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Therapeutic potential and phytopharmacology of tulsi

Renu Kadian[1]* and Milind Parle[2]
1, IIMT College of Pharmacy, Greater Noida, (U.P.) - India
2, Pharmacology Division, Department of Pharmaceutical Sciences, Guru Jambeshwar University of Science and Technology, Hisar, (Haryana) - India

Abstract

World health organization (WHO) has advocated the evaluation of therapeutic potential of plants for diseases where we lack safe allopathic drugs. *Ocimum sanctum* described as sacred and medicinal plant in ancient literature, commonly known as *Tulsi* is derived from *'Sanskrit'*, which means "the incomparable one". This plant belongs to the family Lamiaceae which is native throughout the Old World tropics and cultivated for religious and medicinal purposes. Several medicinal properties have been attributed to the plant not only in Ayurveda and Siddha but also in Greek, Roman and Unani. It is widely known across South Asia as a medicinal plant and an herbal tea. The chemical constituents isolated from various parts of the plant include eugenol, cardinene, cubenol, borneol, linoleic acid, linolenic acid, oleic acid, palmitric acid, steric acid, Vallinin, Vicenin, Vitexin, Vllinin acid, Orientin, Circineol, Gallic Acid, vitamin A, vitamin C, phosphrous and iron. *Ocimum sanctum* has been shown to possess multifarious medicinal properties such analgesic activity, anti-ulcer activity, antiarthritic activity, immunomodulatory activity, antiasthmatic activity, antifertility activity, anticancer activity, anticonvulsant activity, antidiabetic activity, antihyperlipidemic activity, anti-inflammatory activity, antioxidant activity, antistress activity in addition to possessing useful memory enhancer and neuroprotective activity. The present review article provides up-to-date information on the therapeutic potential of tulsi. We have tabulated the chemical constituents of *Ocimum sanctum*. This review article will help the scientists working in the area of traditional medicines and medicinal food in their research.

Key-Words: *Ocimum sanctum*, Tulsi, Chemical constituents, medicinal properties

Introduction

Plants are of the important sources of medicine & a large numbers of drugs in use are derived from plants. The therapeutic uses of plant are safe, economical & effective as their ease of availability[1]. Among the plants known for medicinal value, the plants of genus Ocimum belonging to family Lamiaceae are very important for their therapeutic potentials. *Ocimum sanctum* has two varieties i.e. black (*Krishna Tulsi*) and green (*Rama Tulsi*), their chemical constituents are similar[2]. *Ocimum sanctum* is widely distributed covering the entire Indian sub continent, ascending up to 1800 m in the Himalayas and as far as the Andaman and Nicobar Island[3]. Tulsi is a Sanskrit word which means "the incomparable one" and has a very special place in the Hindu culture. Several medicinal properties have been attributed to the Tulsi plant not only in Ayurveda and Siddha but also in Greek, Roman and Unani systems of medicine[4].

*** Corresponding Author**
E.mail: renukadian23@gmail.com
Mob.: +91- 9560538683

Various synonyms used in India (refer table I) and all over the world (refer table II) for *Ocimum sanctum* have also been enumerated in this review article. The phytoconstituents isolated from various parts of the plant include eugenol, cardinene, cubenol, borneol, linoleic acid, linolenic acid, oleic acid, palmitric acid, steric acid, Vallinin, Vicenin, Vitexin, Vllinin acid, Orientin, Circineol, Gallic Acid, vitamin A, vitamin C, phosphrous and iron (refer table III). *Ocimum sanctum* is one such plant showing multifarious medicinal properties viz. analgesic activity, anti-ulcer activity, antiarthritic activity, immunomodulatory activity, antiasthmatic activity, antifertility activity, anticancer activity, anticonvulsant activity, antidiabetic activity, antihyperlipidemic activity, anti-inflammatory activity, antioxidant activity, antistress activity in addition to possessing useful memory enhancer and neuroprotective activity. (refer table IV). This review article summarises various phytoconstituents present in *Ocimum sanctum*, enlists various biological activities of *Ocimum sanctum.*

Table I: Synonyms of Tulsi in Indian Languages

S/No	Name	Language	State/Region
1.	Tuloxi, Tulasii.	Assamese	Assam , North-East India
2.	Tulsi, Kalotulsi, Kural	Bengali	West Bengal
3.	Tulsi, Niyan Posh	Dogri	Himachal Pradesh
4.	Sabje, Talasi	Gujarati	Gujarat
5.	Karitulasi,, Tulasiya	Kannada	Karnataka
6.	Pachcha, Kunnakam	Malayalam	Kerala
7.	Mayangton, Naoshek lei	Manipuri	North-eastern India
8.	Sabja, Tulasa	Marathi	Maharashtra
9.	Dhala tulasi, Karpura	Oriya	Orissa
10.	Tulsi	Punjabi	Punjab
11.	Tulsi, Manjari, Ajaka	Sanskrit	India, Nepal, Bengladesh
12.	Tiruttizhai, Tiviragandam	Tamil	Tamilnadu
13.	Oddhi, Rudrajada	Teligu	Andhra Pradesh
14.	Tulsi, Janglitulsi	Urdu	Kashmir, North India

Table II: Synonyms of Tulsi in International Languages

S/No	Name	Language	Country/Region
1.	Dohsh, Schadjant, Vasub	Arabic	Middle East , North Africa
2.	Shahasbram, Rehan	Armenian	Armenia
3.	Bosilek	Bulgarian	Bulgaria
4.	Laun, Pinzainpinzin	Burmese	Burma
5.	Loh lahk, Yu heung choi	Chinese	China
6.	Basilikum	Danish	Denmark, Greenland
7.	Baziel, Koningskruid	Dutch	Netherlands, South Africa
8.	Basilie, Sweet Basil	English	England
9.	Basilika	Finnish	Finland, Sweden, Norway
10.	Basilic sacre, Herbe royale	French	France
11.	Rekhani, Rehani	Georgian	Georgia
12.	Indisches Basilikum	German	Germany
13.	Besil, Tulsi, Jangli tulsi	Hindi	India
14.	Basilika	Icelandic	Iceland
15.	Basilico	Italian	Italy
16.	Bajiru, Kami-meboki	Japanese	Japan
17.	Che tak, Mareah proeu	Khmer	Cambodia
18.	Naruk-pul, Yanggajuk	Korean	Korea
19.	Saphaa, Phak i tou thai	Laotian	Northeast of Thailand
20.	Kemangi, Selasi jantan,	Malay	Malaya
21.	Tulsi patta, Bavari phul,	Nepali	Nepal
22.	Madurutala, Mudura tulla.	Sinhalese	Sri Lanka
23.	Alfabega, Albacar	Spanish	Spain
24.	Basilika, Basilkaort	Swedish	Sweden and Finland
25.	Horapa, Kaphrau	Thai	Thailand
26.	Nhu tia, Cay hung que	Vietnamese	Vietnam

Table III: Phytochemicals Present in *Ocimum sanctum*

S/No	Extracts	Phyto Chemicals	Plant Parts
1.	Fixed oil [5]	Linoleic acid, Linolenic acid, Oleic acid, Palmitric acid, Stearic acid.	Seeds
2.	Essential oil [6, 7, 27]	Aromadendrene oxide, Benzaldehyde, Borneol, Bornyl acetate, Camphor, Caryophyllene oxide, cis-α-Terpineol, Cubenol, Cardinene, D-Limonene, Eicosane, Eucalyptol, Eugenol, Farnesene, Farnesol, Furaldehyde, Germacrene, Heptanol, Humulene, Limonene, n-butylbenzoate, Ocimene, Oleic acid, Sabinene, Selinene, Phytol, Veridifloro, α-Camphene, α-Myrcene, α-Pinene, β-Pinene, α-Thujene, β-Guaiene, β-Gurjunene, methyl chavicol and linalool.	Leaves
3.	Mineral Contents[8]	Vitamin C, Vitamin A, Calcium, Phosphours, Chromium, Copper, Zink, Iron.	Whole Plant
4.	Alcoholic Extract [2]	Aesculectin, Aesculin, Apgenin, Caffiec acid, Chlorgenic Acid, Circineol, Gallic Acid, Galuteolin, Isorientin, Isovitexin, Luteolin, Molludistin, Orientin, Procatechuic acid, Stigmsterol, Urosolic acid, Vallinin, Viceni, Vitexin, Vllinin acid.	Leaves/ Areal Parts

Table IV: Medicinal Properties of Tulsi

S/No	Pharmacological Activity	Plant Parts	Extracts
1.	Analgesic Activity	Leaves/seeds	Aqueous Suspension / Fixed oil
2.	Anti ulcer Activity	Seeds	Fixed oil
3.	Antiarthritic Activity	Seeds	Fixed oil
4.	Antiasthmatic Activity	Leaves	Hydroalcholic Extract
5.	Antibacterial Activity	Leaves	Aqueous / Chloroform/ Alcohol extract/ Fixed oil
6.	Anticancer Activity	Leaves	Alcoholic extract
7.	Anticataleptic Activity	Leaves	Alcoholic Extract.
8.	Anticataract Activity	Leaves	Aqueous Extract
9.	Anticoagulant Activity	Fixed oil	Fixed oil
10.	Anticonvulsant Activity	Stem/ Leaves	Alcholic/ Chloroform extract
11.	Antidiabetic Activity	Whole Plant	Aqueous decoction
12.	Antiemetic Activity	Leaves	Leaf Extract
13.	Antifertility activity	Leaves	Benzene extract
14.	Antifungal Activity	Leaves	Essential oil
15.	Anti-helminthic Activity	Leaves	Essential oil
16.	Antihyperlipidemic Activity	Seeds/Leaves	Fixed oil, Essential oil
17.	Antihypertensive Activity	Seeds	Fixed oil
18.	Antiinflammatory Activity	Whole Plant	Alcholic extract/ fixed oil
19.	Antioxidant Activity	Whole plant	Alcoholic extract
20.	Antiplasmodial Activity	Leaves	Alcholic extracts
21.	Antipyretic Activity	Seeds	fixed oil
22.	Anti-spasmodic Activity	Leaves	Leaf infusion
23.	Antistress Activity	Whole Plant	Alcholic extract
24.	Antithyroidic Activity	Leaves	Leaf extract
25.	Antitussive Activity	Areal Parts	Aqueous / Alcholic extract
26.	Antianxiety Activity	Leaves	Alcholic extract
27.	Antidepressant Activity	Leaves	Alcholic extract

S/No	Pharmacological Activity	Plant Parts	Extracts
28.	Cardioprotective Activity	Whole Plant	Fixed oil
29.	Chemopreventive Activity	Seeds	Fixed oil
30.	Demulcent/Stimulant/expectorant.	Leaves	Leaf juice
31.	Eye Disease	Leaves	Leaf juice
32.	Genoprotective Activity	Leaves	Hydroalcholic extract
33.	Hepatoprotective Activity	Leaves	Hydroalcholic extract
34.	Immunomodulatory Activity	Seeds/ Whole Plant	Seed oil /Aquous extract
35.	Memory Enhancer Activity	Whole Plant/ Leaves	Aquous / Alcoholic Extract.
36.	Larvicidal Activity	Seeds	Fixed oil
37.	Neuroprotective Activity	Leaves	Alcholic extract
38.	Piles	Seeds	Fixed Oil
39.	Radio-protective Activity	Leaves	Alcholic extract

Analgesic Activity: Singh et al., in 1995 studied the analgesic activity of fixed oil from the seeds of *Ocimum sanctum* (OS) in mice and rats using the tail flick, tail clip, tail immersion and acetic acid-induced writhing methods. It was found it be effective against acetic acid induced writhing in dose dependent manner, suggesting that writhing inhibiting activity of the oil is peripherally mediated due to combined inhibitory effects of prostaglandins, histamine and acetylcholine.[9]

Antiulcer Activity: The aqueous extract of *Ocimum sanctum* (100mg /kg an 200 mg/kg orally) exhibited significant protection against ethanol induced gastric ulceration in Wistar rats. OS exhibits antiulcer activity by enhancing antioxidant potential of gastric mucosa there by reducing mucosal damage.[10] The fixed oil of OS administered i.p. shows significant antiulcer activity against aspirin, indomethacin, alcohol (ethanol 50%), histamine, reserpine, serotonin or stress-induced ulcers in rats. The fixed oil significantly possessed antiulcer activity due to its lipoxygenase inhibitory, histamine antagonistic and antisecretory effects.[11]

Antiarthritic Activity: The fixed oil of *Ocimum sanctum* seeds was screened for antiarthritic activity by Singh et al. in 1996 using Freund's adjuvant arthritis, formaldehyde-induced arthritis and turpentine oil-induced joint edema in rats. The fixed oil showed significant anti-arthritic activity in both models and anti-edema activity against turpentine oil-induced joint edema.[12]

Antiasthmatic Activity: 50% aqueous ethanol extract of dried and fresh leaves, and the volatile and fixed oils of OS was evaluated against histamine and acetylcholine induced preconvulsive dyspnea (PCD) in guinea pigs. The 50% ethanol extract and volatile oil extracted from fresh leaves and fixed oil from the seeds significantly protected the guinea pigs against histamine and acetylcholine induced pre convulsive dyspnea. However, the 50% ethanol extract of dried leaves did not protect the guinea pigs against histamine induced preconvulsive dyspnea.[13]

Antibacterial Activity: Antibacterial activity of the aqueous, alcoholic, chloroform extract and oil obtained from leaves of Ocimum sanctum were studied against E.coli, P.aeruginosa, S. typhimurium and S.aureus. Extract obtained from OS were observed equally effective against pathogenic gram positive and gram negative bacteria.[14] **Anticancer Activity:** Antimelanoma activity of 50% alcoholic aqueous leaf extract of different species of Ocimum was studied by Monga et al. in 2011. Leaf extract administered orally (200mg/kg, p.o.) resulted in significant reduction in tumor volume, increase in average body weight, and survival rate of mice.[15]

Anticataleptic Activity: Aswar at all in 2010 studied the anticataleptic activity of the aqueous extract (300 mg/kg, i.p) and the alcoholic extract (300 mg/kg, i.p) of the leaves of *Ocimum sanctum* and observed a significant ($P < 0.001$) reduction in cataleptic scores.[16]

Anticataract Activity: The Aqueous Extract of fresh leaves of OS (1g/kg and 2 g/kg) significantly delayed the the onset as well as subsequent maturation of cataract in galactosemic cataract model in rats by 30% galactose and naphthalene cataract model in rabbits by 1 g/kg naphthalene.[11]

Anticoagulant Activity: *Ocimum sanctum* fixed oil (3 ml/kg, ip) was studied for anticoagulant activity. It was observed that blood clotting time was prolonged and the response was comparable to that obtained with aspirin (100 mg/kg). The effect appears to be due to the anti-aggregatory action of oil on platelets.[17]

Anticonvulsant Activity: Different extractives of stem, leaf and stem callus of *Ocimum sanctum* were tested for anticonvulsant activity against standard drug phenytoin using maximal electroshock (MES) model. Ethanol and chloroform extractives of stem, leaf and stem calli were effective in preventing tonic convulsions induced by transcorneal electroshock.[18]

Antidiabetic Activity Ten fractions (F1-F10) were isolated from hydroalcoholic extract of OS aerial part by column chromatography. All the fractions F1 to F10 were screened for antidiabetic activity in alloxan induced diabetic rats by estimating serum glucose level and lipid parameters. The bioactive fraction (F5) was found to be potent antidiabetic by ameliorating glucose and lipid parameters (total cholesterol, triglycerides, low and high density lipoprotein cholesterol). The extensive spectroscopic data analysis reveals that, the isolated bioactive compound elucidated as tetracyclic triterpenoid.[19] Hannan et al., in 2006 studied the effects of ethanol extract and five partition fractions of OS leaves on insulin secretion together with an evaluation of their mechanisms of action and concluded that *Ocimum sanctum* leaf extracts stimulate insulin secretion from perfused pancreas, isolated islets and clonal pancreatic–cells.[20] The antidiabetic effects of Ethyl acetate, Petroleum-ether, and Chloroform fractions from ethanolic extract of the leaves of OS were investigated in normal and alloxan induced diabetic rats (AIDRs). Administration of these fractions to the AIDRs resulted in the significant elevation of liver glycogen content. In diabetic rats, SGOT and SGPT levels were significantly elevated that were further reduced after i.p. administration of these fractions. These results indicate that different fractions of OS have favorable effects in bringing down the severity of diabetes together with hepatoprotectivity.[21] Methanolic extracts of leaves of various Ocimum species were explored and compared for antidiabetic activity. All extracts were able to show antidiabetic activity at 0.5 mg/Kg concentration. The activities are well comparable with the standard drug, glibenclamide. The methanolic extract of OS showed better antidiabetic activity in comparison with other species of Ocimum and standard drug. The data were verified as statistically significant by using one way ANOVA at 5 % level of significance ($p < 0.05$).[22]

Antiemetic Activity: Tulsi leaves also check vomiting and used for antiemetic action.[23]

Antifertility activity: Treatment of albino rats with a benzene extract of *Ocimum sanctum* leaves (250 mg/kg body weight) for 48 days decreased total sperm count, sperm motility, and forward velocity. The results suggest that such effects are due to androgen deprivation, caused by the anti-androgenic property of OS leaves. The effect was reversible because all parameters returned to normal 2 week after the withdrawal of treatment.[24] A significant decrease was noted in the sperm count in rabbits. Serum testosterone levels showed marked increase while FSH and LH levels were significantly reduced in OS-treated rabbits (2 g fresh leaves/rabbit for 30 days). The results suggest the potential use of OS as an effective male contraceptive agent.[25]

Antifungal Activity: Methyl chavicol and linalool obtained from essential oil of Ocimum sanctum showed significant antifungal activity against Candida, including azole-resistant strains. Their fungicidal action resulted from extensive lesions of the plasma membrane and a considerable reduction in the amount of ergosterol.[26] Antifungal activity of Ocimum sanctum leaves was determined against clinically isolated dermatophytes. Minimum inhibitory concentration (MIC) and minimum fungicidal concentration (MFC) of various extracts and fractions of OS leaves were also determined against dermatophytic fungi used.[27]

Anti-helminthic Activity: The essential oil of Ocimum sanctum and eugenol, tested in vitro, showed potent anthelmintic activity in the Caenorhabditis elegans model.[28]

Antihyperlipidemic and Cardioprotective Activity Suanarunsawat et al in 2010, studied the antihyperlipidemic and cardioprotective activity of *Ocimum sanctum* fixed oil in rats fed with a high fat (HF) diet and concluded that treatment with OS fixed oil decreased the high serum lipid profile and expressed antiartherogenic and cardioprotective actions against hyperlipidemia. The anti-hyperlipidemic action of OS fixed oil was mainly resulted from the suppression of liver lipid synthesis. Linolenic acid and linoleic acid contained in Ocimum sanctum fixed oil were possibly responsible for both lipid-lowering and cardiac protective action against hyperlipidemia.[29]

Antihypertensive Activity: The OS fixed oil administered i.v. produced hypotensive effect in anaesthetized dog, which seems to be due to its peripheral vasodilatory action. Essential fatty acids like linoleic and linolenic acids, contained in the OS oil produce series 1 and 3 (PGE1 and PGE3) prostglandins and inhibit the formation of series 2 prostglandins (PGE2).[11]

Antiinflammatory Activity: *Ocimum sanctum* fixed oil and linolenic acid were found to possess significant antiinflammatory activity against PGE2, leukotriene and arachidonic acid-induced paw edema. Plant lipids like linseed oil and soyabean oil containing linolenic acid when tested along with OS fixed oil, also showed significant inhibition of carrageenan-induced paw edema. The results suggest that linolenic acid present in OS O fixed oil has the capacity to block both the cyclooxygenase and lipoxygenase pathways of arachidonate metabolism and could be responsible for the antiinflammatory activity of the oil.[30] Different extracts of stem, leaf and stem calli of OS were tested

for antiinflammatory activity using carrageenan-induced rat paw oedema model in comparison with the standard indomethacin. The ethanol extract of callus tissue exhibited maximum significant antiinflammatory activity out of all extracts studied followed by ethanol extracts of leaves of OS.[31] Anti-inflammatory activity of essential oil extract of *Ocimum sanctum* L. leaf (Eugenol) was studied in wistar rats by using carrageenan induced hind paw edema method. The extract was administred 100 mg/kg body weight per i.p and the standard paracetamol was also administered 5 mg/kg body weight per i.p. The extracted Eugenol and paracetamol exhibited significant ($p< 0.05\%$) activity when compare with carrageenan control.[32]

Antioxidant Activity: Muralikrishnan et al., in 2012 studied the antioxidant effects of *Ocimum sanctum* in experimental streptozocin-induced diabetic rats. Administration of OS to streptozocin-induced diabetic rats for 30 days significantly reduced the plasma level of thiobarbituric acid reacting substances and improved the status of the antioxidant enzymes catalase, superoxide dismutase and glutathione peroxidase in vital organs such as the liver and kidney.[33] A hydroalcoholic extract of OS leaves has been investigated for its antioxidant activity in animal models of peptic ulcer with the aim of exploring a possible correlation between its antioxidant and antiulcer activities. The antioxidant activity was by evaluated by estimating plasma malondialdehyde (MDA) in ethanol treated rats and histamine treated guinea pigs and estimating superoxide dismutase (SOD) in pyloric ligated rats and histamine treated guinea pigs. In ethanol treated rats and histamine treated guinea pig ocimum sanctum leaf extract (100 mg/kg & 200 mg/kg) significantly decreased the levels of MDA in comparison the diseased control. The extract (100 mg/kg & 200 mg/ kg) also increased the levels of SOD in pyloric ligated rats and histamine treated guinea pigs when compared to the diseased control.[34]

Antiplasmodial Activity: Leaf extract, root extracts, the stem and flower extracts of OS showed excellent antiplasmodial activity in a study carried out by Inbaneson et all in 2012 on three different species of ocimum. The in vitro antiplasmodial activity might be due to the presence of alkaloids, glycosides, flavonoids, phenols, saponins, triterpenoids, proteins, resins, steroids and tannins in the ethanolic extracts of tested plants.[35]

Antipyretic Activity: The antipyretic activity of OS fixed oil was evaluated by testing it against typhoid-paratyphoid A/B vaccine-induced pyrexia in rats. The oil on ip administration considerably reduced the febrile response indicating its antipyretic activity. At a dose of 3 ml/kg, the antipyretic activity of the oil was comparable to aspirin. Further, the fixed oil possessed prostaglandin inhibitory activity and the same could explain its antipyretic activity.[11]

Antistress Activity: Fresh leaves of Ocimum sanctum were evaluated for antistress activity against experimentally induced oxidative stress in albino rabbits by Jyoti et al in 2007.[36]

Antithyroidic Activity: Effects of *Ocimum sanctum* leaf extract was investigated on the changes in concentrations of serum T3, T4 in the male mouse. OS leaf showed anti-thyroidic activity.[37]

Antitussive Activity: Aqueous and methonolic extract of *Ocimum sanctum* was studied for antitussive activity in guinea pigs at the doses of 1.55 gms and 0.875 gms/kg body wt respectively. Cough was induced by exposure to the aerosol of citric acid (7.5% w/v). The study showed that both the test extracts posses significant antitussive activity and aqueous extract showed a higher activity than the methonolic extract.[38]

Antianxiety and Antidepressant Activity: Chatterjee et all. In 2011 studied the effect of ethanol extract of leaves of *Ocimum sanctum* in Swiss albino mice, against both anxiety and depressive disorder. Depression was studied through tail suspension test and forced swim test. Anxiety experiments included light dark test, elevated plus maze test, and holeboard test. The *Ocimum sanctum* extracts shows antianxiety and antidepressant properties at the same dose and can be a potential therapeutic agent against mixed anxiety and depressive syndrome.[39]

Chemopreventive Activity: The seed oil of *Ocimum sanctum* was evaluated for chemopreventive activity against subcutaneously injected 20-methylcholanthrene induced-fibrosarcoma tumors in the thigh region of Swiss albino mice. The enhanced survival rate and delay in tumor incidence was observed in seed oil supplemented mice. Potential chemopreventive activity of the oil is partly attributable to its antioxidant properties. The chemopreventive efficacy of 100 microl/kg seed oil was comparable to that of 80 mg/kg of vitamin E.[40] OS has been investigated for its chemopreventive activity against 7, 12-dimethylbenz (a) anthracene (DMBA)-induced hamster buccal pouch carcinogenesis. OS, in the form of fresh leaf paste, aqueous extract and ethanolic extract were topically applied and the extracts were orally administered to buccal pouch mucosa of animals exposed to 0.5% of DMBA. Incidence of papillomas and squamous cell carcinomas were significantly reduced, and increased the survival rate in the topically applied leaf paste and orally administered extracts to animals. Among them,

the orally administered aqueous extract showed profound effect than the other two forms.[41]

Demulcent/Stimulant/expectorant: Traditionally, juice of the leaves of OS plant was used as demulcent, stimulant, expectorant. The seeds are mucilaginous and demulcent and are given in different ailments of genito-urinary system. An infusion of leaf had been used as anti-spasmodic in gastric disorders of children.[2]

Eye Disease: The leaf juice of *Ocimum sanctum* along with triphla is used in ayurvedic eye drop preparations recommended for glaucoma, chronic conjunctivitis & other painful eye disease. In daily routine one may use about three drops of tulsi oil alog with honey and it is supposed to improve eye sight.[19]

Genoprotective Activity: Protective effect of *Ocimum sanctum* was evaluated on chlorpyrifos-induced genotoxicity in in vivo and in vitro models. It was observed that rats pretreated with OS extract, showed a significant ($P<0.01$) increase in mitotic index a significant decrease in the frequency of aberrant cells as compared to the rats treated with chlorpyrifos alone. A significant ($P<0.05$) increase in chromosomal aberrations was observed in cultures treated with 75 µg/ml chlorpyrifos as compared to controls, which decreased significantly ($P<0.05$) with Ocimum sanctum extract pretreatment.[42]

Hepatoprotective Activity: Lahon et al. in 2011 studied hepatoprotective activity of Ocimum sanctum alcoholic leaf extract against paracetamol-induced liver damage in Albino rats synergism with silymarin and concluded that Ocimum sanctum alcoholic leaf extract showed significant hepatoprotective activity and synergism with silymarin.[43]

Immunomodulatory Activity: Jeba et al. in 2011 studied that aqueous extract of Ocimum sanctum at the oral doses of 100, 200 mg/kg/day in rats enhances the production of RBC, WBC, haemoglobin and also enhanced the production of antibodies without affecting the biochemical parameters.[44]

Larvicidal Activity: Larvicidal activity of essential oils and different extracts of Ocimum. Sanctum, O. basilicum and O. gratissimum were compared on laboratory reared and field collected larvae of Culex quinquefasciatus. The LD50 value of O. basilicum and O. sanctum oil were 39.31 and 40.02 on laboratory reared larvae and 129.53 and 139.49 on field collected larvae. Laboratory reared larvae were more sensitive than field collected larvae.[45] The acetone, chloroform, ethyl acetate, hexane, and methanol leaf and flower extracts of Ocimum sanctum were studied against fourth instar larvae of Aedes aegypti and Culex quinquefasciatus. The highest larval mortality was found in leaf extract of O. sanctum against the larvae of A. aegypti and C. quinquefasciatus.[46]

Memory Enhancer Activity: Aqueous (300 and 500 mg/kg) and alcoholic (300 and 500 mg/kg) extracts of *Ocimum sanctum* Linn. Leaves were studied for antidementic and anticholinesterase effect in rats. Maximal electroshock, atropine, and cyclosporine were used to induce dementia. The passive avoidance task was used for assessing memory. Acetylcholinesterase (AChE) activity was estimated in different parts of the brain, and immune status was studied using dinitrochlorobenzene (DNCB) skin sensitivity tests. In all the three models both aqueous and alcoholic OS extracts decreased the time taken to reach the shock-free zone and the number of mistakes and significantly decreased the AChE activity in rats. OS treatment significantly increased the induration in the DNCB skin test. Therefore, OS was shown to be useful for the management of experimentally induced cognitive dysfunctions in rats.[47] The alcoholic extract of dried whole plant of OS ameliorated the amnesic effect of scopolamine (0.4 mg/kg) and aging-induced memory deficits in mice. Passive avoidance paradigm served as the exteroceptive behavioural model. OS extract increased step-down latency (SDL) and acetylcholinesterase inhibition significantly.[48] Various behavioural tests and biochemical were performed to explore the possible role of OS in alzheimer's disease.OS exhibited anxiolytic activity in open field test. In elevated plus maze test OS significantly allevated ibotenic acid and colchicine induced anxiety and depression in Porsolt's swim test. In Morris' water maze test, OS pretreatment improves reference memory, working memory and spatial learning. Both ibotenic acid and colchicine induced deficits in active avoidance learning and retention of learned behaviour were significantly reversed. OS might be effective in clinical Alzheimer's disease by virtue of its cognition enhancement, antidepressant and antianxiety properties, which are primary needs to be addressed in alzheimer's disease.[49]

Neuroprotective Activity: *Ocimum sanctum* shows ameliorative potential in attenuating vincristine-induced peripheral neuropathic pain in rats, which may be attributed to decrease in oxidative stress and calcium levels. Administration of OS (100 and 200 mg/kg p.o.) and its saponin rich fraction (100 and 200 mg/kg p.o.) for 14 days significantly attenuated vincristine-induced neuropathic pain along with decrease in oxidative stress and calcium levels.[50]

Radio-protective Activity: Joseph et al., in 2011 studied the radioprotective effect of *Ocimum sanctum* on the salivary gland of rats administered radioiodine

((131)I) and compared its efficacy with a known radioprotectant, amifostine. OS and amifostine presupplemented and subsequently exposed to (131)I rats at 3 and 6 months duration exhibited comparable histopathology with controls. The study indicated possible radioprotective effect of OS and amifostine against high-dose (131)I exposure.[51] Flavonoids extracted from the leaves of, OS were studied as a raddioprotector on the erythrocyte antioxidants in oral cancer. Results of the study suggest that erythrocytes from cancer patients responded to oxidative stress by elevating glutathione levels, while a decrease in glutathione levels observed in OS flavonoids treated patients , could be due to the free radical scavenging effect of OS flavonoids, sparing the glutathione. However OS flavonoids did not seem to exert its effect on other antioxidants of erythrocytes.[52]

Conclusion: Plants have been used for the treatment of diseases throughout the world since the beginning of civilization. Tulsi is cultivated for religious and medicinal purposes. It is widely known across South Asia as a medicinal plant and an herbal tea. Several medicinal properties have been attributed to the plant not only in Ayurveda and Siddha but also in Greek, Roman and Unani.The vast survey of literature showed that *Ocimum sanctum* has a huge spectrum of pharmacological activities. It has an esteemed status in herbs with diverse biological potentials and has a great scope for further new area of investigations. Traditionally crude extracts of various parts of plants have been used for their antidiabetic, antioxidant, antistress, antihyperlipidemic and antibacterial properties. Future research on sacred basil should be emphasized for control of various diseases especially it should be explore as a significant remedy regarding neuropsychological disorders for the welfare & service of mankind.

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