International Journal of Current Research in Physiology and Pharmacology
Volume 5, Issue 2; 2021
DOI: 10.31878/ijcrpp.2021.52.01

Ocimum Species: Ethnomedicinal Uses, Phytochemistry and Pharmacological Importance

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Plant species belonging to the Ocimum genus are among the most popular medicinal plants and are being used for several purposes in ethnomedicine. Ocimum is universally cultivated however; the geographical distribution highlights three major centers of Ocimum diversity, these are: the tropical areas of America, the tropical region of Asia and the tropical and subtropical regions of Africa. Ocimum species have been employed traditionally for several medicinal purposes including antioxidant, antibacterial, hypoglycaemic, hepatoprotective, antiviral and other medicinal purposes. Though scientists have carried-out studies and chronicled the pharmacological potentials of Ocimum species, documents containing these data seem to be disassembled, making it difficult to really distinguish the pharmacologically useful species from those that are not and also to get comprehensive information about the medicinal species in this genus. Hence, the aim of this review is to outline classified information on the ethnopharmacology, phytochemistry and pharmacological importance of some Ocimum species that have been reported by different researchers. In carrying-out this review, the search for literature was done via relevant databases including PubMed, Springer, Web of Science, Science Direct, Embase, SciFinder, Google Scholar and Scopus. The species reviewed are the most widely used from the Ocimum genus in traditional medicine and they are also the most researched for intended use in conventional therapeutic practice. Literature reveals that these species contain several compounds which are responsible for the numerous pharmacological activities elicited by them including antimalarial, anticancer, antidiabetic, antiinflammatory and antioxidant effects.

Keywords: *Ocimum species, ethnomedicine, pharmacological potential*

Introduction

In the past few years, scientists and researchers have largely focused on natural products in search of potent and safer agents for curative, prophylactic and other medicinal purposes.[1] This have led to extensive scientific studies on suspected medicinal plants and other natural products. [2] Scientific chronicles have shown that remarkable success have evolved from this trend, as several pharmacological agents currently in use were developed from natural products (including plants).[3]

Plant species belonging to the Ocimum genus are among the most popular medicinal plants and are being used for several purposes in ethnomedicine. Of the entire genus stemming from the subfamily Nepetoideae (under the family Lamiaceae), Ocimum (also known as Basil) is referred to as the most the most important of them.[4] The name Ocimum was derived from the word ‘‘Ozo” (Greek), which means smell.[5]Due to its enormous use in both traditional medicine and pharmaceutical industry, and as well for perfumery purpose, it is also referred to as ‘‘king of herbs.” [6] According to the report documented by Pushpangadan and Bradu, the genus Ocimum

with over 160 species is said to be the largest genera belonging to Lamiaceae Family.[7] About 65 of the species are said to be native to Ocimum, while the others are considered as synonyms.[1, 7] Ocimum is universally cultivated however, the geographical distribution highlights three major centers of Ocimum diversity. These are: the tropical areas of America, the tropical region of Asia and the tropical and subtropical regions of Africa. The African tropical rain forest has the highest number of Ocimum species.[8] The main species of Ocimum with documented pharmacological activity includes *Ocimum gratissimum*, *Ocimum basilicum*, *Ocimum sanctum*, Ocimum *americanum,* and*Ocimum Kilimandscharicum*. These species have been reported traditionally to possess different culinary and medicinal activities. In different parts of the world, people employ plant species from this genus for several medicinal purposes such antioxidant, antibacterial, hypoglycaemic, hepatoprotective, antiviral and several other medicinal purposes. [9 - 12] Though scientists have carried-out studies and chronicled the pharmacological potentials Ocimum, documents containing these data seem to be disassembled, making it difficult to really distinguish the pharmacologically useful species from those that are not and also to get comprehensive information about the medicinal species in this genus. Hence, the aim of this review is to outline classified information on the ethnopharmacology, phytochemistry and pharmacological importance of some Ocimum species that have been reported by different researchers.

In carrying-out this review, the search for literature was done via relevant databases including PubMed, Springer, Web of Science, Science Direct, Embase, SciFinder, Google Scholar and Scopus. The keywords used for the search includes: Ocimum, Ocimum species, phytochemical, phytochemistry, pharmacological activity, pharmacological evaluation of extracts, fractions, or isolated compounds from Ocimum. Selection and inclusion of articles for the study was based on publications done in English language only. All selected manuscripts were analyzed for relevance to the topic, reported plant species, isolated chemical compounds, and evaluated biological activities.

Ethnopharmacology of Ocimum s pecies

Literature shows that traditionally, plant species belonging to the Ocimum genus are widely employed for the treatment and management of several ailments including mental illness, diarrhea, measles, gonorrhea, rheumatism, paralysis, high fever, influenza, epilepsy, abdominal pains, cold and cough. They are also used as antipyretic, antihelmentic, antiemetic and antimalarial agents traditionally. [13 - 14] The specific documented tradomedical application of the different species belonging to the Ocimum genus is summarized in table 1 below.

Species	Region	Parts	Traditional Uses	References
Ocimum americanum	China, India, Thailand, Nigeria, Cameroon, Mali, Guinea	Leaves	It is used for treating coughs, bronchial catarrh, ulcers, haemorrhoids, tuberculosis, stomach pains ear and eye ailments. It is also used for lowering high blood pressure, and to treat constipation, stomach ache, diabetes, diarrhea, dysentery and haemorrhoids.	[15 - 19]
Ocimum basilicum	Cameroon, Egypt, Nigeria, Guinea, Mali, Rwanda	Leaves	Used for prophylaxis and treating of cardiovascular disorders, diabetics, aches and pains, cough, headache, kidney malfunctions and diarrhea. It also used in the treatment of skin infections, snake bites	[20- 23]

			and insect stings, and as a sedative.	
Ocimum gratissimum	India, China, Nigeria, New Zealand, Australia	Leaves, stem, root and flowers	It is used as an antidiabetic, antiseptic, antidiarrhoeal, antitussive, antihelmintic, antipyretic, anti-inflammatory, antispasmodic and antimicrobial agent. Also used for the treatment and management of various stomach and kidney ailments, upper respiratory tract infection, pneumonia, epilepsy, fever, convulsion, diarrhea, headache and influenza.	[27 - 34]
Ocimum Kilimandscharicum	India, Thailand, Ethopia, Tanzania, Kenya, Uganda, Sudan, Ethopia	Leaves	It is employed in the treatment of cough, cold, measles, abdominal pain, measles, diarrhea and diarrhea. It is used as an insect repellant and for storage pest control.	[35 - 37]
Ocimum sanctum	Asia, Africa, Malaysia, Australia, United Arab Emirates	Leaves	It is used traditionally for the management and treatment of several ailments such as headache, fever, cough, common cold, flu, sore throat, colic pain, asthma, diarrhea, digestive disorders, bronchitis, influenza, insomnia, hepatic diseases, arthritis, and malaria fever. It is also used as an antidote for scorpion sting and snake bite	[38 - 40]

Table 1. *The tradomedic al uses of different Ocimum species*

Phytochemical Studies

Ethnomedicinal plants contain complex plant chemicals also known as phytochemicals. These phytochemicals are made up of several compounds. The enormous information revealed by the ethnomedicinal applications of *Ocimum species* spurred scientific investigation into its chemical constituents. These studies have led to the identification and isolation of divers phytochemicals from different plant parts of Ocimum species. These include alkaloids, terpenoids, organic acids, tannins, flavonoids, coumarins, quinones, polyphenols, saponins, and their derivatives.

Ocimum americ anum

Phytochemical analysis carried-out by Dhale *et al*[41] showed that *Ocimum americanum* is rich in alkaloids, phenolic compounds, tannins, lignin, saponins, flavanoids, terpenoid and anthraquinone. Alciléia *et al*[42] also gave a similar report, and as well documented compounds such as α-pinene, camphene, sabinene, β-pinene, β-mircene and other compounds which have been identified and

isolated from its essential oil.

Ocimum basilicum

Sanni *et al*[43] and Ismail[44] reported the presence of carbohydrate, tannins, cardiac glycosides, flavanoids, terpenes and steroids in *Ocimum basilicum* leaves. Using a GC-MS, Andrew *et al*[45] carried-out a chemical analysis which showed the presence of α-Pinene, β.-Myrcene, 4-Hexen-1-ol, acetate and other important bioactive compounds in its leaf essential oil. Sarfaraz *et al*[46] also documented the presence of these compounds in a report on their analysis.

Ocimum gratissimum

A phytochemical report documented by Offiah and Chikwendu[47] revealed the presence of tannins, steroids, triterpinoids and carbohydrates in *ocimum gratissimum*. Prabhu *et* al[48] also showed the presence of alkaloids, tannins, flavonoids and oligosaccharides. Pandey and Chowdhury, [49] Matasyoh *et* al, [50] Kéita *et al*,[51] and Jirovetz *et al*[52] have also documented specific compounds which have been isolated from *Ocimum gratissimum*, this have been summarized in table 2 and some of the structures shown in figure 1.

Ocimum Kilimandscharicum

According to a report by Tewari *et al*, [53] alkaloids, glycosides, saponins, flavanoids, phenols, carbohydrates, steroids, protein and amino acids are among the phytochemicals present in *Ocimum Kilimandscharicum*. Charles and Simon[54] in their work isolated seventeen compounds from its essential oil and this includes α- pinene, Camphene, ß-pinene and Eugenol [table 2].

Ocimum sanctum

In a research work published by Xia *et al*, [55] carbohydrates, terpenoids and alkaloids were present in the ethanolic extract of *Ocimum sanctum*. Similarly, Devendran and Balasubramanian[56] also reported the presence of flavanoids, cardiac glycosides, steroids, saponin and tannins, as well as carbohydrates, terpenoids and alkaloids. Furthermore, using a GC-MS, analysis of the hydro-alcoholic extract showed the presence of several compounds including Eugenol and Caryophyllene.

Reported compounds isolated from the various Ocimum species have been outlined in table 2, while some of the structures are shown in figure 1.

Species	Compounds Isolated	Reference
Ocimum americanum	α-pinene, Camphene, Sabinene, β-pinene, β-mircene, Limonene, 1,8 cineole, linalool oxide, Fenchone, Linalool, Camphor, Borneol, 4-terpineol, α-Terpineol, cis-piperitol, Estragole, Eugenol, β-selinene, β-caryophyllene, biciclogermacrene, β-bisabolene.	[42]
Ocimum basilicum	α-Pinene; β-Myrcene; 4-Hexen-1-ol, acetate; 4 Eucalyptol; cis-Linaloloxide; 1,6-Octadien-3-ol, 3,7-dimethyl; Methyl ethyl cyclopentene; L-Menthone; L-(-)-menthol; Estragole; N-Cyano-3-methylbut-2-enamine; Citral; Cyclohexene, 4-methyl-1-(1-methyle thyl); Phenol, 2,3,5-trimethyl; Eugenol; Formic acid, cyclohexyl ester; Copaene; cis-7,10,13,16-Docosatetraenoic acid, methyl ester; Neoisolongifolene; trans-α-Bergamotene; Alloaromadendrene; Humulene, beta.-copaene; beta.-Bisabolene; cis-muurola-3,5-diene;	[45 - 46]

	cis-.alpha.-Bisabolene; Nerolidol; trans-4-Methoxycinnamaldehyde; Benzeneacetic acid,.alpha.-hydrox; Phenylethanolamine; 3-Methyl-2-phenylindole; N-Benzyl-N-ethyl-p-isopropylbenzamide	
Ocimum gratissimum	Eugenol, methyl eugenol, cis-ocimene, trans-ocimene, pinene, camphor, germacrene-D, trans-carypohyllene, farnesene and l-bisabolene, Thymol, methyl chavical, linalool, limonene, methyl eugenol, β-caryophyllene, farnesene, α-terpineol, methyl isoeugeneol, geraniol, α-copaene, bisabolol, fenchone, cubenene, camphene, T-cadanol, sabinene, myrcene, β-bisoboline, α-humelene and β-elemene.	[47 -5 2]
Ocimum Kilimandscharicum	ß-pinene, Myrcene, 1,8-cineole, Limonene , Terpinen-4-ol, α-terpineol, Bornyl acetate, α-pinene, Camphene, Eugenol, ß-caryophyllene, α-humu lene, Linalool, Camphor, γ-muurolene, Germacerene B, Epi-α-cadinol	[5 3-54]
Ocimum sanctum	Eugenol; Cyclohexane, 1,2,4-triethenyl- ; Caryophyllene; 10-Heptadecen-8-ynoic acid; Cyclopentane, cyclopropylidene-; Z,Z-4,16-Octadecadien-1-ol acetate; Benzene methanamine, N,N-α,4-tetramethyl-; 3’,8,8’-trimethoxy-3-piperidyl-2,2’-binaphthalene1,1’,4,4’-tetrone; Octadecane, 1,1-dimethoxy-; Pentanedinitrile, 2-methyl-	[55-56]

Table 2. *Compunds isolated from different Ocimum species*

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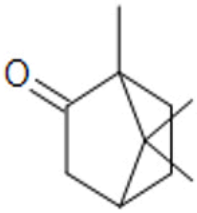
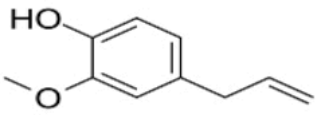
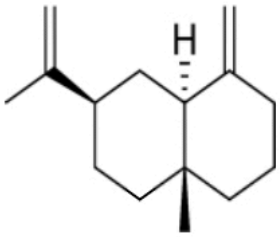


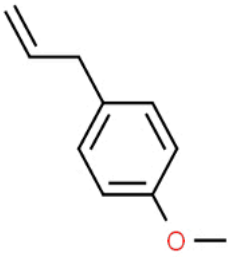
Camphor



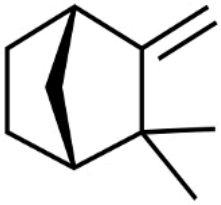
Eugenol



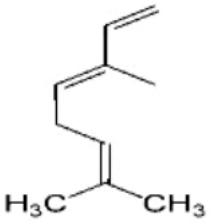
β-Selinene



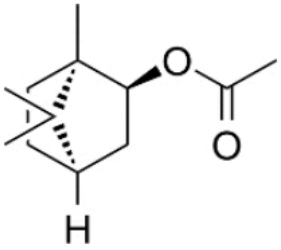
Estragol



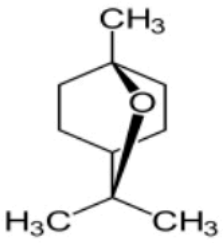
Camphene



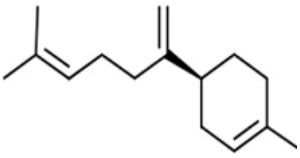
***Trans* β-Ocimene**



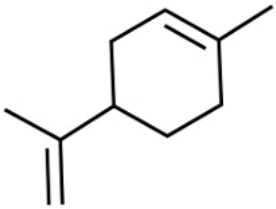
Bornyl acetate



1, 8 Cineole

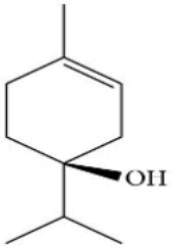


β-Bisobline

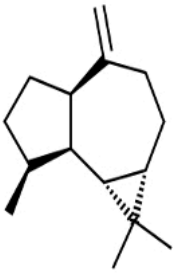


Limonene

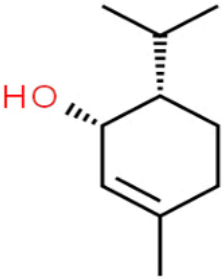
Sabinene



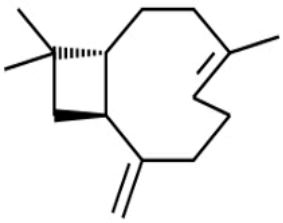
Terpinen-4-ol



Alloaromadendrene



Cis-piperitol



β-caryophyllene

Figure 1. *Structures of some compounds identified/isolated from Ocimum species Pharmacology*

Several pharmacological studies have confirmed/establish the efficacy of *Ocimum* species for their various therapeutic applications.

Ocimum americanum

Ocimum americanum have been documented to elicit significant antifungal activity,[57 - 59] gastric cyto-protective and antiulcer effect against acute gastric ulcer causative organism,[57 - 60] wound healing activity,[57] larvicidal and insecticidal activity.[61] Theessential oils also have effects such as cytotoxic, antimicrobial and mosquito repellent effect.[59, 62] The antioxidant activity of *Ocimum americanum*has also been documented.[63 - 64] Sutilifj et alreported that *Ocimum americanum* whole plant have a significant hemolytic effect. [65] Sethi et al documented the antifungal activity of the plant, [66] while Priscila et al reported the bactericidal activity. [67] The anti-microbial activity against gram positive and gram negative bacteria have been reported by Thaweboon et al. [68] Aluko et al also reported its anti-oxidant effect,[69] Sripriya et al reported the significantanalgesic and anti-inflammatory activities of the leave in laboratory mice.[70] According to Sinitha et al, *Ocimum americanum* elicits immune-modulatory effect, [71] while Lenise et al have also documented its anesthetic activity. [72] Aluko et al carried-out a study to evaluate the hepatoprotective activity of *Ocimum americanum* leaves in laboratory rats with paracetamol – induced liver damage, and reported it to be having an hepatoprotective effect.[73]

Ocimum basilicum

According to reports by Politeo et al and Ramesh et al, *Ocimum basilicum* is rich in antioxidants compounds and hence have a high antioxidant activity.[74 - 75] Dwivedi et al stated that the Solvent extracts of the plant elicits significant activity at cellular level including inhibition of HIV-1 reverse transcriptase and anti-aggregatory effect on blood platelets.[76] Clinical studies reported by Siurin et al and Niture et al revealed that *Ocimum basilicum* volatile oil have characteristic antioxidant activities.[77 - 78] Bravo et al also reported the protective activity of the ethanolic extract of *Ocimum basilicum* against mutagenesis and oxidative DNA damage, with accompanying decrease in cholesterol synthesis and accumulation of lipid in human macro-phages.[79] Report by Wannissorn et al and Ahmet et al reveals that *Ocimum basilicum* exhibits antibacterial effect against a several bacteria including *C. perferingens, Salmonella spp., C. jejunii* and *E. coli*.[80 - 81] Also, Opalchenova and Obreshkova revealed that the plant aerial parts volatile oil elicits significant activity against drug immune clinical isolates of *Pseudomonas, Enterococcus* and *Staphylococcus*.[82] Patel et al have documented the significant antimicrobial effects of *Ocimum basilicum* from their study.[83] In vitro studies by Yamasaki et al revealed that *Ocimum basilicum* exhibits marked inhibitory actions against cytopathogenicity induced by HIV-1 in MT-4 cells.[84] Renzulli et al reported that rosmarinic acid (a compound present in *Ocimum basilicum*) has a significant inhibitory activity against inflammatory processes. In vitro studies reveal that rosmarinic reduces the production of oxygen species, as well as inhibits protein and DNA synthesis induced by mycotoxins, hence prevents cell death.[85] In vitro study on P388 and KB cell lines by Manosroi et al revealed that the essential oil *Ocimum basilicum* elicited moderate anti-proliferative activity compared to the standard drug, 5-fluorouracil.[86] Mohan et al reported the hypolipidemic and hypoglycemic activity of aqueous extract of *Ocimum basilicum* in laboratory rats. They observed marked reduction in serum lipid, lipid peroxidation products, blood glucose level, as well as improvement in glucose tolerance.[87]

Ocimum gratissimum

The antibacterial and antifungal efficacy of *Ocimum gratissimum* has been reported in various studies.[88 - 89] Pharmacological study of the aqueous extract revealed it has analgesic effect in mice,

stomach strip blocking effect in rat and inhibitory effect on rabbit jejunum pendular movement.[90] Report by Iwalokun et al revealed that the oil elicits a significant inhibitory activity against the virulent strains of Shigella, *E. coli* and Salmonella.[91] The hexane fraction exhibits a highly significant antimicrobial activity against *K. pneumonia* and *V. cholera*.[92] It is significantly active against *P. aeruginosa, S. typhi, V.cholera* and *N.gonorrhea*.[93] It has a good synergic activity with ampicillin, eliciting highly significant antibacterial effects against *E.coli* and *P. mirabilis*, and also possess similar synergic activity with nystatin and ketoconazole, eliciting significant antifungal effect against *C. albicans*.[94] The anti-diarrheal activity of the leaf extract was established in a study by Ilori et al which used the disc diffusion and tube dilution methods to ascertain its effect against bacteria *S. typhi, E. coli, S. dysenteriae, P. shigelloides* and *A. sobria*, and it proved to be a significant antibacterial agent.[95] Report by Pratheeba et al also revealed that the chloroform leaf extract had a good insecticidal effect against filariasis causing mosquito vector Culex quinquefasciatus.[96] The plant leave have been shown to possess a broad-spectrum anti-bacterial activity against *P. mirabilis, E. coli* and *S. aureus*.[97] The methanolic leaf extract have been reported to be active against nicotine toxicity due to its ability to decrease free radical generation and lipid-protein damage, and its antioxidant activity.[98] The aqueous leaf extract have been reported to show significant hypoglycaemic effect, reducing lipid MDA, LDL- cholesterol and triacylglycerol levels[99] and also, caused a marked decrease in the plasma glucose level in laboratory rats in streptozotocin induced diabetic model.[100] The aqueous leaf extract have been observed to inhibit proliferation, chemotaxis, induction of COX-2 protein and morphogenesis and as well decrease size of breast cancer tumor.[101] The dichloromethane leaf extract in an in vitro study inhibited myeloid leukemia,[102] hence, may be useful in treating human cancer. The methanolic crude leaf extract have been documented to be having haematinic and haemopoietic activity in laboratory rats.[103] Increase in erythrocytes, hemoglobin packed cell volume, thrombocytes and neutrophils count, as well as increase in platelet distribution width, mean platelet volume, and platelet–large cell ratio (P–LCR) have been observed to be elicited by the leaf extract.[104] Reduction in the serum total protein and urea level, packed cell volume, neutrophils and hemoglobin, and increase uric acid, in total acid, prostatic acid, phosphatases, leucocytes and lymphocytes have also been reported to be elicited by the plant.[105] Its leaf essential oil have been reported to show both fungistatic and fungicidal activity at different concentration against *A. alternata, S. rolfsii* and*C. capsici*.[106]

Ocimum kilimandscharicum

Hakkim et al evaluated the antioxidant potential of the Methanolic leaf extract of *Ocimum kilimandscharicum* using an in vitro model. They reported it to exhibit a moderate activity compared to butylated hydroxyl anisole (BHA).[107] Mwangi et al also carried-out an experiment to examine the antinociceptive activity of the alcoholic leaf extract of *Ocimum kilimandscharicum* in mice using the tailflick model. The outcome revealed it to be a significant antinociceptive agent. [108] Based on their in-vitro antiplasmodial study using dichloromethane extract of leaves and twigs of *Ocimum kilimandscharicum*, Owuor et al reported significant activity against both chloroquine resistant and chloroquine sensitive Plasmodium parasites, [109]while Runyoro et al reported that the oil elicited larvicidal activity on Culex quinquefasciatus larvae. [110] Using castor-oil induced diarrhoea model and castor oil induced enteropooling assay in rats; and charcoal meal test/intestinal motility test in mice, Serin et al demonstrated that the aqueous leaf extract has a significant anti-diarrheal activity. [111] Kumar et al reported the significant antimicrobial activity of volatile oil of whole plant of *Ocimum kilimandscharicum* against Gram negative bacteria (*E. coli, E. cloacae, Vibrio cholera, S. dysenteriae, P. aeruginosa, Klebsiella sp*), [112] while Shinde et al also reported its effectiveness against Gram positive bacteria (*S. aureus, S. epidermidis, S. mutans, S. viridians, B. subtilis, M. luteus*). [113] Monga et al also reported the antimelanoma and radioprotective effect of alcoholic aqueous extract in mice.[114] Jambere et al carried-out a laboratory test on the leaves of *Ocimum kilimandscharicum* against the following insects *Rhyzopertha dominica, Sitophilus zeamais, Sitotroga cerealella* in maize and sorghum grains to evaluate its insecticidal activity. The reported experimental outcome showed it to be an effective insecticidal agent.[115] Mahesh et al has also documented the significant wound healing activity of

the aqueous extract as a result of the experiment they carried out on laboratory rats, using the excision, incision and dead space wound model.[116]

Ocimum sanctum

Ocimum sanctum has been chronicled and described to be having several pharmacological activities. Report by Rahman et al reveals that *Ocimum sanctum* shows antimicrobial activity against wide range of bacteria including *Staphylococci sp., E. coli, Shigella sp., S. aureus, Enterobacteria sp., P. aernginosa, S. typhi, Staphylococci sp.,C. albicans, K. pneumonia, M. tuberculosis* and *M. pyogenes*. [117]According to an in vitro study by Farivar et al, *Ocimum sanctum* extract proved to be an effective anti-tuberculosis agent. [118] Khan et al reported that aqueous, hexane, choloroform, n-butanol extracts and essential oil of *Ocimum sanctum* showed significant antifungal activity against several fungi including *A. solani, C. guillermondii, C. capsici, Curvularia sp., F. solani, H. oryzae and A. flavus*.[119 - 120] Kelm et al also reported that the methanolic, hydroalcoholic and aqueous extracts of *Ocimum sanctum* elicits significant antioxidant activity, both *in vitro* and *in vivo*. [121] According to Geetha et al, Oral intake of *Ocimum sanctum* gives significant protection of liver and aortic tissue from hypercholesterolemia induced peroxidative damage.[122] Siva et al documented that the Oral administration of *Ocimum sanctum* extract significantly reduced blood sugar level in streptozotocin-induced and glucose-fed hyperglycemic diabetic rats. A different study by Gholap and Kar also showed that *Ocimum sanctum* reduced the serum concentration of cortisol and that of glucose and as well elicited antiperoxidative activity.[123] Aruna et al in their study revealed that *Ocimum sanctum* leaves significantly reduced the squamous cell hematoma incidences and carcinoma in experimental rats.[124] Result from a study by Ganasoundari et al revealed that *Ocimum sanctum* aqueous leaf extract inhibited hydroxyl (OH) radical-induced deoxyribose degeneration significantly. They also showed the synergic activity WR-2721 and *Ocimum sanctum* which produced a better effect against OH radical activity when compared with the individual agents alone.[125] Shetty et al performed an experiment to evaluate the activity of *Ocimum sanctum* aqueous leaf extract on tumor necrosis factor-Alfa (TNF-Alfa) in laboratory rats, using the excision model. The result showed that *Ocimum sanctum* extract increased the rate of epithelization and wound contraction, hence possesses a significant wound healing effect. [126] In antiulcer study carried-out by Govind et al in rats using aspirin, indomethacin, alcohol (ethanol 50%), histamine, reserpine, serotonin or stress-induced ulcers models, the oil of *Ocimum sanctum*showed significant antiulcer activity. [127] Mediratta et al, reported that steam distilled leave extract of *Ocimum sanctum*caused modification in laboratory rat humoral immune response and this could be attributed to antibody production, release of mediators of hypersensitivity reactions and tissues responses to mediators in the target organs.[128] Godhwani et al in a separate experiment also demonstrated the immunomodulatory effect of *Ocimum sanctum* using widal and sheep erythrocyte agglutination tests. [129] Sridevi et al showed that *Ocimum sanctum* has significant benefits when employed in the treatment of asthma and other related conditions. They also reported that *Ocimum sanctum* has the potential to cause mast cell stabilization, suppression of IgE and inhibition of release of inflammatory mediators, hence, may be the cause of these effects. [130] According to Ravindran et al, *Ocimum sanctum* normalizes noise stress induced alteration in neurotransmitter levels due to, and this is a proof of its anti-stress activity. [131] Asha et al showed the significant antihelmentic activity of *Ocimum sanctum* essential oil using the caenorhabditis elegans model.[132] Different extracts of stem and leaves of *Ocimum sanctum* were subjected to experimental studies for anticonvulsant activity by maximal electroshock model using phenytoin as standard, and was observed the that ethanol and chloroform extract of leaf and stem produced significant preventive effect against toxic convulsions induced by trans corneal electroshock. [133] *Ocimum sanctum* have also been shown to have strong cardio protective effect against myocardial agents. An experiment by Sood et al revealed that *Ocimum sanctum* elicited significant protection against isoproterenol-induced myocardial necrosis in laboratory rats by increasing the activity endogenous antioxidants. [134] Joshi et al reported that *Ocimum sanctum* L. alcoholic extract ameliorated scopolamine-induced amnesic effect as well as memory deficits caused by aging in laboratory mice. *Ocimum sanctum* both increased significantly step-down latency (SDL) and acetylcholinenesterase inhibition. This may be useful in the treatment

of dementia, alzheimer's disease and other cognitive disorders.[135] *Ocimum sanctum* have been documented to have significant antidote effect against dog bite, snake bite, scorpion bite and insect bites.[136]

Con clusion

Ocimum species have been employed traditional for therapy globally. The species reviewed are the most widely used from the Ocimum genus in traditional medicine and they are also the most researched for intended use in conventional therapeutic practice. These species contain several compounds which are responsible for the numerous pharmacological activities elicited by them including antimalarial, anticancer, antidiabetic, antiinflammatory and antioxidant effects.

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