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# Chemical Composition of Essential Oils from *Ocimum Kilimandscharicum:* A Review

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***Abstract***
*Traditional medicine plays an important role in disease especially in developing countries. The essential oils of Ocimum species showed anti-oxidant, anti-inflammatory, anti-cancer and insecticidal activities. Essential oils from O. kilimandscharicum are widely used in modern perfumery and the pharmaceutical industry. However information about the chemical composition remains scanty. This study reviewed the chemical composition of essential oils the plant. Peer-reviewed articles were retrieved from Scopus, Science Direct, SciFinder and Google Scholar. Fifteen articles reporting on chemical composition of essential oils extracted from O. kilimandscharicum were accessed. The major compounds in the essential oils were identified to be camphor, linalool, limonene, methyl eugenol, 1,8-cineole, camphene, β-caryophyllene and α-terpineol. Camphor was reported to be in the range of 0.1-70.4%, linalool 0.2-58.9 %, limonene 1.2-13.6%, methyl eugenol 0.1-53.9%, β-Caryophyllene 0.2-31.5%, 1,8-cineole 0.6-20.1% and camphene 0.4-13.6%. Results from this study have confirmed that Ocimum kilimandscharicum essential oils contain a wide range of chemical compounds. The type of compounds and the percentage composition of compounds present in the essential oils were differed. Further studies to determine medicinal activities of the compound present in the essential oils both in pure and blended forms are necessary.*

***Keywords****: Ocimum kilimandscharicum; essential oils; compounds; composition*

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## I. Introduction

Plants extracts have been used in traditional medicine for several thousands of years. In most developing countries, traditional medicine plays an important role in meeting the primary healthcare needs of the population[1-2]. Plants produce chemical compounds that are toxic to pathogenic microorganism as well as pests[3-15]. Despite the availability of modern synthetic drugs, continued search for novel bioactive compounds is unavoidable as most of the synthetic drugs have limitations in terms of side effects and drug resistance[16-19]. The use of plant extracts in disease management is preferred because the extracts are environmentally friendly and non-toxic to non-targeted organisms[20-23]. In addition, chances pathogenic microorganisms developing resistance to botanical remedies are highly unlikely[24-26]. In recent years, many researchers have focused on authenticating efficacy of medicinal plant extracts through *in-vivo* and in-vitro experiments, isolation and characterization of the bioactive compounds[19, 27-28]. This has led to the identification of several important bioactive secondary metabolites which belong to different classes[15, 29-32].

*Ocimum* genus (Lamiaceae) comprises of more than 150 species which are distributed in the tropical and subtropical regions of the world and from sea level up to 6000 feet. The species possess a great variation in plant morphology and biology, essential oil content and chemical composition[33-35]. Alkaloids, glycosides, saponins, flavonoids, phenols, carbohydrates, steroids, protein, and amino acids are among the phytochemicals present in Ocimum Kilimandscharicum[36-40]. *Ocimum kilimandscharicum* Guerke (camphor basil) extracts have been reported to have antidiarrheal[41], antibacterial, antiviral[42-44], antifungal[44], antipyretic, stimulant, gastro-protective, digestive, carminative[45], antioxidant[46], neuro-protective[47], anti-parasitic[48], wound-healing[49] and immunomodulatory[50] properties. Essential oil of *Ocimum* species have potent anti-oxidant[33, 44], anti-inflammatory[33, 51], anti-cancer[52] and insecticidal activities[53]. Essential oils from *O. kilimandscharicum* are widely used in modern perfumery and the pharmaceutical industry[54,56] . The compounds present in plant extract determine its bioactivity against the disease causing pathogens. Despite numerous medicinal applications of essential oils from *O. kilimandscharicum*, information on chemical composition is scanty. In addition bioactive principles from the oil have not been investigated. This study reviewed the chemical components of essential oils the plant.

## II. Compounds present in *Ocimum kilimandscharicum* essential oils

Peer-reviewed articles were retrieved from Scopus, Science Direct, SciFinder and Google Scholar. Fifteen articles reporting on chemical composition of essential oils extracted from *O. kilimandscharicum* were accessed. Most of *O. kilimandscharicum* plant samples studied originated from India[34, 57- 62], Kenya[35, 48, 63], Brazil[33], Nigeria [64] and Germany[65]. The major compounds in the essential oils whose chemical compositions have been investigated include camphor, linalool, limonene, methyl eugenol, 1,8-cineole, camphene, *β*-caryophyllene and *α*-terpineol (Table 1). Composition of camphor was reported to be in the range of 0.1-70.4%, linalool 0.2-58.9 %, limonene 1.2-13.6%, methyl eugenol 0.1-53.9%, *β*-Caryophyllene 0.2-31.5%, 1,8-cineole 0.6-20.1% and camphene 0.4-13.6%.

Some of the compounds (Table 1) reported from the essential oils of *O. kilimandscharicum* include ß-pinene, myrcene, 1,8-cineole, limonene, terpinen-4-ol, α-terpineol, bornyl acetate, α-pinene, camphene, eugenol, ß-caryophyllene, α-humulene, linalool, camphor, γ-muurolene, germacerene B and epi-α-cadinol [57, 66-67]. Anand *et al*,[58] reported the chemical components of *O. kilimandscharicum* seed oil collected from Uttarakhand, India to contain α-pinene (1.23%), camphene (7.32%), β-myrcene (1.58%), ethylamyl carbinol (0.88%), phellandrene (0.26%), α-terpinene (0.33%), *p*-cymene (0.62%), limonene (13.56%), 1,8-cineole (0.85%), β-ocimene (2.00%), γ- terpinene (0.88%), *trans*- sabinene hydrate (0.49%), α-terpinolene (1.33%), linalool (1.70%), cis-sabinene hydrate (0.47%), camphor (56.07%), 4-terpineol (3.50%), myrtenol (1.24%), *trans*-caryophyllene (0.33%) and germarcrene- D (0.43%). GC analysis of essential oil from freshly harvested aerial parts of *Ocimum kilimandscharicum* grown in Uttarakhand, India revealed thirty two (32) compounds and the major components were camphor (64.9%), limonene (8.7%), camphene (6.4%), (E)-ocimene (3.0%), α-terpineol (2.7%), linalool (1.4%) and (Z)-sabinene hydrate (1.4%)[59]. In a study by Joshi[60], forty-one compounds were identified from essential oil of *O. kilimandscharicum* leaves collected from Karnataka, India representing 97.1% of the total oil. The most abundant compound was camphor (45.9%), followed cineol-1,8 (14.6%) and limonene (8.1%). The chemical composition of essential oil from air dried aerial parts of *Ocimum kilimandscharicum* collected form West Bengal in India was found to contain camphor (21.65%), eugenol (9.65%), cineole (2.07%) and citral (1.23%) as the major components[34]. Analysis of essential oil from leaves of *Ocimum kilimandscharicum* obtained from India gave 41 constituents and the major components were found to be camphor (45.9%), 1,8-cineol (14.6%), limonene (8.1%) camphene (5.5%) and (*E*)-*β*-Ocimene (4.2%) [60]. Essential oil of aerial parts of the plant collected from India contained camphor (28.8 %), β-selinene (11.4 %), α-selinene (9.6 %), maaliol (7.6 %), β-caryophyllene (6.4 %) and β-gurgunene (5.2 %) as the major components [62]. Chemical composition of the essential oils of Ocimum kilimandscharicum Guerke grown in sub-tropical region of northern India was analyzed by capillary gas chromatography (GC-FID) and gas chromatography-mass spectrometry (GC-MS)[42]. Major components identified were camphor (63.4%), limonene (7.9%), camphene (5.8%), and γ-terpinene (4.7%) [42].

The major chemical components of essential oils of leaves of *O. kilimandscharicum* collected from Naivasha, Kenya were found to be camphor (70.4%), 1,8-cineole (7.2%), limonene (6.2%) and camphene (5.1%) [48]. Essential oils from plants collected five regions in Kenya had 9 major compounds but in different percentage compositions: namely camphor, camphene, limonene, linalool, caryophyllene, 4-terpineol, 1,8-cineole and ocimene[63]. In GC analysis of aerial parts of the plant collected from Kisumu city in Kenya, the major compounds identified in were α-cubebene 5,8-dimethyl-quinoline, longifolene, α-terpineol, *B*-terpineol, Terpinen-4-ol and β-Caryophyllene[35]. Analysis of leaves collected from Brazil let to identification of 45 compounds with the major constituents being camphor (51.81%), 1,8 cineole (20.13%) and limonene (11.23%). In addition, α-pinene, camphene, γ-cadinene, myrtenol and flavesone, were present in concentrations between 1.20 and 3.22% [33]. Hydro-distilled essential oils extracted from the flowers and leaves of *Ocimum kilimandscharicum* (R. Br.) Guerke grown in Nigeria were analyzed by GC and GC/MS. The major components of the flower oil were methyl eugenol (40.4%), borneol (11.9%) and linalool (10.6%) while the leaf oil consisted mainly of methyl eugenol (53.9%) and γ-cadinene (16.2%)[64].

## III. Bioactivity of the essential oils

The importance of essential oils increases in recent years due to their applications such as being used as perfumes, flavors for foods and beverages, or body care[68]. Essential oils extracted from *O. kilimandscharicum* have been reported to exhibit various medicinal activities such as antioxidant, antibacterial, antifungal, anti-inflammatory, anticancer and insecticidal activities[33, 44, 69, 70]. Biological activities of the essential oils have been attributed to the chemical components present in the essential oils. In previous studies, camphor was reported to exhibit various biological properties including antimicrobial, insecticidal, antiviral, anticoccidial, anticancer, anti-nociceptive, antitussive and skin penetration enhancing activities[71]. Thujone-containing plants have long been used in traditional medicine to treat various ailments, such as bronchial catarrh, enuresis, cystitis, psoriasis, uterine carcinomas, amenorrhea, and rheumatism[72]. The α-and β-pinene have cytogenetic, gastroprotective, anxiolytic, cytoprotective, anticonvulsant, neuroprotective, anti-inflammatory and anti-carcinogenic effects[73].

Camphene exhibited antioxidant and antiinflamatory activities[74]. Sabinene showed antioxidant, anti-fungal and anti-inflammatory activities[75, 76]. β-Myrcene showed sedative, anxiolytic, antioxidant, anti-ageing, anti-inflammatory and analgesic activities[77]. Alpha-phellandrene showed antitumoral, antinociceptive, larvicidal and insecticidal activities[78]. Limonene gave anti-inflammatory, antioxidant, antinociceptive, anticancer, antidiabetic, antihyperalgesic, antiviral, and gastroprotective effects[79]. 1,8-cineole was reported to exhibit anti-inflammatory and antioxidant effects[80]. Linalool and linalool-rich essential oils exhibit have anti-inflammatory, antimicrobial, anticancer and anti-oxidant properties[81]. Previous studies have demonstrated that α-terpineol possesses anticonvulsant, sedative, antinociceptive and hipotensive[82]. Eugenol is known for its medicinal value as an antiseptic, dental anesthetic, antioxidant, anti-inflammatory, antiviral, antimicrobial, antibacterial, antifungal and anthelmintic[83-86]. Beta-caryophyllene was shown to have anti-inflammatory, antibiotic, antioxidant, anticarcinogenic and local anaesthetic activities[87]. Myrtenol has antimicrobial, anxiolytic, anti-inflammatory and gastroprotective properties[88, 89]. Citral possesses antifungal, bactericidal, insecticidal deodorant, expectorant, appetite stimulating, spasmolytic, diuretic and anti-inflammatory activities[90, 91].

## IV. Conclusion

Results from this study have shown that *Ocimum kilimandscharicum* essential oils contain a wide range of chemical compounds. However, the type of compounds as well as the percentage composition of compounds present in the essential oils differed. This is in agreement with previous reports that chemical composition of plant extracts depends on plant species, plant part, age, season of harvest as well as geographical location. Further studies to determine medicinal activities of the compound present in the essential oils both in pure and blended forms are necessary.

**Table 1**: Chemical composition of essential oils from *Ocimum kilimandscharicum*

| Compound | Composition % | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Camphor | 17.02 | 15.82 | 56.07 | 64.9 | 21.65 | 45.9 | | 56.97 | 70.4 | | 45.51 | 36.1 | 51.81 | 0.1 | 0.2 |
| Linalool | 41.94 | 58.85 | 1.7 | 1.4 | 0.23 | | | 0.35 | 0.5 | 7.9 | 4.93 | 2 | | 10.6 | 4.5 |
| Limonene | 5.09 | 3.21 | 13.56 | 8.7 | | 8.1 | | 9.46 | 6.2 | | 3.44 | 21.2 | 11.23 | 4.1 | 1.2 |
| Methyl eugenol | | | | t | | | 0.1 | | | | | | | 40.4 | 53.9 |
| 1,8-Cineole | 10.18 | 6.38 | 0.85 | 0.7 | 2.07 | 14.6 | | 14.63 | 7.2 | | 0.61 | 0.8 | 20.13 | | |
| Camphene | 1.59 | 1.32 | 7.32 | 6.4 | | 5.5 | | 0.4 | 5.1 | | 13.57 | 5.65 | 3.08 | 1.2 | |
| *β*-Caryophyllene | 1.34 | 1.75 | 0.33 | 1.2 | | 1.9 | 6.4 | | 2.8 | 31.5 | 0.24 | 2.48 | | | |
| α-Cubebene | | | | | | | | | | 29.4 | | | | | |
| *α*-Terpineol | | | | 2.7 | | 2.4 | | 1.56 | 0.6 | 11.5 | 4.63 | 4.82 | | | |
| *γ*-Cadinene | | | | | | | | | | | | | | 7.4 | 16.2 |
| *α*-Terpinen-4-ol | | | 3.5 | 0.6 | | | | 6.59 | 1.4 | 11.4 | | | | | |
| Borneol | | | | | | | | | | | | | | 11.9 | 7.2 |
| β-Thujone | | | | | | | | | | 18.4 | | | | | |
| Caryophyllene oxide | | | | 0.1 | | t | | | | 11.7 | | | | | |
| B-Selinene | | | | | | | 11.4 | | | | | | | | |
| *β*-Ocimene | | | 2 | 3 | | 4.2 | | | | | 0.91 | 1.27 | | | |
| *γ*-Muurolene | 2.67 | 4.26 | | | | 2.1 | 0.2 | | | | | | | 1.9 | |
| Myrtenol | | | 1.24 | | | | | | 1.3 | | 4.53 | 2.43 | 1.48 | | |
| Eugenol | 0.28 | | | | 9.65 | t | | | | | | | 0.84 | | |
| Longifolene | | | | | | | | | | 10 | | | | | |
| *α*- Selinene | | | | | | | 9.6 | | | | | | | | |
| *γ*-Terpinene | 1.14 | 0.55 | 0.88 | 0.6 | | 0.8 | | 1.49 | | 0.3 | | | | 3.1 | |
| Isoaromadendrene epoxide | | | | | | | | | | 8.4 | | | | | |
| *β*-Pinene | 3.83 | 1.23 | | t | 1.02 | 1.9 | | | | | | | | | 0.3 |
| *α*-Pinene | 0.64 | 0.33 | 1.23 | 1.4 | 0.98 | 0.1 | | 0.79 | | | | | 1.48 | 1.1 | 0.1 |
| Humulene II epoxide | | | | | | | | | | 7.8 | | | | | |
| Maaliol | | | | | | | 7.6 | | | | | | | | |
| 8,9-dehydro-cycloisolongifolene | | | | | | | | | | 7.2 | | | | | |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Myrcene | - | | 1.58 | 1.2 | | 1.7 | | 1.82 | | | | | | | |
| Terpinolene | | | 1.33 | 1.1 | | 1.3 | | 1.58 | | | | | | | |
| B-Gurgunene | | | | | | | 5.2 | | | | | | | | |
| *δ*-Cadinene | | | | | | 0.1 | 1.3 | | | | | | 2.94 | | |
| *α*-Terpinene | | | 0.33 | 0.5 | | t | | 0.62 | | 2.6 | | | | | |
| Eucalyptol | | | | | | | | | | 3.6 | | | | | |
| *β*--Phellandrene | | | | | | | | | | | | | | 3.4 | |
| Epi-α-cadinol | 1.78 | 1.28 | | | | | | | | | | | | | |
| Germacerene B | 1.42 | 1.24 | | | | | | | | | | | | | |
| Germacrene-D | | | 0.43 | 0.7 | | | 0.2 | 1.22 | | | | | | | |
| *trans*-Sabinene hydrate | | | 0.49 | 1.4 | | 0.6 | | | | | | | | | |
| Isolongifolene, 9,10-dehydro- | | | | | | | | | | 2.3 | | | | | |
| *cis*-Sabinene hydrate | | | 0.47 | | | 1.7 | | | | | | | | | |
| *β*-Elemene | | | | t | | 0.1 | 1.8 | | | | | | | | |
| *α*-Humulene | 0.26 | 0.36 | | | | 0.2 | 0.8 | | | | | | | | |
| *p*-Cymene | | | 0.62 | | | 0.2 | | 0.43 | | | | | | | |
| Citral | | | | | 1.23 | | | | | | | | | | |
| α-Cadinol | | | | | | 0.4 | 0.7 | | | | | | | | |
| Terpin-4-ol | | | | | | 0.8 | | | | | | | | | |
| *α*-Thujene | | | | 0.2 | | 0.2 | | | | | | | | 0.4 | |
| Isoborneol | | | | | | 0.2 | | | 0.6 | | | | | | |
| Bornyl acetate | 0.62 | 0.18 | | | | | | | | | | | | | |
| Globulol | | | | | | t | 0.7 | | | | | | | | |
| *α*-Phellandrene | | | 0.26 | | | t | | 0.42 | | | | | | | |
| 3-Allyl-6-methoxyphenol | | | | | | | | | | 0.6 | | | | | |
| Citronellal | | | | | 0.51 | | | | | | | | | | |
| 7-*Epi*-α-selinene | | | | | | | 0.5 | | | | | | | | |
| Geraniol | | | | | 0.49 | | | | | | | | | | |
| *α*-Copaene | | | | | | t | 0.4 | | | | | | | | |
| Germacrene D-4.ol | | | | | | | 0.4 | | | | | | | | |
| Isosylvestrene | | | | | | 0.3 | | | | | | | | | |
| Vanillin | | | | | 0.3 | | | | | | | | | | |
| Estragole | | | | | | | | 0.3 | | | | | | | |
| Germacrene A | | | | | | | 0.3 | | | | | | | | |
| Tricyclene | | | | | | 0.2 | | | | | | | | | |
| *α*-Campholenal | | | | | | 0.2 | | | | | | | | | |
| β-Farnesene | | | | 0.2 | | | | | | | | | | | |
| Guaiol | | | | | | | | | | 0.2 | | | | | |
| *α*-Gurgunene | | | | | | | 0.2 | | | | | | | | |
| Sabinene | | | | | | 0.1 | | | | | | | | | |
| Cubebol | | | | | | 0.1 | | | | | | | | | |
| Spathulenol | | | | | | 0.1 | | | | | | | | | |
| Cubenol | | | | | | 0.1 | | | | | | | | | |
| Geranial | | | | | | | 0.1 | | | | | | | | |
| 1-*epi*-Cubenol | | | | | | | 0.1 | | | | | | | | |
| Aromadendrene | | | | | | | 0.1 | | | | | | | | |
| Cyclosativene | | | | | | | 0.1 | | | | | | | | |
| Viridiflorol | | | | | | | 0.1 | | | | | | | | |
| *α*- Muurolol | | | | | | | 0.1 | | | | | | | | |
| Reference | 57 | 57 | 58 | 59 | 34 | 60 | 62 | 65 | 48 | 35 | 63 | 63 | 33 | 64 | 64 |

Key: t = trace amounts

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