INTERNATIONAL RESEARCH JOURNAL OF PHARMACY

www.irjponline.com ISSN 2230 – 8407

Review Article

SECONDARY METABOLITES OF *OCIMUM GRATISSIMUM* AND THEIR BIOLOGICAL ACTIVITIES

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Article Received on: 15/06/13 Revised on: 21/07/13 Approved for publication: 11/08/13

DOI: 10.7897/2230-8407.04803

IRJP is an official publication of Moksha Publishing House. Website: www.mokshaph.com

ABSTRACT

Ocimum gratissimum synthesizes and accumulates a variety of secondary metabolites. Some of the biologically active secondary metabolites such as eugenol, thymol, methyl cinnamate and geraniol are responsible for the antimicrobial activity of the well-known plant of this species and substantiate the claim in traditional system of medicine. The present review summarizes the information available on the secondary metabolites isolated from *Ocimum gratissimum*.

Keywords: Biological activity, chemical composition, *Ocimum gratissimum* and secondary metabolites.

INTRODUCTION

Ocimum gratissimum L. is a tall and branched perennial shrub, 1-2.5 m high. *Ocimum gratissimum* L. is found almost throughout India and Andeman and Nicobar and Luccadive Island. *Ocimum*, a member of the family Labiateae, is a versatile genus with about 160 species distributed in the tropical and warm temperate regions of the world. It has innumerable species, which has vast and varied combination of both terpene and non-terpene phenolic constituents in their essential oil-camphor, citral, geraniol, linalool, eugenol, methyl chavicol, linalyl acetate. It is reported to be cultivated in Congo, Benin, Rwanda, Cuba, Aruba, Nigeria, Bangladesh, Sudan, Hungary, Brazil, Tanzania, Portugal, Albania, Togo, Seychelles, USSR, Ceylon and Ethiopia. In India, it is mainly grown in Andhra Pradesh, Jammu and Kashmir, Bangalore and Delhi.[1-24] *Ocimum gratissimum* is an important aromatic plant. In this article, the secondary metabolites isolated from the plant and their biological activities have been reviewed.

Chemical Constituents

The search for the concerned active compound has led to isolation of the several sesquiterpenoids, mucilage, alkaloids, tannins, phylates, flavonoids, glycosides, oligosaccharides, saponin, steroids, lipids and monoterpenoids from different plant parts of *Ocimum gratissimum*. The phytohemicals[25-28] isolated from different parts of plants are listed in Table 1, which shows the percentage of the phytochemicals present in different plant parts in different countries.

Monoterpenoids

The essential oil constituents[8,17,19,21,22,24,29-42] (monoterpenoids) of *Ocimum gratissimum* reported from various countries are listed in Table 2. The GC-MS analysis of essential oil of *Ocimum gratissimum* characterized a large number of monoterpenoids. The yield of the oil is generally ranging between 0.2–2.2 %. Bhattacharya *et al.*[8] reported 0.45 % essential oil content (v/w) in *Ocimum gratissimum* grown in Andhra Pradesh, India in 1996. Eugenol (87.68 %) and β-selinene (2.82) were the main constituents identified. The Bangladesh[24] oil contained thymol (58.2 %), para-cymene (7.7 %) and γ-terpenene (12.3 %). Eugenol found in this analysis was 0.1 %. In 2005, Huguette *et al*[33] analysed Gabon oil content in dry leaves of two varieties V_1 and V_2 between 1.0-2.1 %. The major constituents of variety 'V_1' were eugenol (75.4 %), germacrene-D (6.2 %) and β-caryophyllene (3.2 %). The major constituents of variety 'V_2' were thymol (31.5 %), 1, 8- cineole (33.3 %) and β-caryophyllene (3.6 %).

Biological Activity

Biological activity is reported for the compounds isolated from *Ocimum gratissimum* are Brine shrimp, antimicrobial, relaxant, anti-nociceptive, anti-inflammatory, hypoglycemic, hepatoprotective, analgesic, wound healing, insect growth retardant and radical scavenging activity etc. The various biological activities[26,33,43-58] reported from different extracts and essential oils of *Ocimum gratissimum* are summarized in Table 3.

Brine shrimp Lethality Test

Ocimum gratissimum is used in the management of the baby's cord after delivery among the Igbos of Nigeria. It is also used in the preparation of herbal teas given to women after delivery. Ijeh *et al.*[26] designed a study to access the level of bioactive materials present in *Ocimum gratissimum* with a view of providing preliminary information on their effective doses, extract of this plant material showed very high bioactivity at low doses. Aqueous and ethanolic extracts of *Ocimum gratissimum* had ED_{50} values of 23.98 µg / ml and 26.30 µg / ml, respectively. Brine shrimp eggs were hatched in seawater. Ten shrimps were counted into McCatnney bottles and incubated in extract for 24 hours. The number of shrimps surviving after 24 hours were counted. The data was analyzed using the Finney probit table to calculate percentage probit kill from which the ED_{50} was determined.

Antimicrobial Activity

Essential oil of *Ocimum gratissimum* grown in Rwanda[43] was screened for antimicrobial activities. *Escherichia coli*, *Staphylococcus aureus* and *Trichophytus mentgraphytes* were used as test organisms. Different techniques were applied in the screening such as the biogram and agar overlay techniques and dilution techniques yielding maximum inhibitory dilution (MID) values 1:1600, 1:3200 and 1:16400 respectively. Also some growth curves were determined.

Antibacterial and antifungal activities of essential oil of *Ocimum gratissimum* grown in Congo[44] has been reported considering results of disc diffusion method, appeared to be particularly active antibiotics against *S. aureus*, *S. faecolis*, *E. coli*, *Salmonella species*, *K. pneumonical*, *P. vulgaris*, *C. albicans*, *A. fumigatus*, *T. mentagraphytes*, *S. marcescens* and *P. areuginosa*. MIC results showed strong activity. Larger activity of oil of *Ocimum gratissimum* from Congo may be attributed to thymol, its main constituent. These results are important because of the possible medicinal uses of *Ocimum gratissimum* oils in the place of some antibiotics. Antifungal antibiotics activities by the agar dilution method have been reported minimum inhibitory concentration of ethyl cinnamate chemotype of *Ocimum gratissimum* essential oil in 2000 by Dubey *et al.*[45] Antimicrobial activity of Nigerian[46] *Ocimum gratissimum* is active against both gram positive and gram-negative organism as exemplified by *E. coli* and *S. aureus*. Dixit *et al.*[49] studied the evaluation of essential oil of *Ocimum gratissimum* against storage fungi. The fungi toxicity of the oil proved the most stable and showed long self-life. The oil exhibited broad fungi toxic spectrum inhibiting 50 out of 52 storage fungi tested. Thus, the oil may constitute an ideal fumigant fungicide for protection of foodstuffs during storage.

Relaxant Effect

Madeira *et al*.[52] studied the relaxant effects of the essential oil of *Ocimum gratissimum* on guinea pig ileum. EOOG (0.1-1000 µg / ml) reversibly and concentration –dependently relaxed the basal tone of the ileum and reversed the tonic contractions induced by 60 mm KCl and 10 µm acetyl choline with IC_{50} values of 23.8 ± 5.2, 18.6 ± 4.0 and 70.0 ± 4.6 µg / ml.

Anti-Nociceptive and Anti-Inflammatory Activity

Ocimum gratissimum is known to have various medicinal and therapeutic properties and its anti-noceptive and anti-inflammatory efficacies. Pain was assessed by tail immersion and acetic acid-induced writhing tests in albino rats and mice. Inflammation was assessed by carrgeenan-induced paw oedema method[53].

Hypoglycaemic Activity

In West Africa and Nigeria, *Ocimum gratissimum* is used for treatment of bacterial infections, diarrhea and as a spice. It has been recently claimed to be useful in the treatment of diabetes (personal; information from Dr. Alzija, traditional practitioner in the Department of Pharmacology, University of Jos, Nigeria). However, no scientific data are available in support of this claim. The hypoglycaemic effect of the methanolic extract of *Ocimum gratissimum* leaves was evaluated in normal and alloxan-induced diabetic rats by Aguiyi *et al*[54]. Intra peritoneal injection of the extract (400 mg / kg) significantly reduced plasma levels both in normal and diabetic rats by 56 and 68 %.

Hepatoprotective Activity

Hepatoprotective effect of 'Chhit Chan Than', pharmacological and pathological studies have been carried out with aqueous extracts of the *Ocimum gratissimum. Ocimum gratissimum* is used in Taiwan herbal remedy named 'Chhit Chan Than', believed to possess anti-inflammatory and detoxication activities. It has also been used in treatment of hepatitis[55].

Analgesic Activity

The pharmacological activities were screened of aqueous extract of *Ocimum gratissimum* in isolated rabbit jejunum (IRJ); rat stomach strip (RSS); and also its analgesic properties in mice. The extract caused a dose dependent inhibition of the rabbit jejunum spontaneous pendular movement. The blocking effect on acetylcholine-induced contraction was non-competitive in the rat stomach strip since maximum contractions were suppressed and no parallel shift was observed in the curve. The result of the analgesic study showed that the extract evoked a prolongation of reaction time of 85 % ($p < 0.05$) over 20 minutes observation time with no overt signs of toxicity. These results suggest the presence of analgesic and spasmolytic activities[56].

Wound Healing Property

Chah *et al*.[57] conducted a study to evaluate methanolic extracts of *Ocimum gratissimum* for its wound healing properties. Wound healing property of *Ocimum gratissimum* was determined using the excision wound model. More than 90 % wound healing was recorded in the extract and cicatrin powder treated groups by 14 days post surgery, where as 72 % healing was observed in the distilled water treated group. By day 14 post surgery the wound areas in the groups treated with *Ocimum gratissimum* and cicatrin powder were 3.75 and 3.63 mm^2, respectively. Throughout the experiment, the percentage healing in the distilled water-treated group was significantly lower ($p < 0.001$) than those of extract.

Insect Growth Retardant Activity

The essential oil of *Ocimum gratissimum* has been tested for growth retardant activity against fruit-fly (*Drosophila melanogaster* Mg) and adults of red flour beetle (*Tribolium castaneum* Herbst) in three concentrations viz., 5, 1 and 0.05 % by incorporation in the diet of the insects. At all the concentrations, the oil caused considerable retardation in the larval activity of fruit flies. At higher concentration, pupal formation was suppressed and adult emergence was inhibited. In case of adults of red flour beetle, the percentage survival and body weight was affected by *Ocimum gratissimum* followed by *E. eriostachya* [58].

Radical Scavenging Activity

The radical scavenging activity of *Ocimum gratissimum* was evaluated comparatively to those of a commercial antioxidant BHT (butylated hydroxy toluene) as well as authentic samples. The experiment results are concordant with the chemical compositions, more especially with the phenolic compounds contents. The oil from *Ocimum minimum* was less active than that from *Ocimum gratissimum* which contained more than 30 % of thymol, showed an intermediary activity and it was about 30 times less efficient than BHT; nevertheless, the SC_{50} obtained for this oil was lower than expected according to the thymol content which seems indicative of a synergistic effect induced by minor components of the natural oil already observed with *Lippia multiflora* oil. Finally the oil obtained with *Ocimum gratissimum* was more efficient than BHT, which is consistent with its eugenol content[33].

Cytotoxic Activity

The essential oil of *Ocimum gratissimum* from Togo, *in vitro* cytotoxicity on the human epidermic cell line HaCat showed that the toxicity (IC_{50}:2400 $\mu g.ml^{-1}$). HaCat, an immortalized human keratinocyte line was a generous gift from Nathalie

Gault. Cells were routinely grown in Costar plastic flasks in monolayer cultures in DMEM medium supplemented with 10 % (V / V) FCS, and 5 M of HEPES and 80 mg / l of gentamicine. They were grown in humidified atmosphere of 5 % CO_2 in air. The medium was routinely renewed 2, 4 and 6 days after passage and when confluence was reached, cells were trypsinized and split for subcultures (seeding density 3500 cells / cm^2 in a 75 cm^2 flask) or used for toxicity assays[59].

Table 1: Compounds Isolated from *Ocimum gratissimum*

S. No.	Compound	Plant part	Country	Concentration	Ref.
1.	Mucilage				
	Capsular Mucilage	Seed	India	14.0 %	25
	Pentoses	-	-	23.8 %	,,
	Hexoses	-	-	48.8 %	,,
	Uronic acid	-	-	9.7 %	,,
	Lipids free	-	-	11.6 %	,,
	Lipids bound	-	-	4.4 %	,,
	D-glucose	-	-	1.2 %	,,
	D-galactose	-	-	1.6 %	,,
	D-mannose	-	-	1.0 %	,,
	D-xylose	-	-	3.8 %	,,
	L-arabinose	-	-	2.7 %	,,
	D-galacturonic acid	-	-	1.0 %	,,
	D-mannuronic acid	-	-	4.2 %	,,
2.	Phytochemicals				
	Alkaloids	L.	Nigeria	1.23 ± 0.01 %	26
	Tannins	L.	,,	42.02 ± 28 mg / 100 g	,,
	Phytates	L.	,,	0.0575 ± 0.00 mg / 100 g	,,
	Flavonoids	L.	,,	0.34 ± 0.028 %	,,
	Cyanogenic glycosides	L.	,,	64.13 ± 4.77 mg / kg	,,
	Oligosaccharides	L.	,,	12.14 ± 1.55 %	,,
	Saponins	L.	,,	Present in traces	,,
	Steroids	L.	,,	,,	,,
3.	Alkaloid, glycosides and Tannins				
	Crude Alkaloid	WP	Nigeria	1.56 %	27
	Crude glycosides	,,	,,	1.52 %	,,
	Proanthoyandins	,,	,,	1.3	,,
	Prodelphinidin	,,	,,	72	,,
	Procyanidin	,,	,,	-	,,
4.	Lipids				
	Arachidonic acid	L.	Nigeria	-	28
	Hydroquinone	,,	,,	-	,,
	Lecithin	,,	,,	-	,,

Table 2: Compounds Isolated from Essential oil of *Ocimum gratissimum*

S. No.	Compound	Plant part	Country	Percentage (%)	Yield	Type of distillation	Compound Type	Ref
1.	Aromadendrene	WP	USSR	0.5	-	,,	Sesquiterpene	42
2.	Alloaromadendrene	WP	USSR	0.2	-	,,	,,	,,
3.	Tert-Armophol	WP	India	1.254	0.4-0.8	Hydro	,,	37
4.	Z-α-Bergamotene	DL	Gabon	0.3- 0	1.0-2.1	,,	Sesquiterpene	33
5.	E-α-Bergamotene	AP	Togo	0.2-0.7	-	Steam	,,	22
		DAP	Portugal	0.5	1.59	Hydro		17
6.	E-β-Bergamotene	DL	Cuba	1.03	1.6	,,	,,	21
		DF	’’	2.29	0.4	,,	,,	,,
7.	Z-α-trans-Bergamotene	DL	West Lafayette	0.43 ±0.18	1.2-1.47	,,	,,	30
		DF	’’	0.85 ±0.13	1.34-1.67	,,	,,	,,
		DS	’’	1.06	0.14	,,	,,	,,
8.	Bicyclogermacrene	AP	Togo	0.4-1.2	-	Steam	,,	22
		DL	Gabon	0-2.9	1.0-2.1	Hydro	,,	33
9.	β -Bisabolene	FH	India	0.16	0.4	,,	Sesquiterpene	29
		WH	”	0.10	0.45	,,	,,	8
		FL	Rwanda	t	0.40	,,	,,	19
		FF	”	0.1	0.65	,,	,,	,,
		DAP	Portugal	4.0	1.59	,,	,,	17
		DL	Gabon	0-1.0	1.0-2.1	,,	,,	33
10.	Bisabolol	FH	India	0.26	0.40	,,	,,	29
11.	Borneol	DL	Cuba	0.55	1.6	,,	Monoterpene	21
		DF	”	0.55	0.40	,,	,,	,,
		FLandFF	Bangladesh	0.2	0.75	,,	,,	24
		AP	Togo	0.2-2.0	-	Steam	,,	22
		DL	Guinea	0.10-0.35	1.0	,,	,,	32
12.	β- Bourbonene	DL	Cuba	0.21	1.6	Hydro	Sesquiterpene	21
		DF	”	0.59	0.4	,,	,,	,,
		DL	West Lafayette	0.41 ±0.08	1.2-1.47	,,	,,	30
		DF	”	0.78 ±0.08	1.34-1.67	,,	,,	,,

S. No.	Compound	Plant part	Country	Percentage (%)	Yield	Type of distillation	Compound Type	Ref
		DS	”	0.89	0.14	,,	,,	,,
		DL	Gabon	1.2-0	1.0-2.1	,,	,,	33
		WP	India	0.608	0.4-0.8	,,	,,	37
		WP	USSR	3.6	-		,,	42
13.	γ-Cadinene	DL	Cuba	0.61	1.6	,,	Sesquiterpene	21
		DF	’’	1.07	0.4	,,	,,	,,
		FL	Rwanda	0.2	0.40	,,	,,	19
		FF	”	0.1	0.65	,,	,,	,,
		DL	Gabon	0.1-0	1.0-2.1	,,	,,	33
		WP	India	1.759	0.4-0.8	,,	,,	37
		W.P.	USSR	0.5	-	,,	,,	42
14.	δ-Cadinene	FL	Rwanda	0.3	0.40	,,	,,	19
		FF	”	0.4	0.65	,,	,,	,,
		DAP	Portugal	-	1.59	,,	,,	17
		DL	Gabon	0-0.1	1.0-2.1	,,	,,	33
		W.P.	USSR	3.0	-	,,	,,	42
15.	Camphene	FH	India	0.19	0.40	,,	Monoterpene	29
		DL	Cuba	0.63	1.6	,,	,,	21
		DF	’’	0.07	0.4	,,	,,	,,
		FL	Rwanda	0.1	0.40	,,	,,	19
		FF	”	0.1	0.65	,,	,,	,,
		FLandFF	Bangladesh	0.1	0.75	,,	,,	24
		DAP	Portugal	0.2	1.59	,,	,,	17
		AP	Togo	0.6-1.0	-	Steam	,,	22
		FL	Nigeria	4.0	-	,,	,,	31
		DL	Guinea	0.08-0.12	1.0	,,	,,	32
		DL	Gabon	0 – 0.1	1.0-2.1	Hydro	,,	33
		LSF	Taiwan	0.01-0.01- -	-	,,	,,	36
16.	Calamenene	WP	India	0.376	0.4-0.8	,,	Sesquiterpene	37
		W.P.	USSR	0.2	-	,,	,,	42
17.	Camphor	DAP	Portugal	0.1	1.59	,,	Monoterpene	17
		FL	Nigeria	0.6	-	Steam	,,	31
		DL	Gabon	0.2- 0	1.0-2.1	Hydro	,,	33
		FL	India	0.45	0.6	Steam	,,	34
18.	Carveol	DWP	India	0.43	1.8-2.0	Hydro	,,	38
		SSS	India	0.40	-	,,	,,	39
		FH	India	0.43	-	,,	,,	40
19.	Carvone	DWP	India	1.19	1.8-2.0	,,	,,	38
		SSS	India	0.25	-	,,	,,	39
20.	Δ-3-Carene	FL	Rwanda	0.2	0.40	,,	,,	19
		FF	”	0.2	0.65	,,	,,	,,
		FLandFF	Bangladesh	0.1	0.75	,,	,,	24
		DAP	Portugal	0.2	1.59	,,	,,	17
		AP	Togo	0.2-2.5	-	Steam	,,	22
		FL	Nigeria	4.1	-	,,	,,	31
21.	Caryophyllene	FL	Nigeria	2.1	-	Steam	Sesquiterpene	,,
		LSF	Taiwan	3.19-4.18-4.40	-	Hydro	,,	36
		DWP	India	0.16	1.8-2.0	,,	,,	38
22.	α-Caryophyllene	AP	Togo	0.2-0.5		Steam	,,	22
		DL	Guinea	1.50-1.73	1.0	,,	,,	32
23.	β-Caryophyllene	FH	India	1.15	0.4	Hydro	,,	29
		WH	”	1.84	0.45	,,	,,	8
		DL	Cuba	7.23	1.6	,,	,,	21
		DF	”	11.50	0.4	,,	,,	,,
		DL	West Lafayette	1.20 +0.26	1.2-1.47	,,	,,	30
		DF	”	1.20 ±0.11	1.34-1.67	,,	,,	,,
		DS	”	2.29	0.14	,,	,,	,,
		FL	Rwanda	2.0	0.40	,,	,,	19
		FF	”	1.2	0.65	,,	,,	,,
		FLandFF	Bangladesh	0.6	0.75	,,	,,	24
		DAP	Portugal	1.6	1.59	,,	,,	17
		AP	Togo	1.3-2.8	-	Steam	,,	22
		DL	Gabon	3.2-3.6	1.0-2.1	,,	,,	33
		FL	India	0.39	0.60	Steam	,,	36
		WP	India	2.638	0.4-0.8	Hydro	,,	37
		SSS	India	0.76	-	,,	,,	39
		FH	India	1.0	-	,,	,,	40
		FF	Benin	2.3-2.3	0.2-0.6	Hydro	,,	41
		W.P.	USSR	39.5	-	,,	,,	42
24.	Caryophyllene-oxide	WH	India	0.07	0.45	,,	,,	8
		DL	Cuba	1.74	1.6	,,	,,	21
		DF	”	3.02	0.4	,,	,,	,,
		FLandFF	Bangladesh	0.5	0.75	,,	,,	24
		DL	Gabon	0-0.9	1.0-2.1	,,	,,	33
		DWP	India	0.89	1.8-2.0	,,	,,	38

S. No.	Compound	Plant part	Country	Percentage (%)	Yield	Type of distillation	Compound Type	Ref
25.	β-Caryophyllene oxide	SSS	India	0.51	-	,,	,,	39
26.	Caryophyllene- β-epoxide	FL	Rwanda	0.3	0.40	,,	,,	19
		FF	”	1.3	0.65	,,	,,	,,
27.	Caryophyllene 4, 5 – epoxide	WP	India	1.102	0.4-0.8	,,	,,	37
28.	Carvacrol	DL	Cuba	2.19	1.6	,,	Monoterpene	21
		DF	”	3.09	0.4	,,	,,	,,
		FL	Rwanda	0.60	0.40	,,	,,	19
		FF	”	0.80	0.65	,,	,,	,,
		DAP	Portugal	1.0	1.59	,,	,,	17
		AP	Togo	0.2-8.4		Steam	,,	22
		DL	Gabon	0 –1.1	1.0-2.1	Hydro	,,	33
		DAP	Togo	1.44	1.3	Hydro	,,	59
29.	β-Chamigrene	DL	Cuba	1.61	1.6	,,	Sesquiterpene	21
		DF	”	2.84	0.4	,,	,,	,,
30.	Cineole-1, 8	FL	Rwanda	0.3	0.40	Hydro	Monoterpene	19
		FF	”	3.5	0.65	,,	,,	,,
		FL	Nigeria	1.1	-	Steam	,,	31
		FL	India	0.15	0.60	,,	,,	34
		LSF	Taiwan	2.93-40.20-23.04	-	Hydro	,,	36
		FF	Benin	2.0-1.8	0.2-0.6	Hydro	,,	41
31.	Citronellol	FL	India	0.42	0.60	Steam	,,	34
		LSF	Taiwan	- 0.02-0.37	-	Hydro	,,	36
		WP	India	0.303	0.4-0.8	,,	,,	37
32.	Citronellyl acetate	LSF	Taiwan	0.63-0.18-0.44	-	,,	,,	36
		WP	India	0.125	0.4-0.8	,,	,,	37
33.	α-Copaene	FH	India	0.65	0.40	,,	Sesquiterpene	29
		WH	”	0.76	0.45	,,	,,	8
		DL	West Lafayette	0.52 ±0.11	1.2-1.47	,,	,,	30
		DF	”	0.89 ±0.14	1.34-1.67	,,	,,	,,
		DS	”	1.10	0.14	,,	,,	,,
		FL	Rwanda	0.4	0.40	,,	,,	19
		FF	”	0.4	0.65	,,	,,	,,
		DAP	Portugal	0.1	1.59	,,	,,	17
		AP	Togo	0.3-1.0		Steam	,,	22
		DL	Gabon	1.2-0.4	1.0-2.1	Hydro	,,	33
		WP	India	1.554	0.4-0.8	,,	,,	37
		WP	USSR	7.2	-		,,	42
34.	β -Copaene	WP	India	0.266	0.4-0.8	,,	,,	37
35.	α –Cubebene	WP	USSR	0.7	-		,,	42
36.	β-Cubebene	WP	India	0.075	0.4-0.8	,,	,,	37
		DL	West Lafayette	-	1.2-1.47	,,	,,	30
		DF	”	-	1.34-1.67	,,	,,	,,
		DS	”	0.02	0.14	,,	,,	,,
37.	Cubebene	WP	India	0.282	0.4-0.8	,,	,,	37
38.	Cubenene	FH	India	0.21	0.40	,,	,,	29
39.	Epi-Cubebol	WP	India	0.212	0.4-0.8	,,	,,	37
40.	Cubebol	WP	India	0.233	0.4-0.8	,,	,,	,,
41.	Epi-Cubenol	WP	India	0.232	0.4-0.8	,,	,,	,,
42.	α -Curcurene	WP	India	0.256	0.4-0.8	,,	,,	,,
43.	Para -Cymene	FH	India	0.22	0.40	,,	Monoterpene	29
		WH	”	0.19	0.45	,,	,,	8
		DL	Cuba	14.0	1.6	,,	,,	21
		DF	”	12.84	0.4	,,	,,	,,
		FL	Rwanda	5.8	0.40	,,	,,	19
		FF	”	18.3	0.65	,,	,,	,,
		FLandFF	Bangladesh	7.7	0.75	,,	,,	24
		DAP	Portugal	12.5	1.59	,,	,,	17
		AP	Togo	13.7-33.0		Steam	,,	22
		FL	Nigeria	16.2	-	,,	,,	31
		DL	Guinea	12.04-12.36	1.0	,,	,,	32
		DL	Gabon	0 – 33.3	1.0-2.1	Hydro	,,	33
		FL	India	5.20	0.60	Steam	,,	34
		LSF	Taiwan	--0.34- -	-	Hydro	,,	36
		WP	India	0.062	0.4-0.8	,,	,,	37
		FF	Benin	35.0-24.5	0.2-0.6	Hydro	,,	41
		DAP	Togo	17.27	1.3	Hydro	,,	59
44.	Para-Cymenene	FLandFF	Bangladesh	0.1	0.75	,,	,,	24
		DAP	Portugal	2.0	1.59	,,	,,	17
		DAP	Togo	2.11	1.3	Hydro	,,	59
45.	Para-Cymene-8-ol methyl ether	DL	Cuba	1.19	1.6	,,	,,	21
		DF	”	0.66	0.40	,,	,,	,,
46.	Para-Cymene-8-ol	FLandFF	Bangladesh	0.4	0.75	,,	,,	24

S. No.	Compound	Plant part	Country	Percentage (%)	Yield	Type of distillation	Compound Type	Ref
47.	β-Elemene	FH	India	0.12	0.40	,,	Sesquiterpene	29
		DL	Cuba	0.24	1.6	,,	,,	21
		DF	”	0.55	0.4	,,	,,	,,
		FL	Rwanda	0.1	0.40	,,	,,	19
		FF	”	0.1	0.65	,,	,,	,,
		FLandFF	Bangladesh	0.1	0.75	,,	,,	24
		AP	Togo	0.2		Steam	,,	22
		WP	India	1.488	0.4-0.8	Hydro	,,	37
		SSS	India	0.36	-	,,	,,	39
		W.P.	USSR	3.9	-	,,	,,	42
48.	Elemol	DL	Gabon	0-0.4	1.0-2.1	,,	,,	33
49.	Estragole	AP	Togo	0.2-1.5		Steam	Monoterpene	22
50.	Eudesmol	SSS	India	0.18	-	Hydro	Sesquiterpene	39
51.	β-Eudesmol	WH	India	0.31	0.45	,,	,,	8
52.	γ-Eudesmol	FH	India	0.18	0.40	,,	,,	29
		WH	”	0.15	0.45	,,	,,	8
53.	Eugenol	FH	India	84.84	0.40	,,	Monoterpene	29
		WH	”	87.68	0.45	,,	,,	8
		FL	Rwanda	0.3	0.40	,,	,,	19
		FF	”	10.7	0.65	,,	,,	,,
		FLandFF	Bangladesh	0.1	0.75	,,	,,	24
		DL	Gabon	75.4-0	1.0-2.1	,,	,,	33
		FL	India	81.24	0.60	Steam	,,	34
		WP	USSR	61.8	0.53	,,	,,	35
		LSF	Taiwan	84.87-17.60-46.11	-	Hydro	,,	36
		WP	India	76.241	0.4-0.8	,,	,,	37
		DWP	India	68.14	1.8-2.0	,,	,,	38
		SSS	India	62.40	-	,,	,,	39
		FH	India	84.45	-	,,	,,	40
54.	Farnesene	FH	India	1.12	0.40	,,	Sesquiterpene	29
55.	α-Farnesene	FL	Rwanda	t	0.40	,,	,,	19
		FF	”	0.1	0.65	,,	,,	,,
56.	Z- β- Farnesene	DL	West Lafayette	-	1.2-1.47	,,	,,	30
		DF	”	-	1.34-1.67	,,	,,	,,
		DS	”	0.26	0.14	,,	,,	,,
57.	E- β- Farnesene	FL	Rwanda	t	0.40	,,	,,	19
		FF	”	0.1	0.65	,,	,,	,,
		DL	Gabon	0-0.4	1.0-2.1	,,	,,	33
58.	Fenchone	FH	India	0.21	0.40	,,	Monoterpene	29
		DL	Guinea	1.43-1.54	1.0	Steam	,,	32
59.	Geranial	LSF	Taiwan	1.64-0.71-1.12	-	,,	,,	36
		WP	India	0.491	0.4-0.8	,,	,,	37
60.	Geraniol	FH	India	0.66	0.40	,,	,,	29
		WH	”	0.28	0.45	,,	,,	8
		DL	West Lafayette	88.82 ±2.71	1.2-1.47	,,	,,	30
		DF	”	83.74 ±1.57	1.34-1.67	,,	,,	,,
		DS	”	84.02	0.14	,,	,,	,,
		FL	India	4.04	0.60	Steam	,,	34
		LSF	Taiwan	- 0.01-0.01	-	Hydro	,,	36
		WP	India	0.382	0.4-0.8	,,	,,	37
		SSS	India	0.25	-	,,	,,	39
61.	Geranyl acetate	WP	India	3.110	0.4-0.8	,,	,,	37
		DWP	India	1.33	1.8-2.0	,,	,,	38
62.	Germacrene-D	WH	India	0.13	0.45	,,	Sesquiterpene	8
		FL	Rwanda	0.1	0.40	,,	,,	19
		FF	”	t	0.65	,,	,,	,,
		DAP	Portugal	0.3	1.59	,,	,,	17
		AP	Togo	1.4-3.8		Steam	,,	22
		DL	Guinea	1.19-1.21	1.0	,,	,,	32
		DL	Gabon	6.2-0.5	1.0-2.1	Hydro	,,	33
		WP	India	0.549	0.4-0.8	,,	,,	37
		FF	Benin	3.0-2.4	0.2-0.6	Hydro	,,	41
		WP	USSR	29.9	-	,,	,,	42
63.	Germacrene-D-4-ol	DL	Gabon	0.5-0	1.0-2.1	,,	,,	33
64.	E-Hex-2- en-al	FL	Rwanda	0.1	0.40	,,	,,	19
		FF	”	0.2	0.65	,,	,,	,,
65.	Z -Hex-3- en-1-ol	FLandFF	Bangladesh	0.1	0.75	,,	Alcohol	24
66.	α -Humulene	FH	India	0.14	0.40	,,	Sesquiterpene	29
		WH	”	0.13	0.45	,,	,,	8
		DL	Cuba	0.71	1.6	,,	,,	21
		DF	”	1.36	0.4	,,	,,	,,
		FL	Rwanda	0.2	0.40	,,	,,	19
		FF	”	0.2	0.65	,,	,,	,,
		FLandFF	Bangladesh	0.1	0.75	,,	,,	24
		DAP	Portugal	0.4	1.59	,,	,,	17
		DL	Gabon	0.3-0.4	1.0-2.1	,,	,,	33

S. No.	Compound	Plant part	Country	Percentage (%)	Yield	Type of distillation	Compound Type	Ref
		WP	India	0.316	0.4-0.8	,,	,,	37
		DAP	Togo	0.30	1.3	Hydro	,,	59
67.	Humulene	WP	USSR	4.4	-	,,	Sesquiterpene	42
68.	Humulene oxide II	DL	Cuba	0.10	1.6	,,	,,	21
		DF	”	0.52	0.4	,,	,,	,,
69.	Humulene epoxide II	FLandFF	Bangladesh	0.1	0.75	,,	,,	24
		WP	India	0.150	0.4-0.8	,,	,,	37
70.	Isolongifolol	FLandFF	Bangladesh	0.1	0.75	,,	Sesquiterpene	24
71.	Isopinocamphone	DL	Gabon	0-0.4	1.0-2.1	,,	,,	33
72.	Iso-eugenol	DWP	India	1.74	1.8-2.0	,,	Monoterpene	38
		SSS	India	1.04	-	,,	,,	39
		FH	India	8.23	-	,,	,,	40
73.	Longifoline	FL	Nigeria	3.0	-	Steam	Sesquiterpene	31
74.	Limonene	FH	India	1.68	0.40	Hydro	Monoterpene	29
		WH	”	1.98	0.45	,,	,,	8
		DL	Cuba	5.27	1.6	,,	,,	21
		DF	”	2.90	0.4	,,	,,	,,
		DL	West Lafayette	1.91 ±0.37	1.2-1.47	,,	,,	30
		DF	”	1.25±0.07	1.3-1.67	,,	,,	,,
		DS	”	0.74	0.14	,,	,,	,,
		FL	Rwanda	0.9	0.40	,,	,,	19
		FF	”	1.0	0.65	,,	,,	,,
		FLandFF	Bangladesh	1.1	0.75	,,	,,	24
		DAP	Portugal	1.5	1.59	,,	,,	17
		AP	Togo	4.4-7.8		Steam	,,	22
		FL	Nigeria	1.8	-	,,	,,	31
		DL	Guinea	0.90-0.95	1.0	,,	,,	32
		DL	Gabon	0-1.4	1.0-2.1	Hydro	,,	33
		LSF	Taiwan	0.02-6.49- -	-	,,	,,	36
		WP	India	0.040	0.4-0.8	,,	,,	37
		DWP	India	0.35	1.8-2.0	,,	,,	38
		SSS	India	0.28	-	,,	,,	39
		DAP	Togo	0.85	1.3	Hydro	,,	59
75.	Linalool	FH	India	1.92	0.40	,,	,,	29
		WH	”	0.53	0.45	,,	,,	8
		DL	Cuba	0.21	1.6	,,	,,	21
		DF	”	0.70	0.4	,,	,,	,,
		DL	West Lafayette	0.26 ±0.05	1.2-1.47	,,	,,	30
		DF	”	0.59±0.25	1.3-1.67	,,	,,	,,
		DS	”	0.38	0.14	,,	,,	,,
		FL	Rwanda	0.2	0.40	,,	,,	19
		FF	”	0.3	0.65	,,	,,	,,
		FLandFF	Bangladesh	0.3	0.75	,,	,,	24
		DAP	Portugal	0.5	1.59	,,	,,	17
		AP	Togo	0.2-0.4		Steam	,,	22
		FL	Nigeria	0.2	-	,,	,,	31
		DL	Gabon	0-0.8	1.0-2.1	Hydro	,,	33
		FL	India	0.22	0.60	Steam	,,	34
		LSF	Taiwan	0.12-0.62-0.74	-	Hydro	,,	36
		WP	India	0.125	0.4-0.8	,,	,,	37
76.	Linalyl acetate	FL	India	2.20	0.60	Steam	,,	34
77.	E -p-Menth-2-en – 1-ol	FL	Rwanda	-	0.40	Hydro	,,	19
		FF	”	0.1	0.65	,,	,,	,,
		DL	Gabon	0-0.3	1.0-2.1	,,	,,	33
78.	Z –p-Menth-2-en – 1-ol	DL	Gabon	0-0.2	1.0-2.1	,,	,,	,,
79.	1, 3,8-para-Menthatriene	FLandFF	Bangladesh	<0.1	0.75	,,	,,	24
		DAP	Portugal	0.1	1.59	,,	,,	17
80.	2-Methyl –2-heptene-6-one	WP	India	0.015	0.4-0.8	,,		37
81.	Menthone	WP	India	0.054	0.4-0.8	,,	Monoterpene	,,
82.	Methyl Eugenol	FH	India	1.48	0.40	,,	,,	29
		WH	”	0.64	0.45	,,	,,	8
		FL	Rwanda	-	0.40	,,	,,	19
		FF	”	0.1	0.65	,,	,,	,,
		FL	Nigeria	1.7	-	Steam	,,	31
		FL	India	0.27	0.60	,,	,,	34
		LSF	Taiwan	0.61-1.61--	-	Hydro	,,	36
		DWP	India	13.88	1.8-2.0	,,	,,	40
		SSS	India	3.9	-	,,	,,	39
		FH	India	1.74	-	,,	,,	40
83.	Methyl chavicol	FL	India	0.22	0.60	Steam	,,	34

S. No.	Compound	Plant part	Country	Percentage (%)	Yield	Type of distillation	Compound Type	Ref
		LSF	Taiwan	0.35-0.71-1.19	-	Hydro	,,	36
84.	Methyl cinnamate	FL	Rwanda	t	0.40	,,	,,	19
		FF	”	0.1	0.65	,,	,,	,,
85.	Methyl iso-eugenol	FH	India	0.74	0.40	,,	,,	29
		WH	”	0.18	0.45	,,	,,	8
		FL	Nigeria	t	-	Steam	,,	31
		DWP	India	0.93	1.8-2.0	,,	,,	38
		SSS	India	7.73	-	,,	,,	39
86.	Methyl thymol	DL	Gabon	0-0.4	1.0-2.1	,,	,,	33
87.	Muuroline –α	DL	Gabon	0.3-0	1.0-2.1	,,	Sesquiterpene	,,
		WP	India	0.145	0.4-0.8	,,	,,	37
		W.P.	USSR	0.5	-	,,	,,	42
88.	γ -Muuroline	DL	West Lafayette	2.42 ±0.43	1.2-1.47	,,	,,	30
		DF	”	1.58±0.16	1.3-1.67	,,	,,	,,
		DS	”	3.88	0.14	,,	,,	,,
		WP	India	0.533	0.4-0.8	,,	,,	37
		WP	USSR	3.0	-	,,	,,	42
89.	α- Muurolol	DL	Gabon	0.4 – 0	1.0-2.1	,,	,,	33
90	Muurolol	WP	India	0.312	0.4-0.8	,,	,,	37
91.	Myrcene	FH	India	0.16	0.40	,,	Monoterpene	29
		DL	Cuba	8.23	1.6	,,	,,	21
		DF	”	2.91	0.4	,,	,,	,,
		DL	West Lafayette	0.26 ±0.06	1.2-1.47	,,	,,	30
		DF	”	0.06±0.00	1.3-1.67	,,	,,	,,
		DS	”	0.08	0.14	,,	,,	,,
		FL	Rwanda	3.1	0.40	,,	,,	19
		FF	”	3.3	0.65	,,	,,	,,
		FLandFF	Bangladesh	2.6	0.75	,,	,,	24
		DAP	Portugal	3.6	1.59	,,	,,	17
		AP	Togo	0.5-8.4		Steam	,,	22
		FL	Nigeria	1.4	-	,,	,,	31
		DL	Guinea	4.60-4.63	1.0	,,	,,	32
		DL	Gabon	0.1-4.2	1.0-2.1	Hydro	,,	33
		FL	India	0.26	0.60	Steam	,,	34
		LSF	Taiwan	0.02-1.57-0.01	-	Hydro	,,	36
		DWP	India	8.87	1.8-2.0	,,	,,	38
		SSS	India	17.33	-	,,	,,	39
		FH	India	4.15	-	,,	,,	40
		FF	Benin	5.2-5.8	0.2-0.6	Hydro	,,	41
		DAP	Togo	3.94	1.3	Hydro	,,	59
92.	Neral	DL	West Lafayette	1.35 ±0.09	1.2-1.47	,,	,,	30
		DF	”	3.82±0.34	1.3-1.67	,,	,,	,,
		DS	”	1.36	0.14	,,	,,	,,
93.	Nerol	LSF	Taiwan	- - 0.02 -	-	,,	,,	36
94.	(6E)-Nerolidol	DAP	Portugal	0.4	1.59	,,	Sesquiterpene	17
95.	New isomenthol	WP	India	0.095	0.4-0.8	,,	Monoterpene	37
96.	Ocimene	WP	USSR	15.0	0.53	Steam	,,	35
		LSF	Taiwan	0.03-1.48-0.03	-	Hydro	,,	36
97.	Z-β-Ocimene	DL	Cuba	0.21	1.6	,,	,,	21
		DF	”	-	0.4	,,	,,	,,
		FLandFF	Bangladesh	0.2	0.75	,,	,,	24
		DAP	Portugal	0.4	1.59	,,	,,	17
		AP	Togo	0.5-1.3		Steam	,,	22
		FL	Rwanda	1.8	0.40	Hydro	,,	19
		FF	”	3.4	0.65	,,	,,	,,
		DL	Gabon	4.0-0	1.0-2.1	,,	,,	33
		WP	India	0.050	0.4-0.8	,,	,,	37
		DAP	Togo	1.75	1.3	Hydro	,,	59
98	E-β-Ocimene	FL	Rwanda	0.3	0.40	,,	,,	19
		FF	”	0.2	0.65	,,	,,	,,
		FLandFF	Bangladesh	0.2	0.75	,,	,,	24
		AP	Togo	0.3-0.4	-	Hydro	,,	22
		DL	Gabon	0.1-0	1.0-2.1	,,	,,	33
		DAP	Togo	0.43	1.3	Hydro	,,	59
99.	Oct-1-en-3-ol	FL	Rwanda	0.3	0.40	,,	Alcohol	19
		FF	”	0.3	0.65	,,	,,	,,
100.	Ocimenone-E	AP	Togo	0.2-0.7		Steam	Ketone	22
101.	3-Octanone	FL	Rwanda	0.1	0.40	,,	,,	19
		FF	”	0.1	0.65	,,	,,	,,
		DAP	Portugal	0.1	1.59	,,	,,	17
102.	Phellendrene	DWP	India	0.62	1.8-2.0	,,	Monoterpene	34
		SSS	India	0.40	-	,,	,,	39
103.	α -Phellandrene	DL	Cuba	0.21	1.6	,,	,,	21
		DF	”	0.07	0.4	,,	,,	,,
		FL	Rwanda	0.3	0.40	,,	,,	19
		FF	”	0.1	0.65	,,	,,	,,

S. No.	Compound	Plant part	Country	Percentage (%)	Yield	Type of distillation	Compound Type	Ref
		FLandFF	Bangladesh	0.3	0.75	,,	,,	24
		DAP	Portugal	0.2	1.59	,,	,,	17
		AP	Togo	0.2-0.8	-	Steam	,,	22
		DL	Gabon	0.4-0.2	1.0-2.1	Hydro	,,	33
104.	β -Phellandrene	FLandFF	Bangladesh	0.1	0.75	,,	,,	24
		DAP	Portugal	0.1	1.59	,,	,,	17
		LSF	Taiwan	0.34-0.54- -	-	,,	,,	36
105.	α -Pinene	FH	India	0.24	0.40	,,	,,	29
		DL	Cuba	4.09	1.6	,,	,,	21
		DF	”	1.07	0.4	,,	,,	,,
		DL	West Lafayette	0.24 ±0.05	1.2-1.47	,,	,,	30
		DF	”	0.44±0.09	1.3-1.67	,,	,,	,,
		DS	”	0.05	0.14	,,	,,	,,
		FL	Rwanda	1.0	0.40	,,	,,	19
		FF	”	1.1	0.65	,,	,,	,,
		DAP	Portugal	3.8	1.59	,,	,,	17
		AP	Togo	3.9-8.4	-	Steam	,,	22
		FL	Nigeria	2.6	-	,,	,,	31
		DL	Guinea	1.34-1.45	1.0	,,	,,	32
		DL	Gabon	0-0.9	1.0-2.1	Hydro	,,	33
		LSF	Taiwan	0.29-2.66-1.49	-	,,	,,	36
		DWP	India	0.21	1.8-2.0	,,	,,	38
		FF	Benin	2.3-1.9	0.2-0.6	Hydro	,,	41
		SSS	India	0.04	-	,,	,,	39
		DAP	Togo	1.84	1.3	Hydro	,,	59
106.	β-Pinene	DL	Cuba	2.22	1.6	,,	,,	21
		DF	”	0.33	0.4	,,	,,	,,
		DL	West Lafayette	0.22 ±0.06	1.2-1.47	,,	,,	30
		DF	”	0.15±0.07	1.3-1.67	,,	,,	,,
		DS	”	0.11	0.14	,,	,,	,,
		FL	Rwanda	0.4	0.40	,,	,,	19
		FF	”	0.4	0.65	,,	,,	,,
		DAP	Portugal	0.4	1.59	,,	,,	17
		AP	Togo	0.9-2.0	-	Steam	,,	22
		FL	Nigeria	0.6	-	,,	,,	31
		DL	Gabon	0-0.4	1.0-2.1	Hydro	,,	33
		FL	India	0.37	0.60	Steam	,,	34
		LSF	Taiwan	0.01-0.28-1.04	-	Hydro	,,	36
		DAP	Togo	0.74	1.3	Hydro	,,	59
107.	Pinocarvone	DL	Gabon	0-0.5	1.0-2.1	,,	,,	33
108.	Sabinene	FH	India	0.18	0.40	,,	,,	29
		WH	”	0.19	0.45	,,	,,	8
		FL	Rwanda	0.5	0.40	,,	,,	19
		FF	”	0.5	0.65	,,	,,	,,
		FLandFF	Bangladesh	0.4	0.75	,,	,,	24
		DAP	Portugal	0.4	1.59	,,	,,	17
		AP	Togo	0.4-0.8	-	Steam	,,	22
		DL	Guinea	0.44-0.51	1.0	,,	,,	32
		DL	Gabon	0-0.9	1.0-2.1	Hydro	,,	33
		LSF	Taiwan	0.01-0.57- -	-	,,	,,	36
		DAP	Togo	0.56	1.3	Hydro	,,	59
109.	Z-Sabinene hydrate	FL	Rwanda	0.1	0.40	,,	,,	19
		FF	”	0.4	0.65	,,	,,	,,
		FLandFF	Bangladesh	0.3	0.75	,,	,,	24
		AP	Togo	0.6-2.8	-	Steam	,,	22
		DL	Gabon	0-2.6	1.0-2.1	,,	,,	33
		DAP	Togo	0.76	1.3	Hydro	,,	59
110.	E-Sabinene hydrate	DL	Cuba	0.79	1.6	,,	,,	21
		DF	”	1.40	0.4	,,	,,	,,
		FL	Rwanda	0.4	0.40	,,	,,	19
		FF	”	1.5	0.65	,,	,,	,,
		DAP	Portugal	1.1	1.59	,,	,,	17
		DAP	Togo	2.26	1.3	Hydro	,,	59
111.	α -Selinene	FLandFF	Bangladesh	0.7	0.75	,,	Sesquiterpene	24
112.	β -Selinene	FH	India	0.85	0.40	,,	,,	29
		WH	”	2.82	0.45	,,	,,	8
		DL	Cuba	4.35	1.6	,,	,,	21
		DF	”	7.96	0.4	,,	,,	,,
		FL	Rwanda	0.9	0.40	,,	,,	19
		FF	”	1.5	0.65	,,	,,	,,
		FLandFF	Bangladesh	1.1	0.75	,,	,,	24
		DAP	Portugal	1.9	1.59	,,	,,	18
		AP	Togo	2.5-2.9	-	Steam	,,	22
		FL	Nigeria	1.6	-	,,	,,	31
113.	Selinene- α-7-epi	FLandFF	Bangladesh	0.2	0.75	,,	,,	24

S. No.	Compound	Plant part	Country	Percentage (%)	Yield	Type of distillation	Compound Type	Ref
114.	Spathulenol	DL	West Lafayette	0.41 ±0.29	1.2-1.47	,,	,,	30
		DF	”	0.87±0.03	1.3-1.67	,,	,,	,,
		DS	”	1.25	0.14	,,	,,	,,
		DL	Gabon	0-0.2	1.0-2.1	,,	,,	33
115.	α-p-dimethyl Styrene	DL	Cuba	1.19	1.6	,,	,,	21
		DF	”	0.70	0.4	,,	,,	,,
		FL	Rwanda	0.9	0.40	,,	,,	19
		FF	”	1.0	0.65	,,	,,	,,
116.	α -Terpineol	FH	India	0.92	0.40	,,	Monoterpene	29
		WH	”	0.86	0.45	,,	,,	8
		DL	Cuba	0.53	1.6	,,	,,	21
		DF	”	0.55	0.4	,,	,,	,,
		FL	Rwanda	0.1	0.40	,,	,,	19
		FF	”	0.1	0.65	,,	,,	,,
		DAP	Portugal	0.3	1.59	,,	,,	17
		FL	Nigeria	2.4	-	Steam	,,	31
		DL	Gabon	0-0.7	1.0-2.1	Hydro	,,	33
		FL	India	0.80	0.60	Steam	,,	34
		LSF	Taiwan	- - - 0.02	-	Hydro	,,	36
		DWP	India	0.51	1.8-2.0	,,	,,	38
117.	δ -Terpineol	FL	Rwanda	-	0.40	,,	,,	19
		FF	”	0.1	0.65	,,	,,	,,
		DL	Gabon	0-0.4	1.0-2.1	,,	,,	33
118.	α -Terpinene	FL	Rwanda	3.0	0.40	,,	,,	19
		FF	”	1.0	0.65	,,	,,	,,
		FLandFF	Bangladesh	1.2	0.75	,,	,,	24
		DAP	Portugal	0.2	1.59	,,	,,	17
		AP	Togo	1.0-4.4	-	Steam	,,	22
		FL	Nigeria	6.2	-	,,	,,	31
		DL	Guinea	3.28-3.62	1.0	,,	,,	32
		DL	Gabon	0.2-1.3	1.0-2.1	Hydro	,,	33
		LSF	Taiwan	0.20-1.01-0.37	-	,,	,,	36
		FF	Benin	3.2-3.2	0.2-0.6	Hydro	,,	41
		DAP	Togo	4.02	1.3	Hydro	,,	59
119.	γ-Terpinene	DL	Cuba	8.23	1.6	,,	,,	21
		DF	”	7.0	0.4	,,	,,	,,
		FL	Rwanda	22.9	0.40	,,	,,	19
		FF	”	3.4	0.65	,,	,,	,,
		FLandFF	Bangladesh	12.3	0.75	,,	,,	24
		DAP	Portugal	5.8	1.59	,,	,,	17
		AP	Togo	2.2-33.0	-	Steam	,,	22
		DL	Guinea	16.65-16.73	1.0	,,	,,	32
		DL	Gabon	0-2.3	1.0-2.1	Hydro	,,	33
		LSF	Taiwan	0.01-2.35-2.24	-	,,	,,	36
		FF	Benin	15.2-13.4	0.2-0.6	Hydro	,,	41
		DAP	Togo	13.32	1.3	Hydro	,,	59
120.	Terpinolene	DL	Cuba	0.24	1.6	,,	,,	21
		DF	”	0.30	0.4	,,	,,	,,
		FL	Rwanda	0.1	0.40	,,	,,	19
		FF	”	0.1	0.65	,,	,,	,,
		FLandFF	Bangladesh	1.5	0.75	,,	,,	24
		DAP	Portugal	0.1	1.59	,,	,,	17
		AP	Togo	0.8-2.5		Steam	,,	22
		DAP	Togo	2.60	1.3	Hydro	,,	59
121.	Terpinen-4-ol	DL	Cuba	4.35	1.6	Hydro	,,	21
		DF	”	3.24	0.4	,,	,,	,,
		FL	Rwanda	1.1	0.40	,,	,,	19
		FF	”	1.2	0.65	,,	,,	,,
		FLandFF	Bangladesh	1.4	0.75	,,	,,	24
		DAP	Portugal	1.3	1.59	,,	,,	17
		AP	Togo	0.3-1.2	-	Steam	,,	22
		DL	Guinea	1.25-1.30	1.0	,,	,,	32
		DL	Gabon	1.9-0.7	1.0-2.1	Hydro	,,	33
		LSF	Taiwan	0.50-2.20-0.85	-	,,	,,	36
		WP	India	0.297	0.4-0.8	,,	,,	37
		DWP	India	1.55	1.8-2.0	,,	,,	38
		DAP	Togo	1.13	1.3	Hydro	,,	59
122.	α -Terpinyl acetate	FL	India	0.22	0.60	Steam	,,	34
		LSF	Taiwan	2.18-5.52-6.34	-	Hydro	,,	36
123.	α -Thujene	DL	Cuba	8.23	1.6	,,	,,	21
		DF	”	2.21	0.4	,,	,,	,,
		FL	Rwanda	3.0	0.40	,,	,,	19
		FF	”	3.4	0.65	,,	,,	,,
		FLandFF	Bangladesh	2.0	0.75	,,	,,	24
		DAP	Portugal	1.2	1.59	,,	,,	17

S. No.	Compound	Plant part	Country	Percentage (%)	Yield	Type of distillation	Compound Type	Ref
		AP	Togo	4.1-11.1	-	Steam	,,	22
		DL	Guinea	5.18-5.33	1.0	,,	,,	32
		DL	Gabon	0-3.2	1.0-2.1	Hydro	,,	33
		FF	Benin	8.2-7.7	0.2-0.6	Hydro	,,	41
		DAP	Togo	3.11	1.3	Hydro	,,	59
124.	α -Thujone	FLandFF	Bangladesh	0.1	0.75	,,	,,	24
125.	Z- α -Thujone	DAP	Portugal	0.3	1.59	,,	,,	17
126.	Thymol	DL	Cuba	19.35	1.6	,,	,,	21
		DF	”	27.33	0.4	,,	,,	,,
		FL	Rwanda	46.7	0.40	,,	,,	19
		FF	”	35.4	0.65	,,	,,	,,
		FLandFF	Bangladesh	58.2	0.75	,,	,,	24
		DAP	Portugal	48.1	1.59	,,	,,	17
		AP	Togo	11.3-22.3	-	Steam	,,	22
		FL	Nigeria	47.6	-	,,	,,	31
		DL	Guinea	46.13-46.99	1.0	,,	,,	32
		DL	Gabon	0.6-31.5	1.0-2.1	Hydro	,,	33
		FF	Benin	8.5-23.1	0.2-0.6	Hydro	,,	41
		DAP	Togo	35.49	1.3	Hydro	,,	59
127.	Thymol Methyl Ether	FLandFF	Bangladesh	0.2	0.75	,,	,,	24
		DAP	Portugal	1.5	1.59	,,	,,	17
128.	Thymyl Acetate	DAP	Portugal	0.2	1.59	,,	,,	,,
129.	Vanillin	WP	India	0.902	0.4-0.8	,,	,,	37
130.	α -Ylangene	WP	India	0.120	0.4-0.8	,,	Sesquiterpene	,,
131.	β-Ylangene	W.P.	USSR	2.7	-	,,	,,	42

Sign Conventions: Z-Cis, E- Trans, FH-Fresh Herb, WP-Whole Plant, DL-Dry Leaf, DF-Dry Flower, DS-Dry Stem, FL-Fresh Leaf, FF-Fresh Flower, DAP-dried Arial Part, LSF-Leaf, Stem and Flower, DWP-Dried Whole Plant, SSS –Seed Set Stage

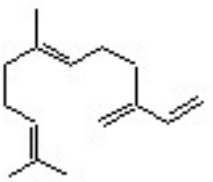
Table 3: Biological Activities of Extract and Essential oil of *Ocimum gratissimum*

S. No.	Extract / Essential Oil	Plant Part	Country	Concentration	Species	Ref.
1.	Brine Shrimp Lethality Test					
	Aqueous Ext.	L.	Nigeria	ED_{50} 23.98 µg / ml	*Brine Shrimp*	26
	Ethanolic Extract	,,	,,	,, 26.30 µg / ml	,,	,,
2.	Antimicrobial Activity					
	Essential Oil	WP	Rwanda	MID 1:1600	*E. coli*	43
	,,	,,	,,	,, 1:3200	*S. aureus*	,,
	,,	,,	,,	,, 1:6400	*T. mentagrophytes*	,,
	,,	L.	Congo	MIC 312.5	*S. aureus*	44
	,,	,,	,,	,, 625	S. *faecalis*	,,
	,,	,,	,,	,, 312.5	*E. coli*	,,
	,,	,,	,,	,, 312.5	*Salmonella sp.*	,,
	,,	,,	,,	,, 312.5	*S. marcescens*	,,
	,,	,,	,,	,, 625	*P. aeruginosa*	,,
	,,	,,	,,	,, 312.5	*K. pneumoniae*	,,
	,,	,,	,,	,, 312.5	*P. vulgaris*	,,
	,,	,,	,,	,, 312.5	*C. albicans*	,,
	,,	,,	,,	,, 625	*A. fumigatus*	,,
	,,	,,	,,	,, 625	*T. mentagraphytes*	,,
	,,	,,	India	MIC 150	*T. rubrum*	45
	,,	,,	,,	,, 200	*T. mentagrohytes*	,,
	,,	,,	,,	,, 250	*T. interdigitale*	,,
	,,	,,	,,	,, 200	*M. canis*	,,
	,,	,,	,,	,, 150	*M. gypseum*	,,
	,,	,,	,,	,, 400	*S. brevicaulis*	,,
	,,	,,	,,	,, 1000	*A. fumigatus*	,,
	,,	,,	,,	,, 350	*C. albicans*	,,
	,,	,,	,,	,, 300	*C. neoformans*	,,
	,,	,,	,,	,, 300	*M. pachydermatis*	,,
	,,	L. and Inflorescence	Nigeria	Inhibition zones (mm) 18.0	*E. coli*	46
	,,	,,	,,	,, 56.0	*S. aureus*	,,
	Ethanolic Ext.	L.	India	Mycelium inhibition at 5 % conc. - 73.3	*M. phaseoulina*	47

S. No.	Extract / Essential Oil	Plant Part	Country	Concentration	Species	Ref.
	,,	,,	,,	,, 76.6	*A. flavous*	,,
	,,	,,	,,	,, 85.8	*A. niger*	,,
	,,	,,	,,	Germination at 5 % conc. - 86.6	*M. phaseoulina*	,,
	,,	,,	,,	,, 88.5	*A. flavous*	,,
	,,	,,	,,	,, 85.5	*A. niger*	,,
	,,	,,	,,	Health seedling at 5 % conc - 49.4.	*M. phaseoulina*	,,
	,,	,,	,,	,, 52.0	*A. flavous*	,,
	,,	,,	,,	,, 48.0	*A. niger*	,,
	,,	,,	,,	Rooted seed and seedlings at 5 % conc - 37.2	*M. phaseoulina*	,,
	,,	,,	,,	,, 36.2	*A. flavous*	,,
	,,	,,	,,	,, 37.5	*A. niger*	,,
	Essential oil	WP	India	MIC (500 ppm) 100	*E. floccossum*	48
	,,	,,	,,	,, (400 ppm) 100	,,	,,
	,,	,,	,,	,, (300 ppm) 100	,,	,,
	,,	,,	,,	,, (200 ppm) 100	,,	,,
	,,	,,	,,	,, (100 ppm) 100	,,	,,
	,,	,,	,,	,, (50 ppm) 100	,,	,,
	,,	,,	,,	,, (25 ppm) 60	,,	,,
	,,	,,	,,	,, (500 ppm) 100	*M. gypseum*	,,
	,,	,,	,,	,, (400 ppm) 100	,,	,,
	,,	,,	,,	,, (300 ppm) 100	,,	,,
	,,	,,	,,	,, (200 ppm) 100	,,	,,
	,,	,,	,,	,, (100 ppm) 100	,,	,,
	,,	,,	,,	,, (50 ppm) 100	,,	,,
	,,	,,	,,	,, (25 ppm) 50	,,	,,
	,,	,,	,,	,, (50 ppm) 100	*A. flavus*	,,
	,,	,,	,,	,, (50 ppm) 100	*A. niger*	,,
	,,	,,	,,	,, (50 ppm) 100	*C. albicans*	,,
	,,	,,	,,	,, (50 ppm) 100	*C. neoformans*	,,
	,,	,,	,,	,, (50 ppm) 100	*E. floccollum*	,,
	,,	,,	,,	,, (50 ppm) 100	*M. pachidermata*	,,
	,,	,,	,,	,, (50 ppm) 100	*M. gypseum*	,,
	,,	,,	,,	,, (50 ppm) 100	*M. audounii*	,,
	,,	,,	,,	,, (50 ppm) 100	*M. nannum*	,,
	,,	,,	,,	,, (50 ppm) 100	*S. brevicaulis*	,,
	,,	,,	,,	,, (50 ppm) 100	*T. rubrum*	,,
	,,	,,	,,	,, (50 ppm) 100	*T. violaceum*	,,
	Essential oil	L.	India	Inhibition % of mycelial growth (500 ppm) 67	*A. spinosa*	49
	,,	,,	,,	,, 100	*A. alternata*	,,
	,,	,,	,,	,, 100	*A. teruissima*	,,
	,,	,,	,,	,, 71	*A. aculeatus*	,,
	,,	,,	,,	,, 86	*A. awamori*	,,
	,,	,,	,,	,, 65	*A. candidus*	,,
	,,	,,	,,	,, 62	*A. ficuum*	,,
	,,	,,	,,	,, 59	*A. fischeri*	,,
	,,	,,	,,	,, 73	*A. flavipes*	,,
	,,	,,	,,	,, 100	*A. fumigatus*	,,
	,,	,,	,,	,, 100	*A. luchuensis*	,,
	,,	,,	,,	,, 88	*A. nidulanas*	,,
	,,	,,	,,	,, 42	*A. ochraceous*	,,
	,,	,,	,,	,, 77	*A. oryzae*	,,
	,,	,,	,,	,, 80	*A. parasiticus*	,,
	,,	,,	,,	,, 71	*A. repens*	,,
	,,	,,	,,	,, 60	*A. ruber*	,,
	,,	,,	,,	,, 63	*A. sulphureus*	,,
	,,	,,	,,	,, 35	*A. sydowi*	,,
	,,	,,	,,	,, 63	*A. tamarii*	,,
	,,	,,	,,	,, 79	*A. terreus*	,,
	,,	,,	,,	,, 83	*A. versicolor*	,,
	,,	,,	,,	,, 65	*Candida sp.*	,,
	,,	,,	,,	,, 69	*C. cladosporioides*	,,
	,,	,,	,,	,, 100	*C. herbarum*	,,
	,,	,,	,,	,, 85	*C. oxysporum*	,,
	,,	,,	,,	,, 100	*C. lunata*	,,
	,,	,,	,,	,, 100	*C. pallescens*	,,
	,,	,,	,,	,, 72	*C. tetramera*	,,
	,,	,,	,,	,, 87	*E quadrillineata*	,,
	,,	,,	,,	,, 50	*E. nigrum*	,,
	,,	,,	,,	,, 100	*F. acuminatum*	,,
	,,	,,	,,	,, 100	*F. monliforme*	,,
	,,	,,	,,	,, 100	*F. oxysporum*	,,

S. No.	Extract / Essential Oil	Plant Part	Country	Concentration	Species	Ref.
	,,	,,	,,	,, 40	*F. semitectum*	,,
	,,	,,	,,	,, 95	*Fusarium sp.*	,,
	,,	,,	,,	,, 95	*Mucor hiemalis*	,,
	,,	,,	,,	,, 65	*N. oryzae*	,,
	,,	,,	,,	,, 100	*P. varioti*	,,
	,,	,,	,,	,, 100	*P. citrinum*	,,
	,,	,,	,,	,, 68	*P. chermesinum*	,,
	,,	,,	,,	,, 63	*P. chrysoqenum*	,,
	,,	,,	,,	,, 86	*P. expansum*	,,
	,,	,,	,,	,, 75	*P. funiculosum*	,,
	,,	,,	,,	,, 90	*P. italicum*	,,
	,,	,,	,,	,, 82	*P. oxalicum*	,,
	,,	,,	,,	,, 62	*Pencillium sp.*	,,
	,,	,,	,,	,, 50	*R. arrhizus*	,,
	,,	,,	,,	,, 100	*R. nigricans*	,,
	,,	,,	,,	,, 74	*S. racemosum*	,,
	,,	,,	,,	,, 84	*White sterile mycelium*	,,
	,,	,,	,,	,, 78	*Yeast like fungi*	,,
	Crude steam distillate	L.	Ghana	Lesion diameter (cm) ± 2 SE at 3 d; 5.18 ± 0.40	*P. palmivora*	50
	,,	,,	,,	,, 6 d; 5.06 ± 0.44	*P. palmivora*	,,
	,,	,,	,,	,, 9 d; 5.03 ± 0.36	*P. palmivora*	,,
	,,	,,	,,	,, 12 d; 5.0 ± 0.24	*P. palmivora*	,,
	Aqueous Ext.	L.	Nigeria	LD_{50} 10	*A. suum GST*	51
	,,	,,	,,	,, 8	*O. volvulus GST*	,,
	,,	,,	,,	,, 1000	*Brine shrimp*	,,
	,,	,,	,,	,, ND	*Heamonchus L_3*	,,
	Essential Oil	L.	India	Mycelial inhibition % of fungi at 25 ppm-10.5	*A. alternata*	34
	,,	,,	,,	,, 50 ppm-34.0	,,	,,
	,,	,,	,,	,, 100 ppm,-70.5	,,	,,
	,,			,,250 ppm -100.0	,,	,,
	,,	,,	,,	,,500 ppm -100.0	,,	,,
	,,	,,	,,	,,1000 ppm-100.0	,,	,,
	,,	,,	,,	,,2000 ppm-100.0	,,	,,
	,,	,,	,,	Mycelial inhibition % of fungi at 25 ppm-00.0	*C. capsici*	,,
	,,	,,	,,	,, 50 ppm-30.0	,,	,,
	,,	,,	,,	,, 100 ppm-64.5	,,	,,
	,,	,,	,,	,,250 ppm –95.0	,,	,,
	,,	,,	,,	,,500 ppm -100.0	,,	,,
	,,	,,	,,	,,1000 ppm-100.0	,,	,,
	,,	,,	,,	,,2000 ppm-100.0	,,	,,
	,,	,,	,,	Mycelial inhibition % of fungi at 25 ppm-40.5	*S. rolfsii*	,,
	,,	,,	,,	,, 50 ppm-100.0	,,	,,
	,,	,,	,,	,, 100 ppm-100.0	,,	,,
	,,	,,	,,	,,250 ppm -100.0	,,	,,
	,,	,,	,,	,,500 ppm -100.0	,,	,,
	,,	,,	,,	,,1000 ppm-100.0	,,	,,
	,,	,,	,,	,,2000 ppm-100.0	,,	,,
3.	Relaxant effect					
	Essential oil	L.	Fortaleza	EOOG (0.1-1000 µg / ml) IC_{50} 23.8 ± 5.2	*Guinea pig*	52
	,,	,,	,,	60 µM KCL ,, 18.6 ± 4.0	,,	,,
	,,	,,	,,	10 µM acetylcholine ,, 70.0 ± 4.6	,,	,,
4.	Anti-nociceptive and anti-inflammatory activity					
	Crude Ext.	L.	Nigeria	180 mg / kg, % of Protection- 72.1	*Mice*	53
	,,	,,	,,	180 mg / kg, % Inhibition of paw thickening- 49.4	*Rat*	,,
5.	Hypoglycemic activity					
	Methanol Ext.	L.	Nigeria	Glucose (nmol / l), Normal-30 min. 5.8 ± 0.02	*Diabetic Rats*	54
	,,	,,	,,	,, -60 min. 4.0 ± 0.17	,,	,,
	,,	,,	,,	,, -120 min. 3.7 ± 0.19	,,	,,

S. No.	Extract / Essential Oil	Plant Part	Country	Concentration	Species	Ref.
	,,	,,	,,	,, -180 min. 2.7 ± 0.07	,,	,,
6.	Hepatoprotectve effect					
	Aqueous Ext.	WP	Taiwan	SGOT (IU / L), dose (mg / kg) -100; 263.2 ± 22.4	*Rats*	55
	,,	,,	,,	SGOT (IU / L), dose (mg / kg) -300; 266.3± 22.3	,,	,,
7.	Analgesic activity					
	Aqueous Ext.	L.	Nigeria	% Inhibitory amount- 5.3 (mg / kg); 51.7	*Mice*	56
	,,	,,	,,	,, - 10.6 (mg / kg); 62.5	,,	,,
	,,	,,	,,	,, - 23.2 (mg / kg); 85.5	,,	,,
8.	Wound healing properties					
	Methanol Ext.	L.	Nigeria	% Wound healing at 4 d post surgery 65.72 ± 2.09c	*Rats*	57
	,,	,,	,,	,, 7 d post surgery 85.86 ± 1.18c	,,	,,
	,,	,,	,,	,, 10 d post surgery 89.74 ± 3.83 bc	,,	,,
	,,	,,	,,	,, 14d post surgery 99.34 ± 0.47 c	,,	,,
	,,	,,	,,	,, 17 d post surgery 100 ± 0.0 b	,,	,,
9.	Insect growth retardant activity					
	Essential oil	L.	India	Average larval mortality (5 % conc.)- 50	*D. melanogaster*	58
	,,	,,	,,	,, (1 % conc.)- 35	,,	,,
	,,	,,	,,	,, (0.05 % conc.)- 13	,,	,,
10	Radical Scavenging Activity					
	Essential oil	L.	Gabon	SC_{50} (mg / L)-7.5	-	33
	,,	,,	,,	,, 317	-	,,
11.	Cytotoxic activity					
	Essential oil	DAP	Togo	IC_{50} ($\mu g.ml^{-1}$) 2400	HaCat	59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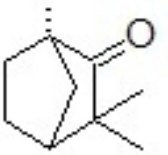
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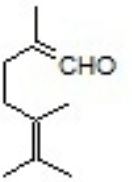
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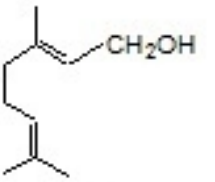
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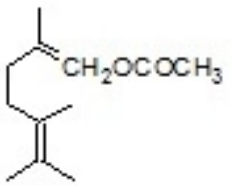
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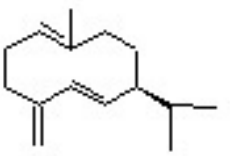
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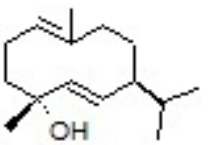
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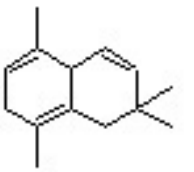
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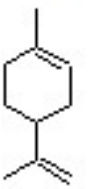
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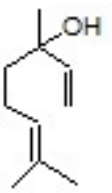
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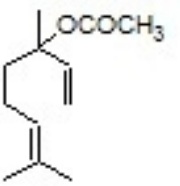
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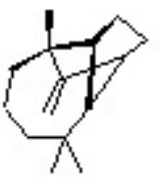
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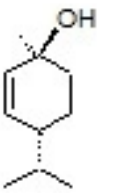
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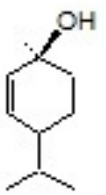
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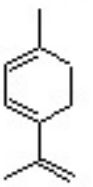
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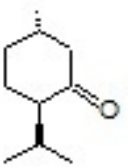
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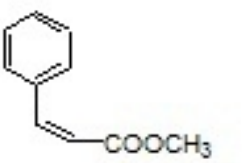
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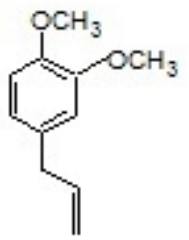
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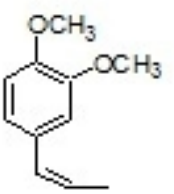
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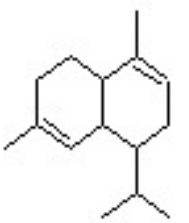
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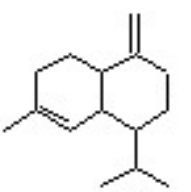
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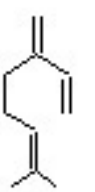
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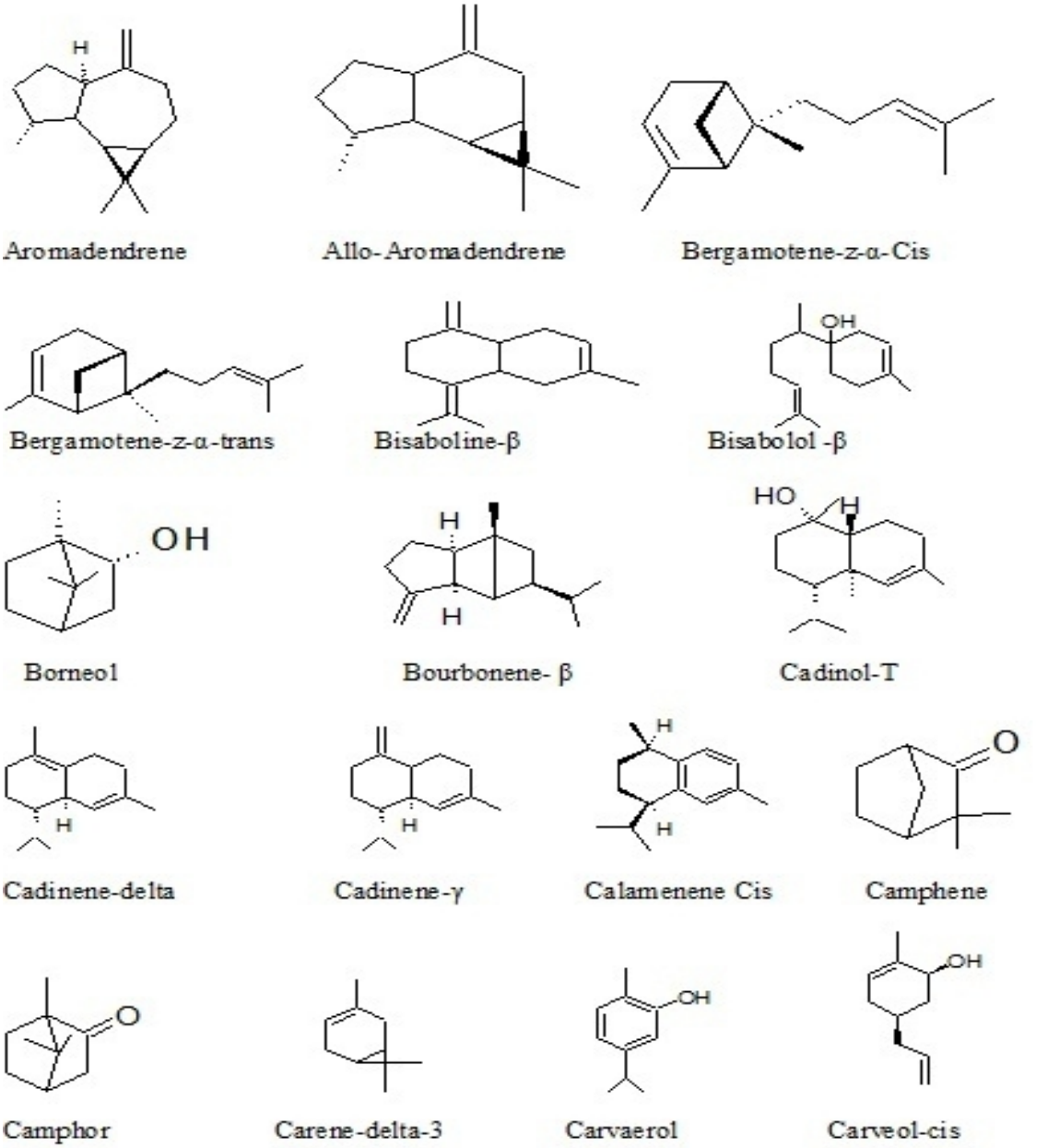
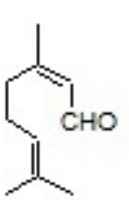
Figures of Ocimum Constituents



Figures of Ocimum Constituents



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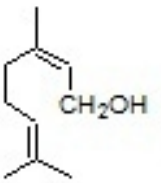

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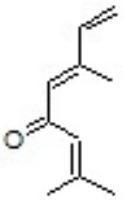
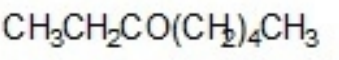


E-Ocimenone



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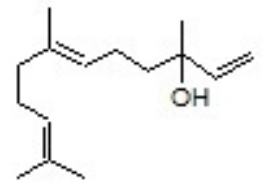

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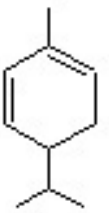

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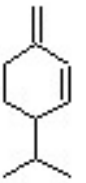
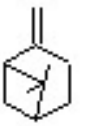
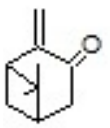


β-Phellandrene

α-Pinene

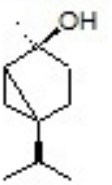


β-Pinene



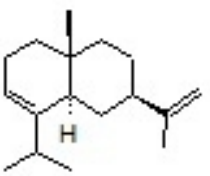
Pinocarvone

Sabinene

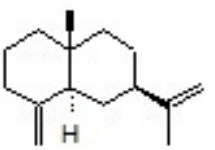


cis-sabinene hydrate

trans-sabinene hydrate



α-selinene



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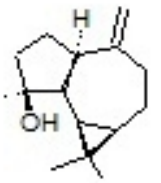

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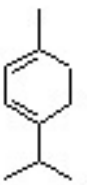
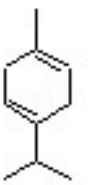


α-terpinene



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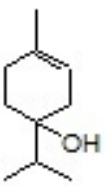
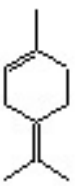
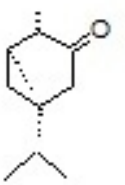


4-Terpineol

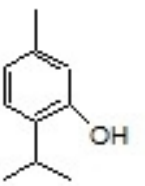


Terpinolene

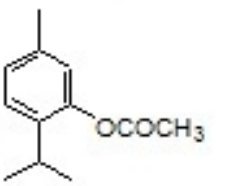
α-thujene



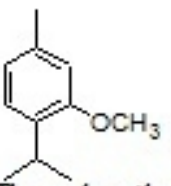
α-thujone



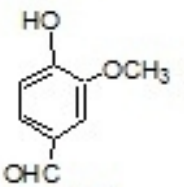
thymol



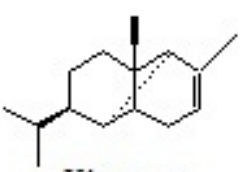
thymol acetate



Thymol methyl ether



Vanillin



α-Ylangene

Figures of Ocimum Constituents

CONCLUSION

Ocimum gratissimum, secondary metabolism appears to be a resource of many biologically active compounds. Eugenol, thymol, methyl cinnamate and geraniol have been already reported in extensive use for antimicrobial and other associated activities. *In vitro* studies on some of the other active compounds identified in *Ocimum gratissimum* could be effective in generating new therapeutic and agricultural products of commercial importance.

ACKNOWLEDGEMENTS

We are grateful to the Director, CDRI, Lucknow, India for providing library facility.

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Cite this article as:

Deeptanjali Sahoo and Ajay Kumar. Secondary metabolites of Ocimum gratissimum and their biological activities. Int. Res. J. Pharm. 2013; 4(8):10-28 http://dx.doi.org/10.7897/2230-8407.04803

Source of support: Nil, Conflict of interest: None Declared