

***Ocimum sanctum*: a review on the pharmacological properties**Siva M.¹, Shanmugam KR^{1*}, Shanmugam B.², Venkata Subbaiah G.², Ravi S.²,
Sathyavelu Reddy K.², Mallikarjuna K³¹Department of Zoology, T.R.R. Government Degree College, Kandukur, Andhra Pradesh, India²Division of Molecular Biology and Ethanopharmacology, Department of Zoology, Sri Venkateswara University, Tirupati, India³Institute of Nutrition (16F), China Medical University, No.91, Hsueh-Shih Road North District, Taichung, Taiwan**Received:** 08 April 2016**Accepted:** 07 May 2016***Correspondence to:**
Shanmugam KR,
Email: krshanmugamphd@gmail.com**Copyright:** © the author(s), publisher and licensee Medip Academy. This is an open-access article distributed under the terms of the Creative Commons Attribution Non-Commercial License, which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.**ABSTRACT**

Herbal medicine, the backbone of traditional medicine in many countries have played an important role in curing the diseases of humans since ancient time. Medicinal plants are great source of bioactive compounds and chemical structures that have potential beneficial effects. The present review compiles information on ethnopharmacologically useful information and pharmacological properties of *Ocimum sanctum*. *Ocimum sanctum* (OS) has many medicinal properties like antioxidant, antidiabetic, antiulcer, anticancer, antibacterial, antifungal and other. The phytochemicals compounds of *Ocimum*, alkaloids, flavonoids, phenolics, essential oils, tannins and saponins play an important role in herbal medicine. Bioactive compounds of *Ocimum* responsible for its various medicinal properties and their effects at the molecular level need to be investigated in more detail. Furthermore, pharmacological properties of bioactive compounds in *Ocimum sanctum* are required to confirm the ethnomedicinal claims of *Ocimum sanctum* for pharmaceutical therapeutic applications.

Keywords: Herbal medicine, *Ocimum sanctum*, Pharmacological properties**INTRODUCTION**

Nature has many useful herbs and plants for human beings. In the 20th century peoples in world mostly depends on traditional medicine for their health problems or diseases due to their safety. Nature has provided a complete storehouse of remedies to cure ailment of mankind. About 80% of the world's population depends wholly or partially on traditional medicine for its primary health care needs.¹

According to a survey of World Health Organization the practitioners of traditional system of medicine treatment about 80% of in India, 85% in Burma and 90% in Bangladesh.² A majority of world's population in developing countries still relies on herbal medicines to meet its health needs. In recent times, focus on herbal research has increased globally and evidence collected from different research survey shows the immense potential of medicinal plants. The attention paid by health authorities to the use of herbal medicines has increased

considerably, because herbal drugs are often the only medicine available in less developed areas³ Today large number of drugs are in use are derived from plants, like morphine from *Papaver somniferum*, aswagandha from *Withania somnifera*, ephedrine from *Ephedra vulgaris*, atropine from *Atropa belladonna*, reserpine from *Roulphia serpentina* etc.

The medicinal plants are rich in secondary metabolites (which are potential sources of drugs) and essential oils of therapeutic importance. Some of the most important bioactive phytochemical constituents in plants are alkaloids, flavonoids, phenolics, essential oils, tannins and saponins.⁵ The plants known as medicinal plants are rich in the secondary metabolites, which include alkaloids, glycosides, steroids and relative active metabolites which are used as drugs in pharmaceutical industry.⁶ The secondary metabolites are accumulated by plants in their leaves, roots and other organs. Despite the fact their biosynthetic origin and role in the plant are poorly understood, secondary metabolites are of considerable interest because of their potential industrial, pharmacological and medicinal value.⁷ These secondary metabolites have been reported to have multiple biological effects, including antioxidant activity. Potential sources of antioxidants have been found in leaves, oilseeds, barks and roots.⁸ Natural antioxidants from plant sources are potent and safe due to their harmless nature and wild herbs have been investigated for their antioxidant properties.⁹

The important therapeutic advantages of medicinal plants are: they are safe, economical, effective and easy availability.² Although the traditional medicinal practitioners in Indian subcontinent have been widely using this medicinal plant for management of various disease conditions from ancient time.⁴

Ocimum is an important symbol of hindu religious tradition. Tulasi (sanskrit:-surasa) has been used for thousands of years in ayurveda for its diverse healing properties. It is mentioned in the Charaka Samhita, an ancient ayurvedic text.¹⁰ Marked by its strong aroma and astringent taste, it is regarded in ayurveda as a kind of "elixir of life" and believed to promote longevity.¹¹ Tulsi, the queen of herbs, the legendary 'incomparable one' of India, is one of the holiest and most cherished of the many healing and healthy giving herbs of the orient. Tulsi, is renowned for its religious and spiritual sanctity, as well as for its important role in the traditional ayurvedic and unani system of holistic health and herbal medicine.¹²

Ocimum has been claimed to possess numerous medicinal properties. Traditionally, fresh juice or decoction of OS leaves are used to promote health and in treatment of various disorders as advocated in ayurveda, the Indian system of medicine.

Plant profile

Ocimum belongs to family Labiateae and OS is very important for their therapeutic potentials. *Ocimum sanctum* L. (Labiatae) is a strongly scented small annual herb, up to 18 inches tall, grows into a low bush and is commonly known as holy basil, tulsi or tulasi three varieties of tulsi are

- Rama or Light Tulsi (*Ocimum sanctum*)
- Shyama or Dark Tulsi (*Ocimum sanctum*)
- Vana Tulsi (*Ocimum gratissimum*)

Scientific classification:

- Kingdom: Plantae
- Division: Magnoliophyta
- Class : Magnoliopsida
- Order : Lamiales
- Family : Lamiaceae
- Genus : *Ocimum*
- Species : *O. Tenuiflorum*
- Binomial name : *Ocimum tenuiflorum* or *Ocimum sanctum* L.

Properties

Ocimum sanctum (OS) or tulsi extracts are used in ayurvedic remedies for common colds, headaches, stomach disorders, inflammation, heart disease, various forms of poisoning and malaria. Traditionally, *Ocimum sanctum* L. is taken in many forms, as herbal tea, dried power or fresh leaf. Several recent investigations using these extracts have indicates anti-inflammatory, antioxidant and immune-modulatory and antistress properties.¹³⁻¹⁶ In addition, it has been reported to have radioprotective and anti-carcinogenic property. Several medicinal properties have been attributed to *Ocimum sanctum* L.^{17,18} *Ocimum sanctum* L. is known as a general vitalizer and increases physical endurance.

Different parts of *Ocimum sanctum* L. like leaves, flowers, stem, root, seeds etc. are known to possess therapeutic potentials and have been used, by traditional medicinal practitioners, as expectorant, analgesic, anticancer, antiasthmatic, antiemetic, diaphoretic, antidiabetic, antifertility, hepatoprotective, hypotensive, hypolipidmic, antistress agents. *Ocimum sanctum* L. has also been used in treatment of fever, bronchitis, arthritis, convulsions etc.

Ocimum sanctum L. has been well documented for its therapeutic potentials and described as antiasthmatic and antikaphic drugs. Indian Materia Medica describe the use of aqueous, hydro-alcoholic and methanolic extract of *Ocimum sanctum* leaves in variety of disorders, like bronchitis, rheumatism and pyrexia.¹⁹

Chemical composition

The chemical composition of *Ocimum sanctum* L. is highly complex, containing many nutrients and other biologically active compounds. The quantity of many of these constituents are significantly affected by differing growing, harvesting processing and storage conditions that are not yet well understood.²⁰

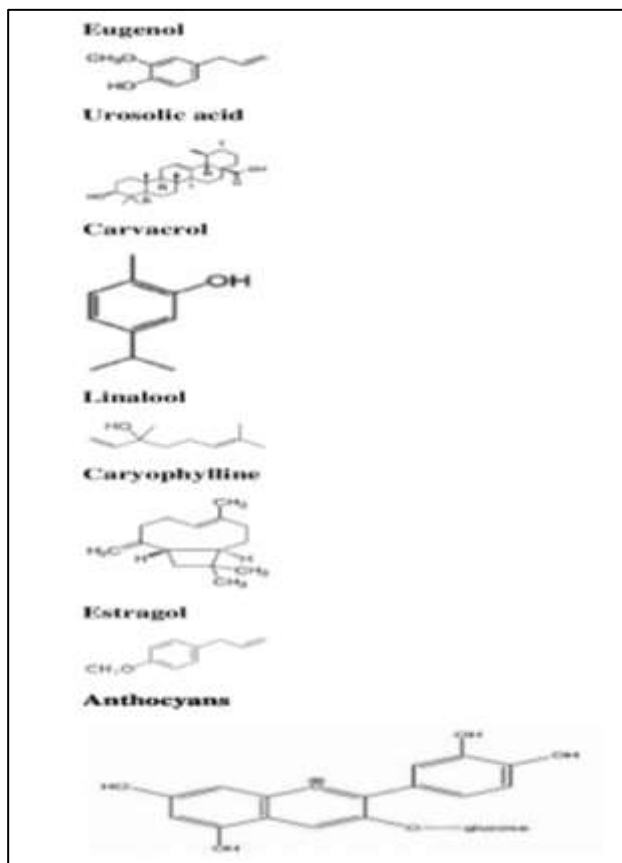


Figure 1: Chemical compound in *Ocimum sanctum*.

Table 1: Phytochemicals present in *Ocimum sanctum*.

Part of the plant	Phytochemicals
Leaf	Flavonoids, alkanoids, saponins, tannins, phenols, anthocynins, terpenoids, sterols. ^{22, 20}
Steam	Phenols, saponins, flavonoids, triterpenoids, tannins.
Seeds	Fatty acids, sitosterol.
Whole plant	Flavonoids, alkanoids, saponins, tannins, phenols, anthocynins, flavonoids, triterpenoids, tannins. ^{21,20}

The nutritional and pharmacological properties of the whole herb in natural form, as it has been traditionally used, result from synergistic interaction of many different active phytochemicals. OS contains volatile oil, eugenol,

urosolic acid, carvacrol, linalool, limatrol, methyl eugenol, sesquiterpine, caryophyllene, estragol.

The sugars are composed of xylose and polysaccharides.^{20,21} Phytochemical investigation of OS stem and leaves have shown constituents like saponins, flavonoids, triterpenoids and tannins.^{20,22} *Ocimum sanctum* L. contains Vitamin C, A and minerals like calcium, zinc and iron, as well as chlorophyll and many other phytonutrients.²³

Pharmacological Properties of *Ocimum sanctum*

Anti-microbial activity

Ocimum sanctum shows antimicrobial activity. Ethanolic, methanolic, and organic solvents extracts of *Ocimum sanctum* L. show wide zones of inhibition against *Escherichia coli*, *Staphylococci sp.*, *Shigella sp.*, *Staphylococcus aureus* and *Enterobacteria sp.*²⁴ *Ocimum sanctum* also acts against *Pseudomonas aeruginosa*, *Staphylococci sp.*, *Salmonella typhi*, *Klebsiella pneumonia*, *Proteus*, *Candida albicans*, *Mycobacterium tuberculosis* and *Micrococcus pyogenes*.^{25,26} These results proves that OS can act as excellent antimicrobial agent against many microbes.

Anti-fungal activity

Ocimum sanctum shows an important property like antifungal activity. Aqueous, hexane, chloroform, n-butanol and other solvent extracts of *Ocimum sanctum* showed antifungal activity. *Ocimum sanctum* acts against bio-deterioration of food stuff during storage. Aqueous and acetone extract of *Ocimum sanctum* L. were also found to be sensitive to many plant fungi such as *Alternaria tenuis*, *Helminthosporium sp.* And *Curvularia penniseli*.

Essential oil of tulsi was tested on *Alternaria solani*, *Candida guilliermondii*, *Colletotricum capsici*, *Curvularia sp.* *Fusarium solani*, *Helminthosporium oryzae*, it showed positive results. Essential oil and eugenol were found efficacious in checking growth of *Aspergillus flavus* and NKDHV.⁸ Hence, *Ocimum sanctum* essential oil and eugenol can be used as plant based safe preservatives against fungal spoilage of food stuff during storage.²⁷

Antioxidant effect

The aqueous, hydroalcoholic and methanolic extracts of *Ocimum sanctum* L. show significant antioxidant activity, both *in vivo* and *in vitro*.²¹ Phytochemical investigations of *Ocimum sanctum* L. leaf extract show phenols (eugenol, cirsilineol, isothymucin, apigenin and vosamarinic acid) and flavonoids (orientin and vicenin). These pharmacophores have been shown to possess potent antioxidant activities (cyclooxygenase inhibitory) activity. Oral feeding of OS provides significant liver and

aortic tissue protection from hypercholesterolemia induced peroxidative damage.²⁸

Antidiabetic effect

Oral administration of *Ocimum sanctum* L. extract led to marked lowering of blood sugar in glucose-fed hyperglycemic and streptozotocin-induced diabetic rats.²⁹ The constituents of *Ocimum sanctum* L. leaf extracts have stimulatory effects on physiological pathways of insulin secretion which may underlie reported antidiabetic action.³⁰ Another study suggested that *Ocimum sanctum* L. decreased the serum concentration of both cortisol and glucose and also exhibited antiperoxidative effect. Therefore, *Ocimum sanctum* L. may potentially regulate corticosteroid-induced diabetic mellitus.³¹

Anti-carcinogenic property

Banerjee et al, reported anticancer activity of OS against many carcinogenic agents.³² Juice of fresh leaves of OS has anticancer property in cancer subjects. Alcoholic extracts of *Ocimum sanctum* act on the activities of cytochrome P-450, cytochrome b₅ and aryl hydrocarbon hydroxylase in liver and glutathione-S-transferase (GST) and a reduced glutathione level in liver, lung. All these enzymes and cofactors play an important role in the detoxification of carcinogens and mutagens.

Ocimum sanctum L. leaves when fed to experimental rats for ten weeks, significantly reduced the squamous cell carcinoma and hematoma incidences.³³ These results show that the anticancer activity of OS.

Radio-protective effect

The radioprotective property of *Ocimum sanctum* L. was first reported by Devi et al.³⁴ Thirty-Day lethality studies in Swiss albino mice were carried out following treatment with single graded doses of aqueous and ethanol extracts from dried leaves of *Ocimum sanctum* L. and it was found that the aqueous extract was more effective in increasing survival, compared with the ethanol extract.³⁵

The flavonoids, orientin and vicenin, were found to be equally effective in rendering protection against γ -radiation-induced lipid peroxidation in mouse liver. These compounds also significantly inhibited the fenton reaction-induced OH radical activity under *in-vitro* conditions.³⁶

The combination of *Ocimum sanctum* L. leaves extract with WR-2721 (a synthetic radioprotector) resulting in higher bone marrow cell protection and reduction in the toxicity of WR-2721 at higher doses, suggested in that the combination would have promising radioprotection in humans.³⁷

Anti-lipid peroxidative effect

The anti peroxidative effect of *Ocimum sanctum* L. was attributed to increased levels of cellular antioxidants such as reduced glutathione (GSH), GSH-peroxidase and reductase as well as superoxide dismutase (SOD). The study of Ganasoundari et al. showed that the aqueous extract of leaves of OS L significantly inhibited the OH radical-induced deoxyribose degeneration.³⁸ A combination of WR-2721 and *Ocimum sanctum* L. extract produced a significantly higher inhibition of OH radical activity compared with either agent individually.³⁷

Antigenotoxic effect

Ocimum sanctum L. leaf extract possesses the protective effect against Cr Hg-1 induced genetic damage.³⁹ *Ocimum sanctum* L. extract treated human lymphocyte culture could reduce experimentally induced mitotic index, sister chromatid exchange and replication index in a dose development manner.⁴⁰

In-vitro assay in *Allium cepa* root tips cells has been carried out to detect the modifying effect of *Ocimum sanctum* L. aqueous leaf extract against chromium (Cr) and mercury (Hg) induced genotoxicity. It was observed that the roots post-treated with the leaf extract showed highly significant ($p < 0.001$) recovery in mitotic index (MI) and chromosomal aberrations (CA) when compared to pre-treated (Cr Hg-1) samples and the lower doses of the leaf extract were found to be more effective than higher doses.

Wound healing effect

Several studies showed wound healing property of *Ocimum sanctum* L. Wound healing activity of cold aqueous extract of *Ocimum sanctum* L. leaves along with its effect on tumor necrosis factor-Alpha (TNF-Alpha) was assessed using excision model of wound repair in Wistar albino rats. After application of the *Ocimum sanctum* L. extract, rate of epithelization with an increase in wound contraction was observed.⁴¹

Ethanol extract of *Ocimum sanctum* L. was investigated for normal wound healing and dexamethasone depressed healing using incision, excision and dead space wound models in albino rats. The extract of *Ocimum sanctum* L. significantly increased the wound breaking strength in incision wound model. The extract treated wounds were found to epithelialize faster and the rate of wound contraction was significantly increased as compared to control wounds.

Significant increase in wet and dry granulation tissue weight, granulation tissue breaking strength and hydroxyproline content in dead space wound model was observed. The extract significantly decreases the antihealing activities of dexamethasone in all the wound models.

The results indicated that the leaf extract promotes wound healing significantly and able to overcome the wound healing suppressing action of dexamethasone. Histological examination of granulation tissue to determine the pattern of lay-down for collagen confirmed the results.⁴¹

Anti-fertility activity

Ocimum sanctum L. has antifertility effect. The leaves of *Ocimum sanctum* L. are said to have abortifacient effect in women. In Kerala the local women as well as the Ayurvedic physicians have been reported to use the leaves of Tulsi for antifertility activities.^{42,43}

Benzene and petroleum extracts of OS leaves have been reported to produce 60 to 80 % of antifertility in female rats. *Ocimum sanctum* L. in male rats showed increased total sperm count, sperm motility and weight of testis.⁴⁴

Anti-ulcer activity

OS showed anti-ulcer activity in rats. The fixed oil of *Ocimum sanctum* L. administered intraperitoneally elicited 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 lipoxigenase inhibitory, histamine antagonistic and antisecretory effects.⁴⁵

Immunologic effect

OS showed response to immune effect. Steam distilled extract from the fresh leaves of *Ocimum sanctum* L. showed modification in the humoral immune response in albino rats which could be attributed to antibody production, release of mediators of hypersensitivity reactions and tissues responses to mediators in the target organs.⁴⁶ Godhwani et al, reported that with OS supplementation showed of humoral immunogenic response as represented by an increase in antibody titer in both the widal and sheep erythrocyte agglutination test as well as by cellular immunologic response represented by rosette formation and lymphocytosis was observed.⁴⁷

Anti-anaphylactic, antihistaminic and mast cell stabilization activity

Sridevi et al. showed potent benefits of *Ocimum sanctum* L. in the treatment of asthma and related conditions.⁴⁸ The findings from various studies reveal that the antihistaminic and antianaphylactic activity of *Ocimum sanctum* L. extract which is mainly due to its mast cell stabilizing potential, suppression of IgE and inhibition of release of inflammatory mediators. Thus use of *Ocimum sanctum* L. leaves proved the strong rationale behind the mentioned therapeutic activities.

Anti-stress activity

Ocimum sanctum L, a medicinal herb that widely claimed to possess antistressor activity and used extensively in the Indian system of medicine for a variety of disorders, Administration of the 70% ethanolic extract of *Ocimum sanctum* L. normalizes the alteration in neurotransmitter levels due to noise stress, emphasizing the antistressor potential of this plant.⁴⁹

Hypolipidemic activity

Ocimum sanctum L. (OS) leaves decrease serum lipid profile in normal and diabetic animals. Essential oil extracted from *Ocimum sanctum* L. leaves has lipid-lowering activity against hypercholesterolemia. The aqueous extract decreased LPO formation and increased antioxidant enzymes in plasma and rat liver, lung, kidney and brain.⁵⁰

Anti-helmenthic activity

The essential oil of *Ocimum sanctum* L. showed potent anti-helmenthic activity in the caenorhabditis elegans model. Eugenol being the predominant component of the essential oil, is suggested as the putative anti-helmenthic principle.⁵¹

Anticonvulsant activity

Different extracts of stem, leaf and leaves of OS were tested for anticonvulsant activity by maximal electroshock model using phenytoin as standard. It was observed that ethanol and chloroform extract of leaf and stem were effective in preventing toxic convulsions induced by trans corneal electroshock.⁵² OS fixed oil (2-3 ml/kg ip) has been reported to show anticonvulsing property in pentobarbitone-induced rats.⁵²

Cardio-protective activity

OS has cardio protective property. OS can act as strong cardio protective agent against myocardial agents. The long term feeding of *Ocimum sanctum* L. offers significant protection against isoproterenol-induced myocardial necrosis in wistar rats through enhancement of endogenous antioxidant activity.⁵³ Urosolic acid isolated from *Ocimum sanctum* L. showed protection against Adriamycin (ADR)-induced lipid peroxidation. Protection with urosolic acid was 13 and 17 % in liver and heart microsomes, respectively.⁵⁴

Memory enhancer activity

Alcoholic extract of *Ocimum sanctum* (OS) L. ameliorated the amnesic effect of scopolamine (0.4 mg/kg) and aging-induced memory deficits in mice. OS extract increased step-down latency (SDL) and acetylcholinesterase inhibition significantly. Hence, OS

can be employed in the treatment of cognitive disorders such as dementia and alzheimer's disease.⁵⁵

Anti-arthritic activity

The anti-arthritic activity of *Ocimum sanctum* L. fixed oil was evaluated against formaldehyde-induced arthritis in rats. The fixed oil significantly reduced the diameter of inflamed paw. Intraperitoneal administration of the fixed oil daily for 10 days, improved the arthritic condition in rats. The fixed oil inhibited carrageenan and inflammatory mediators (e.g. serotonin, histamine, bradykinin and PGE₂) induced inflammation. These results suggest anti-arthritic activity of the inflammation models, including adjuvant as well as turpentine oil-induced joint oedema in rats.¹³

Table 2: Pharmacological properties of *Ocimum sanctum*

Part of the plant	Activity
Leaves	Anti stress, antichronic, anti hypolipidemic, antioxidant, anthelmintic, anti malarial activity (against plasmodium vivex), antifungal (against ring worm and also skin diseases), anti fertility activity, anti cancer (carsinigenic), antiviral activity. ^{25-28,37,44}
Root	Decation of root act as a diaphoretic in malarial fever, anti larvicidal (against to mosquitoes), antifungal (aspergillus niger). ²⁷
Flower	Antispasmodic agent (as smooth muscle relaxant).
Stem	Genitourinary system disorders.
Seeds	Reduced blood and urinary uric acid level in albino rabbits.
Whole Plant	Control diabetes mellitus, anti dot for dog bite, scorpion bite and insects bite. ^{30,31,47,58}

Table 3: Different chemical compounds present in *Ocimum sanctum*

Part	Chemical compounds
Leaves	Eugenol, eugenal, urosolic acid, carvacol, linalool, caryophyllene, limatrol, caryophyllene, methyl carvicol, anthocyan. ²¹⁻²²
Stem	Romarinic acid, apigenin, cirsimaritin, isothymusin, isothymonin.
Seeds	Sugars (xylose and polysaccharides). ^{21,20}

Anti-thyroid activity

Ocimum sanctum L. leaf exhibited anti-thyroidic and anti-oxidative properties.⁵⁶ The effects of *Ocimum sanctum* L. leaf extract on the changes in the concentration of serum T3, T4 were investigated in the male mouse.

Anti-pyretic activity

The antipyretic activity of *Ocimum sanctum* L. fixed oil was evaluated by testing it against typhoid-paratyphoid A/B vaccine-induced pyrexia in rats. The fixed oil possessed prostaglandin inhibitory activity and the same could explain its antipyretic activity.⁵⁷

Antidote activity

OS showed antidote activity to many poisons. OS can be used antidote for dogbite, scorpion bite, snake bite and insect bites.^{47,58}

CONCLUSION

From, the above research survey, it was concluded that traditional medicine is safe and has many therapeutic applications. Of many medicinal plants *Ocimum sanctum* is one of the important herbs which have multiple pharmacological properties. The scientific research on *Ocimum sanctum* L. suggests a huge biological potential of this plant. So it can be concluded that *Ocimum sanctum* L. or tulsi is a traditionally and clinically proved medicinal herb for both its application and efficacy.

ACKNOWLEDGEMENT

The authors are grateful to the University Grants Commission, (UGC), New Delhi, India for the sanction of Major Research Project UGC MR-Major-Zol 2013-36027 dated 15/10/2015.

Funding: University Grants Commission

Conflict of interest: None declared

Ethical approval: Not required

REFERENCES

- Kunwar RM, Adhikari N. Ethnomedicine of dolpa district Nepal: The plant their vernacular names and uses. *Lyonia*. 2005:43-9.
- Siddiqui HH. Safety of herbal drugs-an overview. *Drugs News Views*. 1993;7:10.
- Gurib FA. Medicinal plants: Traditionas of yesterday and drugs tomorrow. *Mol. Aspects Med*. 2006;27:1-93.
- Prakash P, Gupta N. Therapeutic uses of *Ocimum sanctum* Linn. Tulsi with a note on eugenol and its pharmacological actions :A short review. *Indian J Physiol Pharmacol*. 2005;49:125-31.
- Krishnaiah D, Sukla AR, Sikand K, Dhawan V. Effect of herbal polyphenols on artherogenic transcriptome. *Mol Cell Biochem*. 2009;278:177-84.
- Sobli SN, Pushphangadan P. Studies in the genus *Ocimum*: cytogenetics, breeding and production of new strains of economic importance. In: Atal CK, Kapur BM (eds) cultivation and utilization of aromatic plants. Regional Laboratory Council of

- Scientific and Industrial Research, Jammu-Tawi, India;1982:457-472.
7. Farnsworth NR. Bunyaphrathasara N. Thai medicinal plants. Medical Plant Information Center, Bangkok. 1992:180-2.
 8. Marja PK, Anu IH, Heikki JV, Jussi-Pekka R, Kalevi P, Tytti SK et al. Antioxidant activity of plant extracts containing phenolic compounds. J Agric Food Chem. 1999;47(10):395462.
 9. Lee KJ, Min DB. Comp Rev Food Sci Food Safety. 2004;3:21-7.
 10. NIIR Board. National institute of industrial research (India) Compendium of medicinal plants. 2004. National institute of industrial research. 2004:320.
 11. Puri, Rasayana HS. Ayurvedic herbs for longevity and rejuvenation. CRC Press.USA;2002:272-280.
 12. Warrior PK. In: Indian medicinal plants. Longman O, editor. New Delhi: CBS publication;1995:168.
 13. Singh S, Majumdar DK, Rehan HMS. Evaluation of anti-inflammatory potential of *Ocimum sanctum* (holy basil) and its possible mechanism of action. J Ethnopharmacol. 1996;54:19-26.
 14. Mauli G, Maulik N, Bhandari V, Kagan VE, Pakrashi S, Das DK. Evaluation of antioxidants effectiveness of few herbal plants. Free Radic Res. 1997;27:221-8.
 15. Mediratta PK, Sharma KK, Singh S. Evaluation of immunomodulatory potential of *Ocimum sanctum* seed oil and its possible mechanism of action. J Ethnopharmacol. 2002;80:15-20.
 16. Sen P, Maiti PC, Puri S, Ray A, Audulov NA, Valdman AV. Mechanism of anti stress activity of *Ocimum sanctum* Linn, eugenol, *Tinospora malabarica* in experimental animals. Indian J Exp Biol. 1992;32:592-6.
 17. Devi PU. Radioprotective, anticarcinogenic and antioxidant properties of Indian holy basil, *Ocimum sanctum* (Tulsi). Indian J Exp Biol. 2000;39:185-90.
 18. Sethi J, Sood S, Seth S, Talwar A. A protective effect of tulsi *Ocimum sanctum* on lipid peroxidation in stress induced by anaemic hypoxia in rabbits. Indian J Physiol Pharmacol. 2003;47:115-9.
 19. Nadkarni AK. Indian Materia Medica. Popular Prakashan Pvt Ltd., Tardeo, Mumbai, 400 034. 1976;1:183-4.
 20. Pattanayak P, Debajyoti D, Sangram KP. *Ocimum sanctum* Linn. A reservoir plant for therapeutic applications. Phcog Rev. 2010;4:95-105.
 21. Kelm MA, Nair MG, Strasburg GM, DeWitt DL. Antioxidant and cyclooxygenase inhibitory phenolic compounds from *Ocimum sanctum* Linn. Phytomedicine. 2000;7:7-13.
 22. Jaggi RK, Madaan R, Singh B. Anticonvulsant potential of holy basil, *Ocimum sanctum* Linn. and its cultures. Indian J Exp Biol. 2003;41:1329-33.
 23. Anbarasu K, Vijayalakshmi G. Improved shelf life of protein-rich tofu using *Ocimum sanctum* (tulsi) extracts to benefit Indian rural population. J Food Sci. 2007;72:M305.
 24. Rahman MS, Khan MMH, Jamal MAHM. Anti-bacterial. Anti-bacterial evaluation and minimum inhibitory concentration analysis of *Oxalis corniculata* and *Ocimum sanctum* against bacterial pathogens. Biotechnol. 2010;9:533-6.
 25. Mishra P, Mishra S. Study of antibacterial activity of *Ocimum sanctum* extract against gram positive and gram negative bacteria. Am J Food Technol. 2011;6:336-41.
 26. Farivar TN, Fard AHM, Zahedani SS, Naderi M, Moud BS. Anti tuberculosis effect of *Ocimum sanctum* extracts in *in-vitro* and macrophage culture. J Medicinal Sci. 2006;6:348-51.
 27. Khan A, Ahmad A, Manzoor N, Khan LA. Antifungal activities of *Ocimum sanctum* essential oil and its lead molecules. Nat Prod Commun. 2010;5(2):345-9.
 28. Geetha RK, Vasudevan DM. Inhibition of lipid peroxidation by botanical extracts of *Ocimum sanctum*: *In-vivo* and *in-vitro* studies. Life Sci. 2004;76:21-8.
 29. Chattopadhyay RR. Hypoglycaemic effect of *Ocimum sanctum* leaf extract, in normal and streptozotocin diabetic rats. Ind J Expt Biol. 1993;31:891-3.
 30. Hannan JMA, Marenah L, Ali L, Rokeya B, Flatt PR, Abdel YHA. *Ocimum sanctum* leaf extracts stimulate insulin secretion from perfused pancreas, isolated islets and clonal pancreatic beta-cells. J.Endocrinol. 2006;189:127-36.
 31. Gholap S, Kar A. Hypoglycemic effects of some plant extracts are possibly mediated through inhibition in corticosteroid concentration. Pharmazie. 2004;59:876-8.
 32. Banerjee S, Prashar RA, Kumar A, Rao AR. Modulatory influence of alcoholic extract of *Ocimum sanctum* on carcinogen metabolizing enzyme activities and reduced glutathione level in mouse. Nutr Cancer. 1996;25:205-17.
 33. Aruna K, Sivaramakrishnan VM. Anticarcinogenic effects of some Indian plant products. Food Chem Toxicol. 1992;30:953-6.
 34. Devi PU, Ganasoundari A, Radioprotective effect of leaf extract of Indian medicinal plant *Ocimum sanctum*. Indian J Exp Biol. 1995;33:205-8.
 35. Ganasoundari A, Umadevi P, Rao MN. Protection against radiation induced chromosome damage in mouse bone marrow by *Ocimum sanctum*. Mutation Res. 1997;373:271-6.
 36. Devi UP, Ganasoundari A, Rao BSS. Srinivasan KK. *In vivo* radioprotection by ocimum flavonoids; survival of mice. Radiat Res. 1999;151:74-8.
 37. Ganasoundari A, Umadevi P, Rao BSS. Enhancement of bone marrow radioprotection and reduction of WR-2721 toxicity by *Ocimum sanctum*. Mutation Res. 1998;397:303-12.
 38. Ganasoundari A, Zare SM, Umadevi P. Modification of normal tissue sensitivity by some medicinal plants. Br J Radiol. 1997;70:599-602.

39. Babu K, Uma MKC. *In-vivo* studies on the effect of *Ocimum sanctum* L. leaf extract in modifying the genotoxicity induced by chromium and mercury in *Allium* root meristems. J Environ Biol. 2006;27:93-5.
40. Siddique YH, Ara G, Beg T, Afzal M. Antigenotoxic effect of *Ocimum sanctum* L. extract against cyproterone acetate induced genotoxic damage in cultured mammalian cells. Acta Biol Hungarica. 2007;58:397-409.
41. Shetty SS, Udupu S, Udupu A. Evaluation of antioxidant and wound healing effects of alcoholic and aqueous extract of *Ocimum sanctum* Linn. In rats evid based complement. Alternat Med. 2008;5:95-110.
42. Batta SK, Santhakumari G. The antifertility effect of *Ocimum sanctum* and *Hibiscus Rosa Sinesis*. Indian J Medical Research. 1971;59:777-81.
43. Khanna S, Gupta SR, Grover JK. Effect of long term feeding of Tulsi. Indian J Exp Biol. 1986;24:302-4.
44. Seth SD, Johri N, Sundaram KR. Antispermatic effect of *Ocimum sanctum*. Indian J Exp Biol. 1981;19:975-6.
45. Govind P, Madhuri S. Medicinal plants: better remedy for neoplasm. Indian Drug. 2006;43(11):869-74.
46. Mediratta PK, Dewan V, Bhattacharya SK, Gupta VS, Maiti S, Sen P. Effect of *Ocimum sanctum* Linn. On humoral immune responses. Indian J Med Res. 1998;87:384.
47. Godhwani S, Godhwani JL, Vyas DS. *Ocimum sanctum* a preliminary study evaluating its immunoregulatory profile in albino rats. J Ethnopharmacol. 1988;24:193-8.
48. Sridevi G, Gopkumar P, Ashok S, Shastry CS. Pharmacological basis for antianaphylactic, antihistaminic and mast cell stabilization activity of *Ocimum sanctum*. Inetnet J Pharmacol. 2009;7.
49. Ravindran R, Devi RS, Samson J, Senthivelan M. Noise stress induced brain neurotransmitter changes and the effect of *Ocimum sanctum* (Linn) treatment in albino rats. J Pharmacol Sci. 2005;98:354-60.
50. Hussain HEMA, Kaiser J, Rao M. Preliminary studies on the hypoglycaemic effect of *Abroma augusta* in alloxan diabetic rats. Ind J Clin Biochem. 2001;16(1):77-80.
51. Asha MK, Prashanth D, Murali B, Padmaja R, Amit A. Anthelmintic activity of essential oil of *Ocimum sanctum* and eugenol. Fitoterapia. 2001;72(6):669-70.
52. Singh S, Rehan HM, Majumdar DK. Effect of *Ocimum sanctum* fixed oil on blood pressure, blood clotting time and pentobarbitone-induced sleeping time. J Ethnopharmacol. 2001;78:139-43.
53. Sood S, Narang D, Dinda AK, Maulik SK. Chronic oral administration of *Ocimum sanctum* Linn. Augments cardiac endogenous antioxidants and prevents isoproterenol-induced myocardial necrosis in rats. J Pharm Pharmacol. 2010;57:127-33.
54. Balanehru S, Nagarajan B. Intervention of adriamycin induced free radical damage. Biochem Int. 1992;28:735-44.
55. Joshi H, Parle M. Evaluation of nootropic potential of *Ocimum sanctum* Linn. In mice. Indian J Exp Biol. 2006;44:133-6.
56. Panda S, Kar A. *Ocimum sanctum* leaf extract in the regulation of thyroid function in the male mouse. Pharmacol Res. 1998;38:107-10.
57. Singh S, Taneja M, Majumdar DK. Biological activities of *Ocimum sanctum* L. fixed oil-An overview. Indian J Exp Biol. 2007;45:403-21.
58. Komal S, Verma RJ. Protection against butyl p-hydroxybenzoic acid induced oxidative stress by *Ocimum sanctum* extract in mice liver. Acta Poloniae Pharmaceutica Drug Research. 2012;69(5):865-70.

Cite this article as: Siva M, Shanmugam KR, Shanmugam B, Venkata SG, Ravi S, Sathyavelu RK, Mallikarjuna K. *Ocimum sanctum*: a review on the pharmacological properties. Int J Basic Clin Pharmacol 2016;5:558-65.