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Review of Botany, Phytochemistry, Pharmacology, Contemporary applications and Toxicology of *Ocimum sanctum*

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Abstract

Ocimum sanctum L. commonly called as 'holy basil' in English and 'Tulsi' in Hindi is a many branched, erect, stout and aromatic herb about 75 cms high, small sweet scented herb found throughout India and cultivated at a large scale. *Ocimum sanctum* has been used for a wide range of ailments in traditional medicine. Being complex chemical composition, due to its inherent botanical and biochemical complexity and presence of numerous valuable compounds, such as volatile compounds, flavonoids, phenolic compounds, fatty acids, and amino acids, *Ocimum sanctum* has anti-stress, antioxidant, hepatoprotective, immunomodulating, antiinflammatory, antibacterial, antiviral, antifungal, antipyretic, antidiuretic, antidiabetic, antimalarial and hypolipidemic properties. The review aims to gather the fragmented information available in the literature regarding morphology, ethnomedicinal applications, phytochemistry, pharmacology, and toxicology of *Ocimum sanctum*. It also compiles available scientific evidence to identify gaps required to be filled by future research and for the ethnobotanical claims. Traditional uses and scientific evaluation based findings indicate that *Ocimum sanctum* remains to be the most widely used herbal plant. *Ocimum sanctum* has been a good source of traditional medicine that provides a noteworthy basis in pharmaceutical biology and for the development/formulation of new drugs and future clinical uses.

Key-Words: *Ocimum sanctum*, traditional medicine, pharmacology, phytochemistry, toxicology

Introduction

Ocimum sanctum Linn. (Family; Labiatae) "The Queen of herbs" is a many branched, erect, stout and aromatic herb about 75 cms high, small sweet scented herb omnipresent throughout India and is cultivated, worshiped in temples and houses of Hindus. With about 150 species of aromatic plants the genus *Ocimum* is distributed mainly in tropical and subtropical regions of the world.

Tulsi belongs to the genus *Ocimum*, derived from the Greek '*ozo'* which means to smell, in reference to the strong odors of the species within the genus. In French, it is frequently given the name "Herbe Royale," revealing the positive light in which it is viewed. It is called Tulsi in Sanskrit, Kala- Tulsi in Hindi and India's Holy Basil in English. In Sanskrit The name "Tulsi" means "the incomparable one" (Bansod and Rai, 2008).

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With its own mythological background is supposed to be beloved of Lord Krinsha, a reincarnation of lord Vishnu. It is now readily found in west and named as Sulabha 'the easy obtainable one' (Rai Y, 2002).

Ancient Rishis thousands of years ago recognized Tulsi to be one of the India's greatest healing herbs and saw so good for health and healing and was declared as a God in itself. The plant is worshipped as dear to Vishnu in some section of *vaishnavism* commonly known as Vishnu- Priya means the one that pleases Lord Vishnu. Tulsi is known as the "The mother medicine of nature" and "Queen of plants", a plant regarded as a deity in Indian subcontinent (Singh *et al.*, 2010).

Ocimum sanctum (*Holy basil, Tulsi*) is a plant with known medicinal properties since the Vedic period is classified as a "rasayana", - a herb that nourishes a person's growth to perfect health and promotes long life. *Ocimum sanctum* L. is a key herb in Ayurvedic medicine (Gupta *et al.*, 2007). In Hindu houses, basil is the protecting spirit of the family. The British at one time used tulsi as a substitute for a Bible upon which

the Indians would take an oath in a court of law. Tulsi is mentioned in Padam Purana - "Just half a leaf of Tulsi is as useful in keeping a body healthy and away from diseases, as all the items and medicines made from all the flowers and leaves of the world".

Taxonomy: Kingdom- *Plantae;* Subkingdom- *Tracheobionta;* Super division- *Spermatophyta;* Division - *Magnoliophyta;* Classs- *Magnoliopsida;* Subclass- *Asteridae;* Order- *Lamiales;* Family- *Lamiaceae;* Genus - *Ocimum;* Species - *sanctum* L. Botanical name- *Ocimum sanctum*

Botanical description. *Ocimum sanctum* L. is an erect, herbaceous, much-branched, softy hairy, biennial or triennial plant, 30-75cm high. The leaves are elliptic-oblong, acute or obtuse, entire or serrate, pubescent on both sides, minutely gland-dotted; the floweres are puplish or crimson, in racemose, close whirled; the nut-lets are sub-globose or broadly ellipsoid, slightly compressed., nearly smooth, pale-brown or reddish with small, black markings. Within cultivation two types of *Ocimum sanctum L.* are met (a). Tulsi plants with purple leaves known as Krishna Tulsi and (b). Tulsi plants with green leaves known as Sri Tulsi, *Krishna Tulasi* or *Shyam Tulasi* (Pandey, B. P. 1990). However the species irrespective of its colour in Sanskrit is called '*Tulasi'* or '*Parnasa'*.

Traditional and Contemporary Uses

Sacred or Holy Basil, i.e. Green Tulsi (*Ocimum sanctum*), is a well-known medicinal plant, has been traditionally regarded as possessing rejuvenating, tonic and vitalizing properties that contribute to longevity and a healthy life (Singh S, 1997). OS has several medicinal properties attributed not only in Ayurveda and Siddha but also in Greek, Roman and Unani System of Medicine (Gupta SK, 2002).

According to World Health Organization (WHO) survey in 1993, about 80% of patients in India, 85% in Burma and 90% in Bangladesh are treated by traditional system of medicine. Gastric and hepatic disorders are treated with aqueous decoction of OS leaves and as a popular remedy for cold. OS present in herbal preparations has been suggested to cause illness shortening, clinical symptoms and biochemical parameters in viral hepatitis patient. Eye drop of leaf juice of OS with triphala is recommended for glaucoma, cataract, chronic conjunctivitis and eye diseases. Dyspepsia, hemorrhage, dysentery and chronic fever is treated with the juice of fresh leaves which are anthelmintic and check vomiting. Flower tops and fresh leaves of OS have been used as antispasmodic agent (as smooth muscle relaxant). Leaves of OS possess good anti-stress (adaptogenic) analgesic, anti hyperlipidemic, antioxidant potentials in experimental animals. Seeds and leaves of OS have been reported to possess diuretic property and reduce blood and urinary uric acid level in albino rabbits and gastric ulceration and secretion in albino rats are reported to be inhibited by OS. Leaves have abortifacient effect in women and anti-fertility effect. OS leaves have also been reported to be used by the local ayurvedic physician and women of Kerala for antifertility effect and anti-implantation activity in experimental albino rats (P. Prakash and Neelu Gupta, 2005).

osimum sanctum (OS) leaves possess expectorant, diaphoretic, antiseptic, spasmolytic, stimulant and anticatarrhal properties and are used as cold and cough remedies, for fever and pain (Ali M, 1994).

OS leaves juice was traditionally used as demulcent, stimulant, expectorant and in the cure of upper respiratory tract infections, bronchitis, skin infections (Harsa BH, 2003). OS leaves tea is commonly used for intestinal disorders (*IndianMateriaMedica*, 1976). Chicken pox is explored by OS leaves taken with saffron and about 10-20gm OS seeds soaked in water and then mixed with cumin or sugar or either taken with curd cures piles and stops bleeding during piles (Jayral GS, 2003). Together with five tender leaves and five black pepper taken empty stomach every morning is believed to strengthen the weak heart and cures malaria.

Taken along with tea and milk, a decoction of leaves is extremely useful in malaria and also helpful in curing colds, cough and indigestion. Ozaena (offensive discharge from the nose) is also treated by powder of dried leaves as a snuff and is means of dislodging maggots. Leaf juice or paste, is used against earache and other minor ear, eyes and nose infections, can be applied to cure ringworm rashes and other skin diseases. Demulenta and mucilaginous seeds of *ocimum sanctum* are given in genitor-uninary system disorders and about 1gm of seed paste reduces urine burning sensation. Leaves of Tulsi possesses significant insecticidal and larvicidal activity against house flies and especially mosquitoes and the essential oil of leaves is applied to reduce joint pains (M.K. khosla, 195).

Seeds about 2gm taken with cold and warm water checks diarrhaea and removes constipation respectively. The leaves are good for nerves and to sharpen memory. Chewing of Tulsi leaves also cures ulcers and infections of mouth (Prajapati *et al.*, 2003). Powder (safoof) of 1gm made from shade dried leaves of *ocimum sanctum* and ocimum album plant species is given with water twice daily for prophylactic and the

treatment of diabetes in Attock district of Pakistan (Mushtaq *et al.*, 2009).

OS leaf powder is found to cause reduction in fasting blood sugar and postprandial glucose level in N1DDM patients, leaves in considerable amount has been shown to possess antioxidant property and inhibit lipid peroxidation. leaves are also used to control diabetes since antiquity (Jyoti sethi 2004). A kind of medicated stone "Vishakallu" (Poison stone),includes the leaves of OS, *Anisomeles malabarica, Lecas aspera* and pebbles from the river bank is used by the indigenous group "Kani" in Kerala, India to treat snake bite, when placed directly on the bitten area, sticks to the body to absorb the poison and detaches after absorption (Rajasekharan *et al.*, 1992). Stored food grains have been treated with dried leaves powder of Tulsi for centuries to repel insects (Biswas NP; Biswas AK, 2005).

To treat cough, cold and headache, crushed leaves with onion bulbs juice is taken orally by traditional healers from Kacherpuran district of Tamil Nadu India (Chellaiah Muthu *et al.*, 2006).

Juice of flower tops, roots and fresh leaves are considered as a good antidote for snake bite and scorpion sting (wealth of India 1966).

Phytochemistry

Phytochemical research carried out on *Ocimum sanctum* has led to the isolation of highly complex, containing many nutrients and other biological active compounds significantly vary with time, cultivation process and storage. Many research and studies suggest that Tulsi may be a COX-2 inhibitor, like many modern painkillers, due to its significant amount of eugenol. Leaves contain 0.7% volatile oil comprising about 71% eugenol and 20% methyl eugenol. carvacrol and sesquiterpine hydrocarbon caryophyllene is also found in leaves. Some phenolic compounds (antioxidants) such as cirsilineol, circimaritin, isothymusin, apigenin androsameric acid, and appreciable quantities of eugenol, Two flavonoids, viz., orientin and vicenin from aqueous leaf extract of *Ocimum sanctum* have been isolated from fresh leaves and stem. From the leaf extract of OS, Ursolic acid,apigenin, luteolin, apigenin-7-O-glucuronide, luteolin-7-Oglucuronide, orientin and molludistin have also been isolated. A number of sesquiterpenes and monoterpenes viz., bornyl acetate,- elemene, neral, and -pinenes, camphene,campesterol, cholesterol, stigmasterol and –sitosterol have also been found in OS. Five fatty acids – stearic, palmitic, oleic, linoleic, linolenic acids are alos revealed by the fixed oil of OS, a good source of beta carotene, vitamin C and calcium.OS possesses volatile oil (1% including eugenol, linalool, estragol, methyl chaviol, methyl cinnamate, cileole and other terpenes), tannins, camphor, flavanoid (like luteolin, orientin, vicenin), triterpene; urolic acid, Zinc, manganese and sodium are also found using high resolution gamma ray spectrometry (Devesh Tewari *et al*., 2012).

Various studies that have been done in different parts of the world give the present day information about Chemical properties (Kothari *et al.*, 2004; Lawrence *et al.*, 1972; Sukari *et al.*, 1995; Brophy *et al.*, 1993; Nguyen *et al.*, 1993; Skaltsa H, Philianos S; Singh M, 1987; Norr H, Wanger H, 1992; Ravid *et al.*, 1997; Machado *et al.*, 1999; Kicel *et al.*, 2005; Mondello *et al.*, 2002; Vina A, Murillo E, 2003) and it is likely to be varying due to edaphic and geographic factors (Bakkali *et al.*, 2008). Chemical constituents as reported in various literatures are shown in table 1.

Table I: Chemical constituents of *Ocimum sanctum* Linn.

Essential Oil from Leaves	Alcoholic extract of leaves/aerial Parts	Fixed oil from Seeds	Mineral content (per 100 gm)
α-Thujene			
Octane	Ursolic acid	Pammitric acid	Vit. C (83 mg)
Nonane	Apgenin	Stearic acid	Carotene (2.5 mg)
Benzene	Luteolin	Linolenic acid	Ca (3.55 %)
(z)- 3-hexanol	Apignin-7-O-glucuronide	Linoleic acid	P(0.34%)
Ethyl 2-methyl butyrate	Luteolin-7-O-glucuronide	Oleic acid	Cr (2.9µg)
α-piene	Isoreientin	Sitosterol	Cu (0.4 µg)
β- pinene	Orientin	Dilinoleno-linolins	Zn (0.15 µg)

Toulene	Molludistin	Linolenodilinolin	V (0.54 µg)
Citronellal	Stigmsterol	Hexourenicacid	Fe (2.32 µg)
Camphene	Triacontoanol ferulate		Ni (0.73 µg)
Sabinene	Vicenin-2		Insoluble oxalate
Dimethyl enzene	Vitexin		
Myrecene	Isovetexin		
Ethyl benzene	Aescylectin		
Limocene	Aesculin		
1,8-cineole	Chlorgenic acid		
Cis-β-icimene	Galuteolin		
Trans-β-ocimene	Circineol		
p-cymene	Gallic acid		
Terpiniolene	Gallic acid methyl ester		
Allo-ocimene	Gallic acid methyl ester		
Butyl-benzene	Procatechuic acid		
α-cubebene	Villinin acid		
γ-terpene	4-hydroxybenzoic acid		
trans-linalool oxide	Vallinin		
Geraniol	4-hydroxybenzoic acid		
α-copaene	Caffiec acid		
β-bourbene	Chlorogenic acid		
β-cubebene	Phenylpropane glucosides 1		
Linalool	Phenylpropane glucosides 2		
Eugenol	β- Stingmsterol		
Methyl eugenol	Urosolic acid		
β-elemene			
(E)-cinnamyl acetate			
Isocaryophyllene			
β-caryophyllene			
Iso-eugenol			
α-guaiene			
α-amorphene			
α-humulene			
γ-humulene			
4,11-selinadiene			
α-terpenol			
Isoborneol			
Borneol			
Germacrene-D			
α-selinene			
β-selinene			
Myrtenylformat			

α-muurolene
δ – cadinene
Cuparene
Calamenene
Nerolidol
Caryophyllene oxide
Iedol
Humulene oxide
α-guaiol
Geraneol
α-bisbolol
(EZ)- farnesol

Source: *(Shankar Mondal et al., 2009)*

Pharmacological Activities

Ocimum sanctum as an important part of polyherbal formulations in the treatment of different diseases and disorders is officially noted in *Ayurvedic* Pharmacopoeia. A number of studies have been undertaken to evaluate a variety of biological / pharmacological activities such as antibacterial, antiviral, antifungal, anti protozoal, anti malarial, anthelmentic, anti diarrhoeal, analgesic, antipyretic, anti inflammatory, anti allergic, antihypertensive, cardio protective, central nervous system (CNS) depressant, hepatoprotective, anti diabetic, anti asthmatic, anti thyroidic, antioxidant, anticancer, chemopreventive, radio protective, immunomodulatory, anti fertility, antiulcer, anti arthritic, adaptogenic / anti stress, anti cataract, anti leucodermal and anticoagulant activities for which few extracts of *ocimum sanctum* and isolated compounds have been evaluated. A brief of the same is as under.

Antibacterial and antiviral activities. For the cure of numerous infectious disorders of bacterial, fungul, viral and mycobacterial origion *ocimum sanctum* has been used as an ethnic remedy for time immemorial. A bundle of studies have been carried out in the past validating these potential.

Various preparations have been attempted in viral pathogens related problems as acetone extracts (Deepthi *et al.,* 2007), aqueous extracts (Chiang *et al.,* 2005; Parida *et al.,* 1997; Balasubramanian *et al.,* 2007; Bhanuprakash *et al.,* 2007and 2008), ethanolic extracts (Bhanuprakash *et al.,* 2008a,b; Direkbusarakom *et al.,* 1996; Parida *et al.,* 1997, Chiang *et al.,* 2005; Balasubramanian, *et al.,* 2007) and benzene, diethyl ether,petroleum ether, ethyl acetate, methanol, chloroform and ethanol extracts (Balasubramanian *et al.,* 2007), hot aqueous extracts (Jayati et al., 2013), ethanolic extract Bishnu Joshi, Sunil Lekhak and Anuja Sharma (2009), Methanolic extract Bhatt Mehul k *et al.,* 2012). Shiju Mathew (2014) used methanolic extract followed by diethyl and aqueous extracts against *S. aureus, P. aeruginosa, E. coli, S. mutans* and *K. pneumonia.* etc. Ali *et al.,* (2014); crude chloroform, alcoholic, and aqueous extracts of leaf, stem bark and root bark of *Ocimum tenuiflorim* along with *Datura stromonium* (Vidya Shinde and D.A Dhale 2011).The antiviral activity of *ocimum sanctum* has been assessed against many important viral agents as fish pathogenic virus depending upon the type of extracts like Infectious hematopoietic necrosis virus (IHNV); Oncorhynchus masou virus (OMV); Infectious pancreatic necrosis virus (IPNV) (Direkbusarakom *et al.,* 1996), polio virus type-3 (Parida *et al.,*1997), herpes viruses (HSV), adenoviruses (ADV), hepatitis B virus and RNA viruses, viz. coxsackievirus B1 (CVB1), enterovirus 71 (EV71) (Chiang *et al.,* 2005), white spot syndrome virus (WSSV) in shrimp (Balasubramanian, *et al.,* 2007), Buffalo pox virus (GTPV) (Bhanuprakash *et al.,* 2007) and infectious bovine rhinotracheitis virus (IBR) (Sharma *et al.,* 2011). Others also observed the antimicrobial efficacy of *O. sanctum* leaves in various extracts (Baskaran X, 2008; Prasad *et al.,* 2012). Gomathinayagam Subramanian, Brij B. Tewari and Rekha Gomathinayagam used different extracts (Ethanol, Methanol, Ethyl acetate and chloroform) of dried leaf of *Ocimum sanctum* against three human pathogen strains *Escherichia coli, Staphylococcus aureus and Candida albicans.*

Table2: Antibacterial, antimycobacterial, antifungal and antiviral studies carried out on *Ocimum sanctum*

Sr.No	Part used	Type of extract	Active strains	Method	Effective concentration	Reference
1	Leaves	Methanolic	*E-coli, S-aureus*	Agar well diffusion Method	150 µg/plate	Shilpi M, 2014.
2	Leaves	Hot Aqueous extract	NCD virus	Agar Well diffusion assay	10.0 mg/ml	Jayati *et al.*, 2013.
3	leaves	acetone, methanol, chloroform, diethyl ether, dimethyl sulfoxide and aqueous	*S. aureus, P. aeruginosa, E. coli, S. mutans* and *K. Pneumonia*	Agar well diffusion assay	100 µl	Ali R, *et al.*, 2014.
4	leaves	*Ethanol, Methanol, Ethyl acetate and chloroform*	*S. aureus*	well diffusion, poison plate	900 µl	Gomathinayagam S, 2014.
5	Herb	Ethanolic	*E-coli, Salmonella typhi and Vibrio cholera*	culture plate	20mg/ml	Goswami P,
6	Herb	Ethanolic	*Staphylococcus aureus, Bacillus subtilis, Bacilus cereus* and *Bacillus Thuringiensis*	Agar well diffusion method	50µl/well	Bishnu J *et al.*, 2009.
7	Whole Herb	Methanolic	*Bacillus subtilis,E-coli*	Agar well diffusion	5mg	Bhatt MK *et al.*, 2012.
8	Leaf,stem &root bark	Chloroform,alcohol & aqueous	*F.oxysporum,R.stolonifer*	Agar well diffusion method	100%	Vidya Dal Dhale, 2011.
9	Leaf, stem	Ethanol and aqueous extracts	*Citrobacter freundii* and *Micrococcus luteus*	Disc diffusion method	12.5mg/ml	Uma S, *et al.*, 2013.
10	Fresh Leaves	Essential oil extract	Enterococcus faecalis	Spectrophotometric system	100%	Navin M *et al.*, 2013
11	Leaves	Ethanolic	*Streptococcus mutans*	The cup and plate method	4%	Pooja A, *et al.*, 2010

Antioxidant activities: Antioxidants are compounds that can delay or inhibit the oxidation of lipids or other molecules by inhibiting the initiation or propagation of oxidative chain reactions (Vadakkemuriyil Divya Nair et al., 2009).

A number of studies have been carried out for anti-oxidant activities of *Ocimum sanctum.* stem and leaf extracts (Balaji R, Prakash G et al., 2011), with caries active children aged between 8-14, (Dr K. Reshma Pai *et al.*, (2014); for rabbits fed with cholesterol and decreased GHS levels (Shweta Gupta,Pramod K, et, al 2006). Other studies carried out are: (Thamolwan Suanmuehwat et, al, 2010); (Vadakkemuriyil Divya Nair *et al.*, 2009); (Ramesh B, Satakopan VN, 2010; Gurupavithra S, and Jayachitra A, 2013); (Myron Green *et al.*, 2013); (S.K. Bhattacharya *et al.*, 2001). Out of two Polysaccharides isolated from the *ocimum sanctum* and *tinospora malabarica* medicinal plants, only *ocimum sanctum* polysaccharides showed the activity to prevent oxidative damage (Mahesh S, *et al.*, 2005).

Anti-inflammatory Activity. Leaf extract of essential oil extract or Eugenol, against carrageenan induced hind paw edema, exhibited significant (P< 0.05) anti-inflammatory activity at the dose level of 100mg/kg body weight and standard paracetamol at a dose of 5mg/kg (Kiran Thakur and Pitre KS, 2009). Methanolic extract of OS and chloroform extract on carrageenan rat paw edema showed significant activity. Chloroform fraction was most potent (66%, p<0.001) and methanolic extract of OS was non-toxic upto 125 microgm/ml in mouse peritoneal macrophages significantly reduced carrageenan induced paw edema (Basak P *et al.*, 2013).

A study from essential oil extract of OS documented a potent anti-inflammatory action against chronic inflammation induced granuloma in adult albino rats showed statistically significant decrease in dry granuloma weight (P= 0.034) with 35.8% inhibiton (Misra *et al.*, 2013).

Evaluation of anti-inflammatory activity of os fixed oil in adrenalectomised and non adrenalectomised rats results suggested that the activity of the Oil is independent of pituitary adrenal axis. (Rosa D, 1971).

Antistress Activity. The three OS compunds ocimumosides A (**1**) and B (**2**) and ocimarin (**3**), isolated from an extract of the leaves, with other compounds tested for antistress activity in male Sprague–Dawley rats screened at a dose of 40 mg/kg body weight; promising antistress effects by normalizing hyperglycemia, plasma corticosterone, plasma creatine kinase, and adrenal hypertrophy by ocimumoside A (p<0.05), ocimumosides B showed antistress activity but no effect on plasma glucose level while ocimarin showed no such effect (Prasoon Gupta, 2007).

Antifertility Activity. Leaf extract treatment of os on adult swiss albino male mice weighing between 25-30gm caused significant (p<0.001) decline in sperm count, reduction in motility of spermatozoa and decreased pH of seminal plasma while increased significantly (p<0.001) in treated group of mice than the control (Shail Pragya *et al.*, 2012).

Cytotoxicity. Methanolic crude extracts (n-hexane, ethyl acetate and chloroform soluble fraction) of OS

leaves screened for cytotoxic activity using brine shrimp lethality bioassay predicted to possess cytotoxic principles (LC50, 4.36mg/ml, LC50,5.37mg/ml and LC50, 10.00mg/ml respectively), vincristine sulphate (LC50 0.536mg/ml) being control (Aparna Debnath and Mohammad Musarraf Hussain, 2013).

Antigenotoxic activity. In a study (Kambam srilatha, 2013), Fluoride induced genotoxicity using micronuclei assessment from bone marrow and peripheral blood to study anti-genotoxic effect in albino mice, initiating single dose study (100, 400 and 800mg/kg) and as a time course for 1 day, 3 days and 7 days (100mg/kg showed all doses capable of preventing the formation of micronuclei but 100mg/kg of the aqueous extract being most efficacious as a single dose. The effect is possible due to the synergestic action of constituents like polyphenols, triterpenoids and flavonoids.

K. Babu1 and K.C. Uma Maheswari in 2005 studied Allium cepa root tip cells to detect the modifying effect of *Ocimum sanctum* aqueous leaf extract against chromium (Cr) and mercury (Hg) induced genotoxicity by In vivo cytogenetic assay, 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) samples and the lower doses of the leaf extract were found to be more effective than higher doses was observed possessing the OS protective effect against Cr/Hg induced genetic damage.

Anti ulcer activity: ulcer induced by aspirin, indomethacin, alcohol and stress induced in rats was administered by fixed oil Eugenol in the doses of 1,2 and 3mL/Kg intraperitoneally, reduced the ulcer index in dose-dependent mannerandsuggested that the strong antiulcer effect of OS was possibly due to the inhibition of 5- lipooxygenase in aspirin, indomethacin, and alcohol induced ulcer models(S. Singh and D. K. Majumdar, 1999).

Dharmani P, Palit G. (2006) while working with ethanolic extract of OS leaves found that the ethanolic extract of OS not only reduced acid secretion, but also potentially elevated the mucoprotective effect and 100 mg/kg body weight was found to be the most effective dose in dose dependent manner indicating that OS extract exhibited antiulcerogenic in all the five models agaisnt ulcer induced by cold restraint (CRU), alcohol (AL), aspirin (ASP), and pyloric ligation (PL) model in rats, and histamine (HST) induced duodenal ulcer model in guinea pigs.

Ashok Kumar *et al.,* (2011) while working for anti-ulcer activity of poly herbal formulation (PHF) containing *Ocimum sanctum*, *Abutilon Indicum* and *Triumfetta Rhomboidea* in indomethacin and Ethanol induced ulcers showed that PHF has potential antiulcer activity as comparable with standard drugs like Misoprostol (0.012mg/kg) and Omeprazole (10mg/kg), at a dose level of 200mg/kg.

Immunomodulatory effect: In conditions of immunodeficiency in cancer and other immunodeficiency syndrome, immunomodulators are being used as an adjuvant (Mathew and Kuttan 1999). In a study made by R. Carolene Jeba in 2011, OS showed increasing antibody production may be due to the release of mediators of hypersensitivity reactions and tissue responses to these mediators in the target organs by *O. sanctum* (Godhwani, *et al.,* 1988) which is also proved by the methanol extract and aqueous suspension of *Ocimum sanctum* leaves by Mediratta *et al*., (1988).*Ocimum sanctum* seed oil was proved to be both humoral and cell mediated immune responsive, due to the activity on GABA energic pathways (Mitra *et al.,* 1999).

O.sanctum and *Valairasa chendhuram* were efficient in enhancing the immune response and setting back the haematological parameters studied by Anuradha and Murugesan in 2001 against copper acetate induced toxicity on fish *Oreochromis mossambicus.* A poly herbal formulation Immunoplus (containing *O. sanctum*), enhanced the total protein and globulin as well as growth of *Labeo rohita (Kumari et al., 2007).* *O. sanctum, Phllanthus emblica, Withania somnifera* and Shilajit contained herbal immuno modulator is very helpful in boosting the immune system and fighting against *Caecal coccidiosis* (Pangasa, 2005). OS due to the prensence of phenolic compounds was proved as a potent Immunostimulant for *Clarias batrachus* fish (Gayatri Nahak and Rajani Kanta Sahu; 2014); immune-modulatory property in male Wistar rats by *ocimum sanctum* mixed with ground nut oil Bharatt B. K. *et al.,* (2011); *Ocimum sanctum* crude extract in feed and their combinations in broilers exposed to high dose of gentamicin, showed immunoprotective effect (Arivuchelvan *et al.,* 2012).

Hepatoprotective activity. Histologically confirmed that the treatment with Ethanolic Extract of *Ocimum sanctum* (EEOT) significantly ($P<0.05$) and dose-dependently reduced AT induced elevated serum level of hepatic enzymes, studied by Praveen Kumar *et al.,* (2013) and concluded that Atorvastatin (AT) 80 mg/kg treated) group induced acute liver toxicity in rats showed protective effect by EEOS. In another study made by Akilavalli N, Radhika J, Brindha P (2011), Proved that serum marker enzyme level and serum bilirubin content restored to near normal when treated with the aqueous extract of *O. sanctum* Values, $p<0.05$,

in Lead induced liver injury of Wistar strains of Albino rats.

Anthelmintic activity. The OS aqueous, ethanolic and hydro alcoholic extract prepared by cold maceration technique by *Joshi et al., (2013)* showed that dose dependent anthelmintic action was shown by aqueous extract and ethanolic extracts, aqueous extract being more potent at concentration 2, 4 and 10 mg showed paralysis and consequent death of the organism time that was comparable to piperazine at same concentrations, showing good activity against *Pheretema posthuma.* In another study made by *Verma S, et al.*, (2013), while investigating the anthelmintic efficacy of *OS herbal drug* in *Syphacia muris* infected mice on 18th, 19th and 20th post infection days, observed maximum (40 and 26) and minimum (16 and 9)Larval and Adult worm recovery response which indicates the anthelmintic efficacy of *Ocimum sanctum*.

Wound Healing property. The time taken for 50% wound contraction and complete eipthelisation by topical *Ocimum sanctum and* oral *Ocimum sanctum* was significantly ($p<0.001$) less compared to respective controls. After excision and incision resutured wound models in albino rats early inflammatory changes, dense collagen andneovascularisation in wounds treated with oral and topical *Ocimum sanctum*was histologically shown andpromoted better granulation tissue, early and completeepithelisation and better tensile strength (B. Asha et; al 2011).

Toxicity

Tulsi has been is known to bestow an amazing number of health benefits and revered in India for over five thousand years, as a healing balm for body, mind and spirit, having some immediate effects or with regular use. Immense studies have been conducted to evaluate the toxic effects of the plant.On administration by oral route, approximate LD50 of *Ocimum sanctum* was found to be 4505±80 mg/kg body weight(bw) and by intra-peritoneal (ip) routes, 3241±71 mg/kg, bw. OS leaves aqueous and alcoholic extracts with gradeddoses (3500–6300 mg/kg, bw) were injected ip in mice, and after a period of 72 hours it was observed that aqueous extract administration at doses up to 5 g/kg body weight did not produce any toxic effect ie 100% safe while 80% tolerance was shown by alcoholic extract up to a dose of 4g/kg, bw. The acute LD50 (30) values for aqueous extract was found to be 6200 mg/ kg, bw while that of alcoholic extract was found to be 4600 mg/kg, bw (Devi PU, Ganasoundari A, 1995). Another study conducted for fixed oil (seed oil) has been conducted to study toxicity in experimental rats by intra-peritoneal administration. A dose of 30 ml/kg, bw was well tolerated with no mortality, but at 55 ml/kg, bw 100% mortality was observed in acute toxicity study. For sub-acute toxicity study, no behavioral as well as histological changes were seen in the brain, lungs, liver and kidneys on administration of a dose of 3 ml/kg, bw, and LD(50) was calculated and found to be 42.5 ml/kg, bw of fixed oil (Singh S, Majumdar DK, 1994).Pingale SS, (2010) studied toxicity of OS leave powder and observed that from all dose groups (3g/Kg body weight to 7g/body weight) there was no mortality as there was no change in body weight, food and water consumption by the mice proving OS leaves powder non-toxic in mice.

Conclusion

The available literature on *Ocimum sanctum* has shown that it is an important medicinal as it has wide range of ethnomedical treatments like antifertility, anticancer, antidiabetic, antifungal, antimicrobial, hepatoprotective, cardioprotective, antiemetic, antispasmodic, analgesic. Immense studies carried out in present and past indicate that *Ocimum sacntum*possesses diverse health benefits and an important constituent of food. Anti-inflammatory, antimicrobial and antiviral, antimutagenic, antipyretic, antispasmodic, antistress, antiulcer, apoptotic, neuro and cardiovascular, chemomodulatory, cytotoxicity, hepatoprotective, anticancer, anticoagulant, antiarthritic, antidiabetic, radioprotective have been shown by the various extracts of *Ocimum sanctum* supporting its traditional use. The credit for these health benefit goes to the presence of phytochemicals.

Majority of the studies conducted use crude extracts and being difficult to pinout the bioactive compound which necessitates the standardization and bio-activity guided identification of compounds. Both traditional and pharmacological activities indicate that an immence scope still exists for its chemical exploration that can focus on validating the mechanism of action responsible for the reported effects.

Thus, being sacred plant with its various known remedies and life giving properties, there are many areas of research which may be helpful for society to be further explored. Geographical factors, Heavy metals contamination and seasonal variation factors play an important role in authentication of the chemical constituents responsible for the activity also can be an area of research. Thus it is incumbent on researchers to create awareness among pharmacologist as well as investigators towards providing better medicinal value and to fill the gap of insufficient knowledge which can be achieved through writing of critical appraisals (paper) by generating interest among research community and extending the interdisciplinary research area to focused studies on *Ocimum sanctum.*

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