.5),menthone (33.1), Estragol (21.5), menthol (6.1), Menthyl acetate (5.6), Pulegone (3.7)	Iran	[40]
30.	1, 8-Cineole (10.18), Linalool (43.78), *γ*-Cadinene (1.99), *γ*-Terpineol (1.75), α-Epi-cadinol (5.76), Eugenol (13.66).	Thailand	[41]
31.	1, 8-Cineole (1.7) β-Ocimene (2.7), linalool (57.2), eugenol (9.2), *Trans*-α-Bergamotene (2.7), α-cadinol (3.2).	Burkina Faso	[42]
32.	Linalool (55.55), 1, 8 cineole (11.67), β-elemene (2.44), β-farnesene (7.10), Germacrene B (1.95), α-amophene (2.160), δ-cadinene (1.71).	Egiypt	[43]
33.	Linalool (64.35), 1,8 cineole (12.28), eugenol (3.21), germacrene D (2.07)	Thailand	[44]
34.	Linalool (13.1-21.1) *α*-cadinol (6.1-3), germacrene D (6.1-. 2.7) and 1, 8-cineole (2.4-3.5), *γ*-Cadinene (2.5).	Iran	[45]

35.	Linalool (95.0), camphor (32.6 and 31.0).	Kenya	[46]
36.	Methyl chavivol (70.04), linalyl acetate (22.54), camphene (7.32), Camphor (56.07), DL-limonene (13.56).	India	[47]
37.	L-linalool (26.5-56.3), geraniol (12.1-16.5), 1, 8-cineole (2.5-15.1), p-allylanisole (0.2-13.8) and DL-limonene (0.2-10.4).	Oman	[48]
38.	Linalool (12.63), eugenol (19.22), β-elemene (2.68), α-bergamotene (19.23), α-guaiene (2.23), germacrene D (8.55), δ-gurjunene (5.49), δ-cadinene (5.04), ι-cadinol (15.35).	Bucharest	[49]
39.	Linalool (69.92), 1,8-Cineole (6.432), Geraniol (10.85), Geranyl acetate (1.35).	Oman	[50]
40.	Methyl chavicol (62.0), linalool (24.0).	India	[51]
41.	Linalool (17.55), methyl chavicol (43), geranial (13.73), eucalyptol (5.00), methyl cinnamate (5.00), eugenol (2.79), α-bergamotene (3.22).	Malasiya	[52
42.	Methyl cinnamate (59.95), Linalool (16.40), tau-Cadinal (4.37).	Bangladesh	[53]
43.	1,8-cineole (3.7-4.3), linalool (60.9-69.7), geraniol (10.2-11.1), β-elemene (1.2-1.4), methyl eugenol (0.4-3.4),β-selinene (1.9-3.8), α-trans-bergamotene (1.2-2.3), epi-α-cadinol (5.7-7.6).	Poland	[54]
44.	Methyl cinnamate (70.12), Linalool (17.2), camphor	India	[55]
45.	1, 8 cineole (1.5), β-ocimene (3.54), linalool (65.38), eugenol (5.26), δ-guainene (2.27), ι-cadinol (8.18), camphor (2.13), α-bergamotene (1.55).	Romania	[56]
46.	Geraniol (34.89), α-pinene (0.23), eugenol (1.33), linalool (2.21), camphor (0.64).	India	[57]
47.	Linalool (5.8), naphthalene (4.98), estragole (16.5), butylactyl ester (9.72), eicosene (2.17)	Pakistan	[58]
48.	p-Cymène (2.6) Thymol (6.5) Germacrène D (1.1) N-Phéllandrène (15.3) Carvacrol (1.8) N-Bisabolène (0.3) Limonène (30.9) (Z)-N-Ocimène (2.1) R-Cadinène (1.0). (E)-N-Ocimène (0,6%) O-Cadinène (1, 8)	Cameroon	[59]
49.	Copaene (25.5), p-menth-2-en-1-ol (7.70), 3-carene (1.6), δ-himachalene (3.6), eugenyl acetate (4.8), α-cubebene (2.5), bornyl acetate (4.0).	Ethiopia	[60]
50.	1, 8-cineole (6.2), linalool (36.3), camphor (9.7), α-terpineol (3.8), methyl chavicol (9.1) and eugenol (34.9).	Brazil	[61]
51.	linalool (52.42%), methyl eugenol (18.74%) and 1, 8-cineol (5.61%).	India	[62]
52.	α-terpineol (59.78) and β-caryophyllene (10.54).	Burkina Faso	[63]
53.	Linalool (51.86), terpinen-4-ol (2.98), 1, 8, cineole (13.95), eugenol (8.39), trans-*α*-bergamotene (1.39), α-terpineol (1.32), β-ocimene (1.18).	Cameroon	[64]
54.	Linalool(27.82-42.48) Methylchavicol (19.64-22.52), α-Cadinol (6.21-0.96), β-Elemene (4.60-4.08), Carvone (2.33-1.77), α-Bergamotene (1.16-0.94), α-Bulnesene (2.11-1.75), γ-Cadinene (4.09-3.29), Spathulenol (2.19-1.43).	Romania	[65]
55.	Linalool (0.2-58.6), α-terpineol (0.3-1.4),), 1, 8 cineole (0.1-9.3), methyl chavicol (0.1-83.6).	Serbia	[66]
56.	methyl eugenol (39.3%) and methyl chavicol (38.3%), terpinolene (7.7), eugenol (4.5)	N. India	[67]
57.	Linalool (48.4), 1,8-Cineal (12.2), eugenol (6.6), α-Cubebene (5.7),methyl cinnamate (6.3), caryophiline(2.5) Caryophyllene	Egypt	[68]
58.	linalool (69.87%) geraniol (9.75%), p-allylanisole (6.02%), 1,8–cineole (4.90%), trans–α–bergamotene (2.36%) and neryl acetate (1.24%).	Oman	[69]
59.	Methyl chavicol (85.19), 1,8 cineole (3.96), Trans-alpha bergamotene (1.18)	Iran	[70]
60.	Linalool (33.9), eugenol (8.3), α-7-H-Eudesma-3,5-diene (4.24), α-Bulnesene (3.31), α-Amorphene (3.95), β-Cubebene (4.33)	Egypt	[71]
61.	linalool (32.8), linalyl acetate (16.0), 1,8-cineole (6.7), myrcene (5.6), α-terpineol (5.1), geranyl acetate (6.8), alloocimene (2.4), neryl acetate (3.4), elemol (7.41) and β-caryophyllene (5.03).	Algeria	[72]

Table 2: Antibacterial activity of basil essential oil investigated in different countries

S. No.	Name of bacteria	Standard	Zone of inhibition (mm)	MIC	Reference
1	*Bacillus subtilis* ATCC 6333	Streptomycin	41.50±0.31		
	Enterococcus faecalis	25µg/D	38.00±0.24		[76]
	Staphylococcus aureus HI**b**	Penicillin G	34.00±0.31		
	Salmonella typhimurium HI	25µg/D Dimethyl-sulfoxide 25µl/D	33.00±1.06		
	Klebsiella pneumoniae HI		31.50±0.70		
	Escherichia coli HI		30.00±0.35		
2	*p. putida*	Amoxicillin	21.2±1.2		[77]
	p. aeruginosa	21-31 mm	16.1±1.0		
	S. pneumoniae		60±1.3		
	H. influenzae		45±0.6		
	C. albicans		45±0.7		
	A. niger		18.4±1.2		
	B. subtilis (MTCC 441)		15.62		[57]
	M. luteus (MTCC 1541)		31.25		
	S. dysenteriae (clinical isolate		125		
			62.50		
	p. aeruginosa (MTCC 741)		15.62		
			31.25		

	S. flexneri (MTCC 1457)		15.62		
	V. cholera (MTCC 3904				
	E. coli (MTCC 443)				
3.	*Citrobacter fruendii*		0.39	3.12-25µg/ml	[78]
	Enteroheamorrhagic		6.25		
	Escherichia coli (EHEC)		12.50		
	Enterobacter aerogenes		50.00		
	Escherichia coli		50.00		
	Klebsiella pneumoniae		-		
	Providencia alcalifaciens		-		
	Providencia rettgeri		1.56		
	Proteus vulgaris		50.00		
	Pseudomonas aeruginosa				
	Salmonella paratyphimurium		3.13		
	S. typhimurium		1.56		
	Shigella dysenteriae		25.00		
	Staphylococcus aureus		12.50		
4.	*Staphylococcus aureus*		18	9-35µg/ml	[79]
	Bacillus cereus		18		
	Escherichia coli		9		
	Pseudomonas aeruginosa		9		
5.	*Staphylococcus aureus*			MLC 25-50 ppm	[80]
	Escherichia coli				
	Pseudomonas aeruginosa				
	A. niger				
	L. plantarum				
	Y. entacolitica				
	Listeria monocytogenes				
6.	*B. cereus*		11.2-21.1 mm	62.5-500µg/ml	[81]
	B. subtilis				
	B. megaterium				
	S. aureus				
	L. monocytogenes				
	E. coli				
	Shigella boydii				
	S. dysenteriae				
	Vibrio parahaemolyticus				
	V. mimicus				
	S. typhi				
7.	*S. aureus*	Tetracycline 25 mg/ml	0.9-3.0	At high doses	[82]
	S. species				
	Salmonella species				
	Shigella species				
	P. aureginosa				
8.	*S. aureus*	28.2±1.1	22.2±1.0	1330.0	[12]
	B. subtilis	29.3±1.0	21.2±1.2	1370.2	
	P. multocida	31.1±1.2	16.1±1.0	1870.4	
	E. coli	21.4±0.8	11.4±0.6	2560.3	
	A. niger	26.1±0.9	18.4±1.2	3200.0	
	M. mucedo	18.4±0.7	11.1±0.9	4930.4	
	F. solani	23.2±1.1	15.2±0.7	3610.3	
	B. theobrme	20.2±1.2	14.3±1.1	4930.4	
	R. solani	19.3±0.7	12.3±0.7	3610.3	

Table 3: Antioxidant properties of basil essential oil carried out by the authors

S. No.	Antioxidant assay	IC_{50}	References
1.	DPPH	0.96 g/l	[34]
	FRAP	1.378g/l	
2.	DPPH	55.67±3.38	[63]
	ABTS	0.69±0.03m MET/g	
3.	ABTS	50.30±1.5 mm	[77]
4.	ABTS	12.9-35.2 mm	[75]
5.	DPPH	83.54 mg/ml	[72]
6.	DPPH	25µg/ml	[48]
7.	DPPH	92.5-94.6	[76]
8.	Aldehyde/carboxylic acid	Stronger activity against all composition	[29]
9.	DPPH	4.8-6.7µg/ml	[12]

Antioxidant activity

Antioxidants are very important for reducing risk of cancer, basil essential oil has moderate to good antioxidant properties with IC_{50} values and various types of assay carried out by the authors were given in table (3).

Insecticidal activity

The insecticidal activity of ocimen, cineole, linalool, methyl cinnamate and methyl chavicol against stored grain insects (Tribolium castaneum, Sitophilus oryzae, Stagobiom paniceum and Bruchus chinensis) was analyzed [83]. Methyl cinnamate and methyl chavicol were found to be the most effective among these compounds.

Larvicidal activity

Mosquito repellant and larvicidal activities of the essential oil of *Ocimum* species was tested [84] and observed that the strongest larvicidal activity of the essential oil of *O. basilicum* has shown (EC_{50} =81, EC_{90} =113) ppm.

The mosquito repellent activities of essential oils from *H. Spicigera*, *S. hermonthica* and *O. basilicum* (Basil) against *Anopheles gambiae* and *Culex quinquefasciatus* was carried out under laboratory conditions. At 50% concentration, *O. basilicum* and *H. spicigera* oil exhibited higher repellant potential on *Anopheles gambiae* with a protection time of 183 and 120 min, respectively, while *H. Spicigera* and *S. hermonthica* had a protection time of 180 and 175 min, respectively against *Anopheles gambiae.* At 100% concentration, *O. basilicum* oil exhibited the highest protection time against the two species of mosquito tested and at all the concentrations [85].

O. basilicum was equally potent against *Culex quinquefasciatus* with 180 min protection time and an LC ($_{90}$) values of 23.44, 21.17 and 18.56 ppm, respectively. The basil oil was more effective natural larvicidal agents against Cx. *Tritaeniorhynchus,* Ae. *albopictus*and An. *Subpictus* [86].

Anticonvulsant effects

The possible CNS depressant and anticonvulsant effects of *O. basilicum* (access "Maria Bonita") leaf essential oil in different experimental models was analyzed and revealed the depressant CNS activity with the decrease of spontaneous activity, ptosis, ataxia, and sedation. Additionally, all doses of essential oil induced a significant increase of sleeping time ($p<0.05$) and decrease in the latency to sleep ($p<0.01$). Essential oil also increased the latency for development of convulsions in pentylenetetrazol (PTZ) and picrotoxin tests ($p<0.05$). For PTZ, the effect of essential oil was reversed by flumazenil. EO did not interfere with the convulsions induced by strychnine ($p>0.05$) [87].

Fungi toxicity

The Fungi toxicity of essential oils of twelve exotic collections belonging to nine *Ocimum* species in a pure state and four dilutions with dimethyl sulphoxide was evaluated [19]. The pure oil had the maximum fungi toxicity against *A. niger, A. flavus* Link, *F. oxysporum* Schl. ex Fries and *Penicilium* species. Another study showed that the basil essential oil exhibited different degrees of antifungal activity against the tested fungus with MIC in 125-250µg/ml [88].

Cytotoxicity

The cytotoxic and apoptosis induction activity of essential oil from Thai medicinal plants on P388 (murine leukemia) and HeLa (human cervical adenocarcinoma) cell lines was evaluated. Each cell line was treated with the concentration range of oil sample of 0.078-10.0µg/ml for 24h by MTT assay. The IC_{50} µg/ml on P388 and HeLa cell lines were Sweet Basil oil in 303.0µg/ml and 380.0µg/ml respectively. DNA fragmentation was detected by agarose gel electrophoresis and ethidium bromide staining method. Low molecular weight DNA fragmentation was observed at low concentration of 25 µg/ml of Sweet basil [89].

The methyl cinnamate and linalool rich basil essential oil were tested for *in vitro* cytotoxicity against the human cervical cancer cell line (HeLa), human laryngeal epithelial carcinoma cell line (HEp-2) and NIH 3T3 mouse embryonic fibroblasts by MTT assay and the results showed that the basil oil has potent cytotoxic nature and IC_{50} values were 90.5, 96.3 µg/ml, respectively in India. *O. basilicum* oil was less toxic to normal fibroblast (NIH-3T3) cell line with IC_{50} value of 120 µg/ml. [54]. Further the cytotoxicity of Lamiaceae essential oils against MCF-7, LNCaP and normal fibroblast NIH-3T3 cell line was analyzed in Pakistan [12]. The IC_{50} values were found to be 260.3-270.7 µg/ml,170.1-172.1 µg/ml and 149.9-395.3 µg/ml respectively

Anti inflammatory activity

The anti inflammatory effect of *Ocimum basilicum* L. and *Ocimum gratissimum* L xylene-induced ear edema as a model of inflammation was studied [90]. At 50 µg/ear OBV, OGV, exhibited significant ($P<0.05$) topical anti-inflammatory effect with edema inhibitions of 50.0, 63.3, 62.7 and 80 % respectively. The effects were comparable ($P<0.05$) with that of 100 µg/ear hydrocortisone (% edema inhibition of 54.8).

CONCLUSION

Plant and plant products have been used for various purposes since ancient times, especially basil and tulsi plants have an important place in every ones house in India. This comprehensive review revealed that the essential oil from various geographical origins exist a variety of chemical constituents, and the researchers found wide and varied applications in the traditional health care system as well as in modern medicine such as antibacterial, antifungal, anticancer and commercial activities. The review of past studies also stands as a scientific support for the usage of this plant for treating skin disease in traditional medicine. This review may useful for researchers and scientists for further studies on *Ocimum basilicum* essential oil.

CONFLICT OF INTERESTS

Declared none

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