

Tulsi: A holy plant with high medicinal and therapeutic value

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Abstract

The present review article explains medicinal and therapeutic uses of *Tulsi* plant in traditional medicine. *Tulsi* (*Ocimum sanctum* [OS] Linn.) is an aromatic plant belongs to family Lamiaceae. It is traditionally used for preparation of various Ayurvedic formulations for treatment of bronchitis, influenza, and asthma. Hot concoction of *Tulsi* leaves is usually provided for immediate relief in cold, sneezing nose, cough, malaria, and dengue. This article explains the biological effectiveness of OS against diabetes mellitus, hypertension, cancers, respiratory diseases, arthritis, various microbes, and parasites. *Tulsi* extracts and its various bio-organic constituents showed antioxidant activity, anti-atherogenic effect, anti-aging, immunomodulatory, anti-inflammatory, antistress, hepatoprotective, radioprotective, antihelmintic, repellent and larvicidal activity. *Tulsi* active ingredients showed anti-inflammatory properties and also play a role in modulation of both cellular and humeral immunity. Plant shows healing properties in hepatic injury and gastric ulcer. It relieves from stress, restore and improve body immunity and digestion. *Ocimum basilicum* L. contains (-)-linalool, eugenol and methyl chavicol, methyl chavicol (93.0%), gamma-caryophyllene as major constituents. Minor oil constituents are (+)-delta-cadinene, 3-carene, alpha-humulene, citral, and (-)-trans-caryophyllene. *Tulsi* oil contains high alpha-linolenic acid contents mainly eicosanoid precursor polyunsaturated fatty acids which are anti-inflammatory in nature. *Tulsi* also contains camphor, caryophyllene oxide, cineole, methyleugenol, limonene, myrcene, and thymol, which are known insect repellents. Its essential oil (EO) can be used to abate the growth of mosquitoes and control malaria. It is a good repellent and can be used for deterring flies, mosquitoes and insects. No doubt *Tulsi* plant is a good source of natural products mainly phyto-constituents and EO which can be used as alternative medicine for the treatment of various ailments and human health problems but proper composition and appropriate formulation is required before being used.

Key words: Ayurvedic medicine, *Tulsi*, *Ocimum sanctum*, essential oil, medicinal, therapeutic uses

INTRODUCTION

Tulsi or Tulasi or Vaishnavi (*Ocimum tenuiflorum* [OT]) or holy basil is a sacred plant of India. Plant has great spiritual, medicinal and therapeutic value in Hindu belief. Hindus regard it as an earthly manifestation of the goddess *Tulsi*; she is regarded as a great worshipper of the god Vishnu. Usually, plant leaves or dal are offered in every hymen and ritualistic worship of Vishnu and his incarnation Lord Krishna. Traditionally, In India, *Tulsi* is planted in the center of the central courtyard of Hindu houses.^[1] Many Hindus have *Tulsi* plants growing in front of or near their home, often in special pots or a special masonry structure known as *Tulsi Vrindavan*. The plant is cultivated for religious and medicinal purposes, and for its essential oil (EO). In Hindu, literature plant is also recognized by other synonyms such as *Tulsi* (matchless) is known as *Vaishnavi*

(belonging to Lord Vishnu), *Vishnu Vallabha* (beloved of Vishnu),^[2] *Haripriya* (beloved of Vishnu), and *Vishnu Tulsi*. The *Tulsi* with green leaves is called *Shri-Tulsi* (fortunate *Tulsi*); also Shri is a synonym for Lakshmi, the principal consort of Vishnu. Another variety of plant is known as *Rama-Tulsi* (bright *Tulsi*). Rama is also one of the principal avatars of Vishnu. The *Tulsi* with dark green or purple leaves and purple stem is called *Shyama-Tulsi* (dark *Tulsi*) or *Krishna-Tulsi* (dark *Tulsi*); Krishna is also a prominent avatar of Vishnu. This variety is considered especially sacred to

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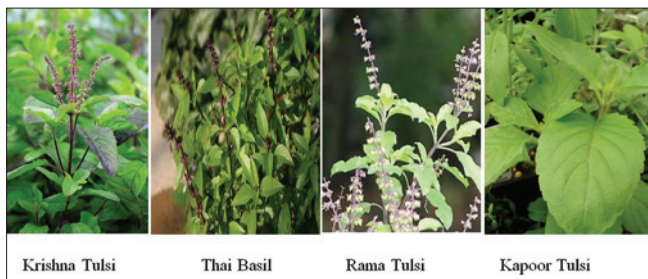
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Krishna, as its purple color is similar to Krishna's dark color (Photograph 1). OT, also known as *Ocimum sanctum* (OS), holy basil, or *tulasi* or *Tulsi* (also sometimes spelled *Thulasi*), is an aromatic plant in the family Lamiaceae which is native to the Indian subcontinent and widespread as a cultivated plant throughout the Southeast Asian tropics.^[2,3] It is an erect, many-branched sub-shrub, 30-60 cm (12-24 in) tall with hairy stems and simple phyllotaxic green or purple leaves that are strongly scented. Leaves have petioles and are ovate, up to 5 cm (2.0 in) long, usually slightly toothed. The flowers are purplish in elongate racemes in close whorls.^[3] The two main morphotypes cultivated in India and Nepal are green-leaved (Sri or Lakshmi *Tulsi*) and purple-leaved (Krishna *tulasi*).^[4] *Ocimum basilicum* L. Cvs. Vikarsudha and CIM-Soumya, OS L. Cvs. Green (CIM-Ayu) and Purple^[4] (Padalia RC and Verma RS. 2011) [Photograph 1].

MEDICINAL USES

Tulsi (OS Linn), commonly known as holy basil has been used for the treatment of a wide range of ailments in many parts of the world.^[5] Plant is widely used in various traditional and folk systems of medicine in Southeast Asia. *Tulsi* extracts and lukewarm concoction acts as a detoxifying, cleansing, and purifying agent both for internal and external. Fine meshed leaves in slurry are good for skin; it can be used and applied topically. It is also used for treatment of skin disorders, itching and issues like ringworms. Its leaf extract or fresh green leaves are used into teas or can be had raw, powdered, paste or in form herbal supplements. It acts like a broad spectrum antibiotic and shows antiviral, antibacterial and anti-carcinogenic efficacies. It is commonly used for relieving from fever, headache, sore throat, cold, cough, flu, and chest congestion. *Tulsi* tea or Kara is highly effective in treating respiratory ailments like chronic bronchitis, and asthma. It relieves from stress, restore and improve body immunity and digestion. Plant leaves contain diverse phytonutrients, EO, Vitamin A and C. Regular consumption of *Tulsi* leaves can also aid in balancing various bodily processes. It counters elevated blood sugar levels and is highly beneficial in diabetes, cancer, and chronic bronchitis. It helps in regulating uric acid levels in body, thereby elimination risks of developing kidney stones.



Photograph 1: Different varieties of *Tulsi* plant found in Indian sub-tropical climate

Tulsi is an essential ingredient in the preparation of Ayurvedic cough syrups. Hot water leaf extract is highly useful in getting rid of cold and flu. The decoction prepared by mixing honey, ginger, and *Tulsi* leaves is quite helpful in combating bronchitis, influenza and asthma. A hot concoction of *Tulsi* leaves is found extremely beneficial during the rainy season, and provide immediate relief in cold, sneezing nose, cough, malaria, and dengue. The juice extracted from *Tulsi* leaves is usually provided to bring down high fever. *Tulsi* leaves are widely used due to their healing power. It is a tonic for the nervous system, and thus, helps a great deal in sharpening the memory. Even, for a sore throat, the leaves of medicinal plant *Tulsi* is of great value. Just boil the leaves of *Tulsi* in water and ask the patient to gargle with this decoction. *Tulsi* has the ability to strengthen the kidneys. For those suffering from the problem of renal kidney stones, the decoction prepared by mixing the juice of *Tulsi* leaves with honey, if taken sincerely for 6 consecutive months can oust these stones via the urinary tract. For maintaining healthy heart, *Tulsi* is of utmost value. *Tulsi* helps in lowering the level of cholesterol in blood and beneficial in kidney stones. *Tulsi* plant serves as the most effective remedy to combat cardiac diseases. *Tulsi* based medicines help in maintaining normal levels of the stress hormone cortisol in the body which can easily wards off harmful effects of free radicals. *Tulsi* is highly useful in treatment of respiratory disorders. This aromatic plant supports the removal of phlegm and catarrhal matter from the bronchial tube. It is highly beneficial in treating conditions such as heart disease, headaches, stomach disorders, hepatitis, malaria, tuberculosis, dengue, and swine flu. Leaf powder and EO are highly useful for dental health and for healthy gums. *Tulsi* plant serves as a fabulous repellent in fighting against flies, mosquitoes and insects. Its EO can be used to abate the growth of mosquitoes and control malaria.

OS Linn. leaf extract shows synergistic antibacterial activity against *Salmonella enterica serovar* Typhi when provided with chloramphenicol and trimethoprim.^[6] OS is potential in combating *Salmonella typhi* drug resistance. Of *Tulsi* plant and eugenol on immune system, reproductive system, central nervous system, cardiovascular system, gastric system, urinary system, and blood biochemistry and have described the therapeutic significance of *Tulsi* in management of various ailments.^[7] *Tulsi* mixed in milk is provided to children during during measles attack. Laung, *Tulsi* leaves and Kishmish is the most common foodstuff given with cow milk and khichdi is a special nutritional care during the attack of measles to their children.^[8]

Tulsi leaves are widely used in several ancient systems of medicine including Ayurveda, Greek, Roman, Siddha, and Unani. *Tulsi* leaves are widely used in the preparation of Ayurvedic medicine for treatment of many diseases and disorders. Plant has vast number of therapeutic applications such as in cardiopathy, hemopathy, leukoderma, asthma, bronchitis, catarrhal fever, otalgia, hepatopathy, vomiting, lumbago, hiccups, ophthalmia, gastropathy, genitourinary

disorders, ringworm, verminosis and skin diseases. *Tulsi* is well known for treatment of bronchitis, bronchial asthma, malaria, diarrhea, dysentery, skin diseases, arthritis, painful eye diseases, chronic fever, and insect bite.^[7] It is also used for preventing stomach disorders. OS plant parts and its chemical constituents showed various pharmacological activities.^[9] Plant possess strong anti-inflammatory, analgesic, antipyretic, antidiabetic, hepatoprotective, hypolipidemic, antistress, and immunomodulatory activities^[10] and is a plethora of biological and pharmacological activities.^[11]

PHYTOCHEMISTRY

Ocimum basilicum L. Contains (-)-linalool (30-40%), eugenol (8-30%), and methyl chavicol (15-27%). Minor basil oil constituents are (+)-delta-cadinene, 3-carene, alpha-humulene, citral, and (-)-trans-caryophyllene.^[12] Thai basil oil

contains methyl chavicol (93.0%), eugenol (41.5%), gamma-caryophyllene (23.7%), and methyl eugenol (11.8%) as major compounds [Figure 1]. Hoary basil oil contained high amounts of geraniol (32.0%) and neral (27.2%) and small amounts of methyl chavicol (0.8%).^[13] *Linum usitatissimum*, oil contains high alpha-linolenic acid contents mainly eicosanoid precursor polyunsaturated fatty acids (PUFA) which are highly anti-inflammatory^[14] [Figure 1]. *Ocimum basilicum* L. EO contains eugenol (67.4% and 72.8%), beta-elemene (11.0% and 10.9%), beta-caryophyllene (7.3% and 8.4%), and germacrene D (2.4% and 2.2%), while the major components in *O. basilicum* cvs. "Vikarsudha" and "CIM-Soumya" were methyl chavicol (68.0% and 64.9%) and linalool (21.9% and 25.6%), along with bicyclogermacrene (2.0% and 0.7%) and alpha-terpineol (1.2% and 0.1%). Eugenol (77.2%), 1,8-cineole (7.6%), germacrene D (2.7%), and beta-caryophyllene (1.7%) were identified as the major constituents of *Ocimum gratissimum* (OG) [Figure 1].

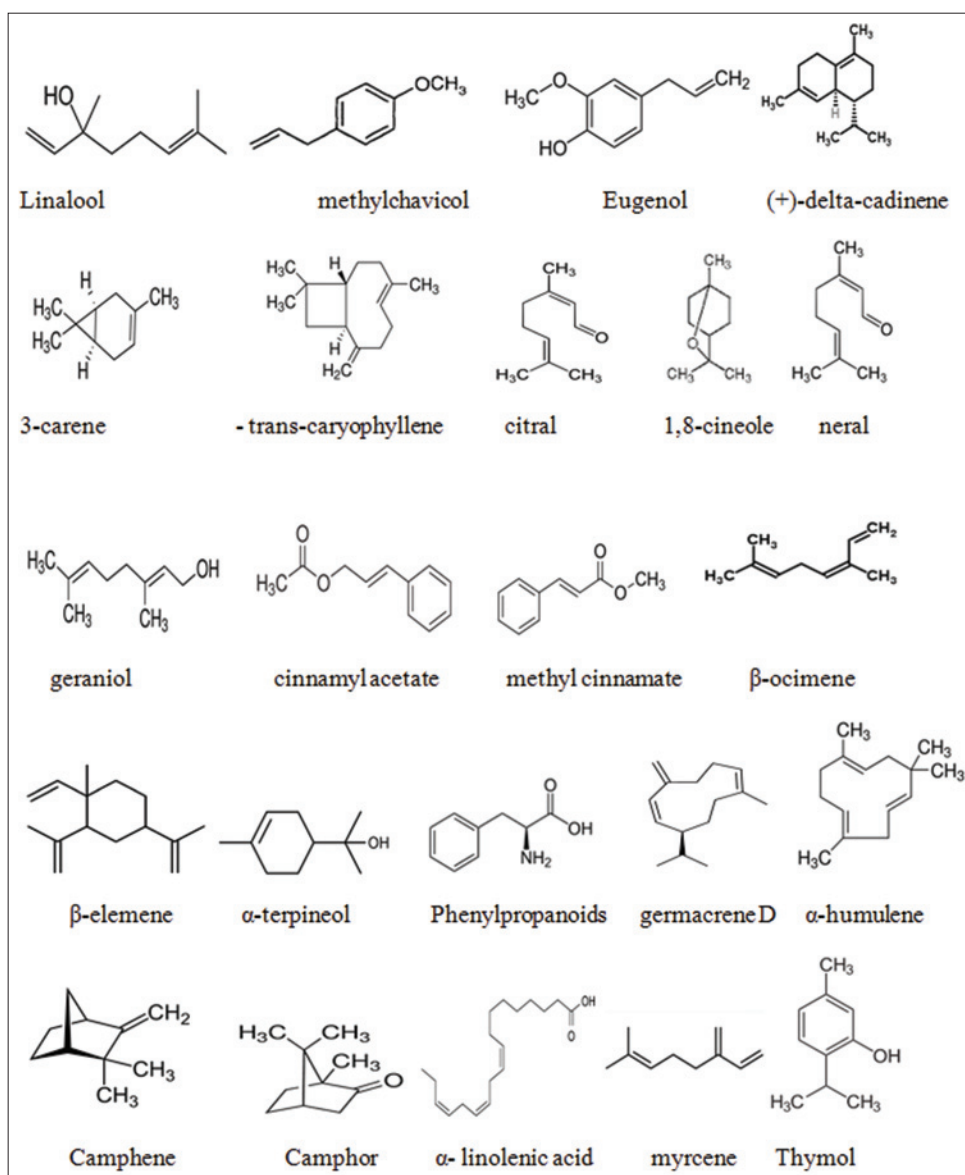


Figure 1: Various bio-organic compounds isolated from various species of *Tulsi*

EO from *Ocimum kilimandscharicum* mainly contains monoterpenoids (95.8%), represented by camphor (64.9%), limonene (8.7%), camphene (6.4%) and (E)- β -ocimene (3.0%),^[14] *O. basilicum* contains methyl chavicol (87.0%) and (Z)- and (E)-methyl cinnamate (69.1%).^[15] EO yield and quality of methyl eugenol rich sacred/holy basil (OT L.f.; Lamiaceae) (E)-cinnamyl acetate, eugenol and beta-elemene constituents of the oil.^[16] Gas chromatographic analysis indicated the presence of camphor, caryophyllene oxide, cineole, methyleugenol, limonene, myrcene, and thymol, all known insect repellents.

PHARMACEUTICAL ACTIVITY

OS Linn. contains diverse category of phytochemicals which show diverse biological and pharmacological activities.^[11] Few important pharmaceutical activities noted are as follows.

Anticancer Activity

OS L. or OT L contains phytochemicals such as eugenol, rosmarinic acid, apigenin, myrethal, luteolin, β -sitosterol, and carnosic acid prevented chemical-induced skin, liver, oral, and lung cancers and to mediate these effects by increasing the antioxidant activity, altering the gene expressions, inducing apoptosis, and inhibiting angiogenesis and metastasis.^[10] The aqueous extract of *Tulsi* and its bio-organic constituents, i.e., flavanoids, orintin, and vicenin are shown to protect mice against γ -radiation-induced sickness and reduced the mortality. It selectively protects the normal tissues against the tumoricidal effects of radiation. The other important phytochemicals such as eugenol, rosmarinic acid, apigenin, and carnosic acid are also shown to prevent radiation-induced DNA damage.^[10] *Tulsi* plant possesses both chemopreventive and radioprotective effects and found highly effective in cancer prevention and treatment.^[10] OS is a dietary herb and well known for its multiple beneficial pharmacologic properties including anti-cancer activity.^[17] Plant possesses antineoplastic effects and it can be used for the prevention and treatment of human cancer. Crude extract of OG and its hydrophobic and hydrophilic fractions (HB and HL) differentially inhibit breast cancer cell chemotaxis and chemoinvasion *in vitro* and retard tumor growth and temporal progression of MCF10ADCIS.com xenografts, a model of human breast comedo-ductal carcinoma *in situ* (comedo-DCIS). Mice fed on OG-supplemented drinking water showed no adverse effects compared with control. OG is non-toxic and obstruct cancerous activity MMP inhibitory activity [Table 1].^[17]

Tulsi (OS Linn) extract shows apoptosis-inducing ability on LNCaP prostate cancer cells.^[5] When LNCaP prostate cancer cells were treated with different concentrations of 70% ethanolic extract of *Tulsi* (EET), they show cytotoxicity after 24 and 48h of treatment. EET can effectively induce

apoptosis in LNCaP cells via activation of caspase-9 and caspase-3 that can eventually lead to DNA fragmentation and cell death.^[5] Flavonoid vicenin-2 (VCN-2), isolated from OS when provided in combination with docetaxel (DTL) stop carcinoma of prostate (CaP).^[18] VCN-2 effectively induces anti-proliferative, anti-angiogenic and pro-apoptotic effect in CaP cells (PC-3, DU-145 and LNCaP). VCN-2 inhibit EGFR/Akt/mTOR/p70S6K pathway along with decreasing c-Myc, cyclin D1, cyclin B1, CDK4, PCNA, and hTERT *in vitro*.^[18] OS Linn (*Tulsi*) extract also shows anti-ulcerogenic property in pyloric and aspirin treated rats.^[19] The extract of OSL reduced the ligated and pyloric ligated ulcer index, free, and total acidity on acute and chronic administration. 7 days pretreatment with the drug increased the mucous secretion and reduce acid secretion.^[19] OG retards breast cancer growth and its progression. It acts as a natural inhibitor of matrix metalloproteases [Table 1].^[17]

Antioxidant Activity

Leaves of different species of *Tulsi* (*Ocimum basilicum* var. *Purpurascens*, *Ocimum basilicum*, OG, *Ocimum micranthum*, and OT (syn. OS) showed variable yield of EO s and types of chemical constituents.^[20] These chemotypic variations also reflect variable antioxidant and free radical scavenging capacity.^[20] The yield of oils obtained was greater in OG (3.5%) and least from *Ocimum basilicum* var. *Purpurascens* (0.5%). Antioxidant capacity was positively correlated ($r = 0.92$, $P < 0.05$) with a high proportion of compounds possessing a phenolic ring such as eugenol, while a strong negative correlation ($r = -0.77$, $P > 0.1$) with other major volatiles was observed.^[20] OS L. leaves contain propanoid compounds including eugenol and methyl eugenol as major constituents which decrease serum lipid profile in normal and diabetic animals. It also shows antihyperlipidemic and antioxidative actions against hypercholesterolemia.^[21] *Tulsi* EO suppressed the high serum lipid profile and atherogenic index as well as serum lactate dehydrogenase and creatine kinase MB subunit without significant effect on high serum levels of aspartate aminotransferase, alanine aminotransferase and alkaline phosphatase in rats fed with HC diet. In addition, EO was found to decrease the high levels of thiobarbituric acid reactive substances (TBARS), glutathione peroxidase (GPx), and superoxide dismutase (SOD) without impacting catalase (CAT) in the cardiac tissue while in the liver, it decreased high level of TBARS without significantly effecting GPx, SOD and CAT.^[21] *Ocimum canum* a Thai plant shows antityrosinase and antioxidant activities.^[22] The EO of OS had the highest level of antioxidant activity, followed by the EO of OG.^[22] The EO obtained from flowering aerial parts of two *Ocimum* species, viz., OG and OS showed the presence of principal constituents as eugenol (75.1%) and methyl eugenol (92.4%), comprising 99.3 and 98.9% of the total oils, respectively.^[23] EO of OG showed comparative antioxidant activity with IC₅₀ values 23.66 ± 0.55 and 23.91 ± 0.49 $\mu\text{g/ml}$ in 2,2-diphenyl-1-picrylhydrazyl and

Table 1: Major and minor biochemical ingredients found in *Tulsi* plant with their biological activity

<i>Tulsi</i> species	Biochemical component/s	Characteristics	Biological activity
<i>O. basilicum</i> L.	Linalool (30-40%)	Terpene alcohol	Developmental and reproductive toxicity
	Eugenol (8-30%)	Phenylpropene, an allyl chain-substituted guaiacol	Germs, fungi and infection with antibacterial and anti-inflammatory
	Methylchavicol (15-27%)	Phenylpropene	Excellent tonic for the mind and nerves. Also good for tiredness, headaches, digestive problems and muscular aches
	Caryophyllene oxide	Natural bicyclic sesquiterpene	An oxygenated terpenoid, well known as preservative in food, drugs and cosmetics, has been tested <i>in vitro</i> as an antifungal against dermatophytes
	Camphor	Terpenoid	Typically to relieve pain and reduce itching, used to treat fungal infections of the toenail, warts, cold sores, hemorrhoids, and osteoarthritis
	Cineole	Cyclic ether and a monoterpene	Used in flavorings, fragrances, and cosmetics
	Methyleugenol	Phenylpropene	Used in insect traps and lure products to attract certain fruit fly
	Limonene	A cyclic terpene	Prevent cancer, treat cancer, and treat bronchitis. In foods, beverages, and chewing gum, limonene is used as a flavoring
	Myrcene	An olefinic natural organic hydrocarbon	Analgesic activity
	(+)-delta-cadinene	Isomeric hydrocarbons	Anti-parasitic
	- trans-caryophyllene	Natural bicyclic sesquiterpene	Cannabinoid-like properties
	Thymol	Natural monoterpene phenol derivative of cymene	As a dental varnish to prevent tooth decay, thyme is used as a flavoring agent
	3-carene	Bicyclic monoterpene	Effective anti-inflammatory
	Citral	3,7-dimethyl-2,6-octadienal or lemonal	Holistic and alternative medicine, potent antiseptic and may prove useful in treating gastro-intestinal infections, including <i>H. pylori</i>
	<i>O. basilicum</i>	Neral	Geranial and citral B
{(Z)-(E)-methyl cinnamate		Methyl ester of cinnamic acid	Use in soaps fragrance, and for flavor
α -humulene		Sesquiterpenes	Pronounced anti-inflammatory
β -ocimene		Monoterpenes	Herbal scent and act as plant defense and have anti-fungal properties
β -elemene α -terpineol		Sesquiterpenes	Anti-proliferative effect
Germacrene D	Sesquiterpene	Hyperglycemia, obesity	

(Contd...)

Table 1: (Continued)...

Tulsi species	Biochemical component/s	Characteristics	Biological activity
<i>O. tenuiflorum</i>	Cinnamyl acetate	3-phenyl-2-propenyl acetate	Antipyretic and larvicidal against <i>Anopheles gambiae</i> larvae
	α -linolenic acid	Fatty acid	Highly anti-inflammatory
<i>O. gratissimum</i>	Methyl eugenol rich sacred/holy basil	Essential oil	Used as a holistic and alternative medicine
<i>O. gratissimum</i>	Eugenol, 1,8-cineole, germacrene D and β -caryophyllene	Multiple components	Multiple biological activity, highly therapeutic
<i>O. kilimandscharicum</i>	Monoterpenoids (95.8%), camphor (64.9%), limonene (8.7%), camphene (6.4%) and (E)- β -ocimene	Essential oil mainly contains Multiple components	Counters elevated blood sugar levels and is highly beneficial in diabetes, cancer and chronic bronchitis

O. basilicum: *Ocimum basilicum*, *O. tenuiflorum*: *Ocimum tenuiflorum*, *O. gratissimum*: *Ocimum gratissimum*, *O. kilimandscharicum*: *Ocimum kilimandscharicum*, *H. pylori*: *Helicobacter pylori*

2,2'-azino-bis(3-ethylbenzthiazoline-6-sulphonic acid) models, respectively. Eugenol showed slightly weaker antioxidant activity compared to oil of OG, while OS oil demonstrated very feeble antioxidant activity and methyl eugenol did not show any activity [Table 1].^[23]

ANTIDIABETIC

OS L. or OT L. shows antidiabetic.^[24,25] Aqueous extract of OT decreases levels of blood glucose in induced hyperglycemic tilapia (*Oreochromis niloticus*).^[26] Extracts/fractions of AM and MC were found to inhibit significantly ($P < 0.05$) α -glucosidase activity, with IC_{50} comparable to the drug 1-deoxynojirimycin. When same treatment was given *in vivo* on glycogen-loaded mice showed significant ($P < 0.05$) depressive effect on elevation of postprandial blood glucose following ingestion of AM and MC extracts. Both floral and leafy parts can be used in alternative nutritional therapy mainly for management of diabetes because these inhibit carbohydrate hydrolyzing enzymes.^[27] Similar antidiabetic activity is reported in tetracyclic triterpenoid ([16-hydroxy-4,4,10,13-tetramethyl-17-(4-methyl-pentyl)-hexadecahydro-cyclopenta[a]phenanthren-3-one] isolated from aerial parts of OS.^[28] Aerial part of OS test compounds significantly decreases elevated level of serum glucose and also caused to reverse the cholesterol, triglyceride, low density lipoprotein (HDL), and high density lipoprotein (LDL) values when compared to untreated diabetic rats.^[28] Administration of OS to streptozocin-induced diabetic rats for 30 days significantly reduced the plasma level of TBARS and improved the status of the antioxidant enzymes catalase, SOD and GPx in vital organs such as the liver and kidney.^[29] Similarly, aqueous extract OS L is used for management of diabetes and related complications^[30,31] (while methanolic extract of OS Linn. reverses dyslipidemia and oxidative stress in alloxan induced type I diabetic rat model.^[32] OS has a therapeutic

role in diabetes and the metabolic stress.^[33] When OS extract is administered in streptozotocin diabetic rats mixed with vitamin it not only control glucose level^[34] but also restore biochemical parameters and retinopathy [Table 1].^[35,36]

OS is used in diabetes related treatment of diabetes-related metabolic disorders,^[37] and act both in hypoglycemic and hyperglycemic activity and restore glucose level.^[38] OT (L.) showed the ability to inhibit glucosidase and α -amylase inhibitory property.^[39] The three extracts of OT showed good inhibition of murine pancreatic and intestinal glucosidases as compared with acarbose, a known glucosidase inhibitor.^[39] Plant extract also normalize the damage induced by free radicals and show antioxidant properties.^[40] OS leaf extracts stimulate insulin secretion from perfused pancreas, isolated islets, and clonal pancreatic beta-cells^[41] hypoglycemic effect.^[42] Ethanolic extract of OS leaves partially attenuates streptozotocin-induced alterations in glycogen content and carbohydrate metabolism in rats.^[43] OS decreased the serum concentration of both cortisol and glucose.^[44] OS shows significant lens aldose reductase inhibiting potential and slow down cataractogenesis an important role in sugar-induced cataract.^[45] Crude ethanolic extract of OS showed STZ induced significant hyperglycemia and a concomitant decrease in islet cell SOD activity;^[46] hypoglycemic effect of;^[47] indigenous hypoglycemic herbs (in crude ethanolic extract) [Table 1].^[48]

Tulsi leaf powder when provided at the 1% level in normal and diabetic rats for a period of 1-month to it causes significant reduction in fasting blood sugar, uronic acid, total amino acids, total cholesterol, triglyceride, phospholipids, and total lipids. In liver, total cholesterol, triglyceride, and total lipids were significantly lowered. Total lipids were significantly reduced in kidney. In heart, a significant fall in total cholesterol and phospholipids was observed. Tulasi leaf powder shows hypoglycemic and hypolipidemic effect in animal model.^[49]

Similarly, leaf extract of OS and *Ocimum album* (holy basil) showed hypoglycemic effect (a significant decrease in fasting and postprandial blood glucose levels during the treatment with holy basil leaves compared to during treatment with placebo leaves. Fasting blood glucose fell by 21.0 mg/dl, confidence interval of difference-31.4(-)11.2 ($P < 0.001$), and postprandial blood glucose fell by 15.8 mg/dl, confidence interval-27.0(-)5.6 ($P < 0.02$). The lower values of glucose represented reductions of 17.6% and 7.3% in the levels of fasting and postprandial blood glucose, respectively. Mean total cholesterol levels showed mild reduction during basil treatment period [Table 1].^[50]

ANTIMICROBIAL ACTIVITY

OT (Lamiaceae), unripe OT fruit extract was found highly effective against a resistant strain of *Staphylococcus aureus*.^[51] Its leaf extract in combination with chloramphenicol (C) and trimethoprim (Tm) strong antibacterial activity against drug resistant *S. enterica serovar Typhi* (*S. typhi*). EET, OS, leaf TLE, in combination with C and Tm, had synergistic activity for *S. typhi* isolates.^[6] Eugenol (1-hydroxy-2-methoxy-4-allylbenzene), the active constituent present in OS L., has been found to be largely responsible for the antimicrobial therapeutic potential of *Tulsi*.^[7] Solvents and water extracts of *Tulsi* have shown antibacterial activity multi-drug resistant *S. aureus*^[52] and MIC was noted 1.56-6.25 mg/ml, whereas higher values (6.25-25 mg/ml) were obtained against the multi-drug resistant isolates *Klebsiella pneumoniae* and *Escherichia coli*.^[52] *Tulsi* (OS) extract was found active against *Streptococcus mutans*.^[53] Eugenol, methyl eugenol, linalool, and 1, 8-cineole, along with TEO *Tulsi* (OS Linn.) oils showed strong cytotoxicity to *Candida* species [Table 1].^[54]

Tulsi (OS Linn) shows strong antimicrobial properties against many microbial strains,^[55] OT contains alkaloids and polyketides active against *S. aureus* ATCC 29213 (MIC 64 µg/ml).^[56] The colloidal solution of silver nanoparticles exhibits high antibacterial activity against three different strains of bacteria *E. coli* (Gram-negative), *Cornebacterium* (Gram-positive), *Bacillus subtilis* (spore forming).^[57] *Ocimum* species EO showed antibacterial activity against 5 Gram-positive and 7 Gram-negative bacteria and antifungal (against 10 fungi) activities. The bacterial species *Bacillus subtilis*, *S. aureus*, *S. mutans*, and *Enterococcus faecalis*, and the fungal species *Epidermophyton floccosum*, *Microsporium gypseum*, and *Sporothrix schenckii* were more sensitive to the EO.^[15] Oil from seeds of OS imparts antibacterial activity against *S. aureus* (Singh *et al.*). OS L leaf extract shows antibacterial activity against *E. faecalis* dental biofilm.^[58] *O. kilimandscharicum* Baker ex Gürke, commonly referred to as Kapur *Tulsi*, is a medicinal herb that belongs to the family of Lamiaceae. It is traditionally popular for its gastroprotective effects, including its use as a digestive and anti-diarrheal.^[59] The EO extract of OS showed antibacterial efficacy against *E. faecalis* [Table 1].^[60]

IMMUNOMODULATORY

Consumption of *Tulsi* leaf (OS Linn.) on empty stomach increases immunity.^[61] Its alcoholic leaf extract shows immunomodulatory effect^[61] *Tulsi* is used for immune-based therapies mainly for treating diseases, control of ecto-and endo-parasites, fertility enhancement, bone setting, and poor mothering management. It also shows immune-modulatory effects such as modulation of cytokine secretion, histamine release, immunoglobulin secretion, class switching, cellular co-receptor expression, lymphocyte expression, and phagocytosis.^[62] *Tulsi* is leaf extract (DTLE) is protective against genotoxicants [Table 1].^[63]

ANTI-INFLAMMATORY

Seeds of OS contain oil that possesses anti-inflammatory activity due to dual inhibition of arachidonate metabolism supplemented by antihistaminic activity.^[14] Seed oil also possesses antipyretic activity due to prostaglandin inhibition and peripherally acting analgesic activity. It also shows hypotensive, anticoagulant and immunomodulatory activities. Lipoxigenase inhibitory, histamine antagonistic and antisecretory activities of the oil contribute toward antiulcer activity.^[14] The oil contains α -linolenic acid, an omega-3 fatty acid, which on metabolism produces eicosapentaenoic acid and the same appears to be responsible for the biological activity. Antioxidant property of the oil renders metabolic inhibition, chemoprevention and hypolipidemic activity.^[14] The presence of linolenic acid in the oil imparts antibacterial activity against *S. aureus* [Table 1].^[14]

Methanolic extract of OS (*Tulsi*) leaves showed anti-inflammation effect in isoproterenol (ISP) induced MI in rats.^[64] The activities of 5-lipoxygenase and cyclooxygenase-2 and levels of leukotriene B4 and thromboxane B2 were also elevated in ISP-treated rats, which were significantly decreased ($P < 0.001$) in extract pre-treated rats. It also shows antioxidant potential and cardioprotective effect which may be due to the high phenolic content of methanolic extract of OS leaves [Table 1].^[64]

Holy basil (OS) fixed oil contains alpha-linolenic acid which showed anti-inflammatory activity and does significant inhibition of paw edema in the highest dose (3 ml/kg). OS oil bear higher alpha-linolenic acid content produced a greater inhibition of paw edema suggesting that modulation of the course of inflammatory disorders may be achieved by altering the eicosanoid precursor PUFA availability through dietary manipulation.^[14] OS Linn: Extracts and its phytochemical constituents show anti-inflammatory activity.^[25] The bioavailability of flurbiprofen with reference to orally administered flurbiprofen in albino rats was found to increase by 2.97, 3.80 and 5.56 times with transdermal patch formulation without enhancer, *Tulsi* and turpentine oil formulations, respectively. *Tulsi* and turpentine oil enhance

penetration potential of transdermal delivery of flurbiprofen, a potent nonsteroidal anti-inflammatory.^[65] *Tulsi* leaves also show immunomodulatory effects such as modulation of cytokine secretion, histamine release, immunoglobulin secretion, class switching, cellular co-receptor expression, lymphocyte expression, and phagocytosis.^[62] OS contains phenolic compound eugenol (60 µg/mL) showed significant anti-inflammatory activity anti-inflammatory effect [Table 1].^[66]

ANTISTRESS ACTIVITY

Fresh leaves of OS cut down oxidative stress that led to a lesser depletion of reduced glutathione (28.80%) and plasma SOD (23.04%) in OS-treated rabbits. This anti-stressor activity of OS is partly attributable to its antioxidant properties [Table 1].^[67]

HEPATOPROTECTIVE ACTIVITY

The OS alcoholic leaf extract shows significant hepatoprotective activity^[68] and synergism with silymarin. In liver, EO and extracts of OS could prevent oxidative stress by increasing glutathione peroxidase and catalase and were also effective in prevention of hepatic steatosis.^[9,68] Its major biochemically active constituents such as eugenol, carvacrol, ursolic acid (UA), β-caryophyllene and rosmarinic acid showed anti-inflammatory, gastric and hepatoprotective properties.^[25] OS L. The oil possesses anti-inflammatory activity due to dual inhibition of arachidonate metabolism supplemented by antihistaminic activity. The oil possesses antipyretic activity due to prostaglandin inhibition and peripherally acting analgesic activity. The oil has been found to be effective against formaldehyde or adjuvant induced arthritis and turpentine oil induced joint edema in animals [Table 1].^[14]

ANALGESIC

OS L. or OT L is analgesic.^[10] The oil possesses anti-inflammatory activity due to dual inhibition of arachidonate metabolism supplemented by antihistaminic activity.^[14] Eugenol (1-hydroxy-2-methoxy-4-allylbenzene), the active constituent present in OS L., has been found to be largely responsible for the therapeutic potentials of *Tulsi*.^[7] The alcoholic leaf extract of OS shows analgesic activity in mice. This analgesic action of OS is exerted both centrally as well as peripherally and involves interplay between various neurotransmitter systems.^[69] The bioavailability of flurbiprofen with reference to orally administered flurbiprofen in albino rats was found to increase by 2.97, 3.80 and 5.56 times with transdermal patch formulation without enhancer, *Tulsi* and turpentine oil formulations [Table 1].^[70]

ANTI-ARTHRITIS

OS Linn. oil has been found to be effective against formaldehyde or adjuvant induced arthritis and turpentine oil induced joint edema in animals.^[14] It is also used for the treatment of skin diseases and arthritis [Table 1].^[7]

ANTI-ATHEROGENIC AND ANTI-CVD

OS, commonly known as Holy basil/*Tulsi*, has been traditionally used to treat cardiovascular diseases (CVD) and manage general cardiac health. OS leaves significantly change the blood lipid profile after a dose 1 g for 4 weeks in albino rabbit.^[71] This resulted in significant lowering in serum total cholesterol, triglyceride, phospholipid, and LDL-cholesterol levels and significant increase in the HDL-cholesterol and total fecal sterol contents. OS contains phenolic compounds and eugenol (EUG) which are traditionally used for treating CVD.^[66] *Tulsi* (OS polyphenolic extracts were found to have the inherent capacity to inhibit the transcriptional expression of genes, i.e., LDLR, LXR alpha, PPARs (alpha, gamma), CD-36 and c-myc which control lipid metabolism, cytokine production and cellular activity within the arterial wall [Table 1].^[72]

RADIOPROTECTIVE EFFECT

OS Linn. contains water soluble organic compounds flavonoids, orientin and vicenin which protect experimental animals against the radiation-induced sickness and mortality at nontoxic concentrations [Table 1].^[73]

ANTHELMINTIC ACTIVITY

The EO of OS and eugenol, tested showed potent anthelmintic activity in the *Caenorhabditis elegans* model. Eugenol exhibited an ED (50) of 62.1 microg/ml. Eugenol being the predominant component of the EO is suggested as the putative anthelmintic principle [Table 1].^[74] OS leaf also shows anthelmintic activity against ovine gastrointestinal nematodes.^[75]

ANTIAGING EFFECT

Tulsi OS Linn. contains UA and oleanolic acid (OA) as major constituents which account for many medicinal activities of the plant. Methods have been developed for rapid detection of UA, OA and their oxidation products from *Tulsi* leaves. These acids are helpful is slow down of cell division and growth [Table 1].^[71]

LARVICIDAL ACTIVITY

Ocimum is a genus of aromatic herbs, undershrubs or shrubs distributed in the tropical and warm temperate regions of the world.^[76] The LD₅₀ value of *O. basilicum* and OS oil was 39.31 and 40.02 on laboratory-reared larvae and 129.53 and 139.49 on field collected larvae. EO obtained from *Ocimum americanum*, *O. basilicum*, *O. basilicum* fa. *Citratum*, OG and OT, have shown repellent and larvicidal activities mosquito^[77]. All the oils exhibited both activities. *O. Basilicum* showed the strongest larvicidal activity (EC (50) = 81, EC (90) = 113 ppm), while OG exhibited the longest duration of action for mosquito repellent activity (more than 2 h). *Tulsi* plants contain camphor, caryophyllene oxide, cineole, methyleugenol, limonene, myrcene, and thymol which are all known insect repellents.^[77] Leaf ethyl acetate extracts of *O. canum* and OS were found larvicidal against fourth instar larvae of malaria vector, *Anopheles subpictus* Grassi, Japanese encephalitis vector, *Culex tritaeniorhynchus* Giles (Diptera: Culicidae). These extracts also showed feeding deterrence to nymphs of cotton pest, *Aphis gossypii* Glover (Homoptera: Aphididae).^[78] The acetone, chloroform, ethyl acetate, hexane, and methanol leaf and flower extracts of OS were studied against fourth instar larvae of *Aedes aegypti* and *Culex quinquefasciatus*. The highest larval mortality was found in leaf extract of OS against the larvae of *A. aegypti* and *C. quinquefasciatus*. The LC₅₀ values of OS against the larvae of *A. aegypti* were 425.94, 150.40, 350.78, 575.26, and 175.67 and against the larvae of *C. quinquefasciatus* were 592.60, 93.92, 212.36, 76.61, and 82.12 ppm, respectively.^[79] Antifeedant and larvicidal activity of acetone, chloroform, ethyl acetate, hexane and methanol peel, leaf and flower extracts of *Citrus sinensis*, *Ocimum canum*, OS were found active against fourth instar larvae of gram pod borer *Helicoverpa armigera* (Lepidoptera: Noctuidae), cotton leaf roller *Sylepta derogata* (Lepidoptera: Pyralidae) and malaria vector *Anopheles stephensi* (Diptera: Culicidae).^[80] Flower ethyl acetate extract of *O. Canum* and leaf acetone extract of OS was found active against the larvae of *S. Derogata* (LC₅₀ = 20.27 ppm), and *A. Stephensi* (LC₅₀ = 28.96 ppm), respectively [Table 1].^[80]

CONCLUSION

Tulsi plant contains various bio-organic components, i.e., methyl chavicol, camphor, limonene, camphene and (E)- β -ocimene, linalool and bicyclogermacrene and α -terpineol, 1,8-cineole (7.6%), germacrene D, and β -caryophyllene. Minor basil oil constituents are (+)-delta-cadinene, 3-carene, alpha-humulene, citral, and (-)-trans-caryophyllene. Its leaf EO contain methyl eugenol, (E)-cinnamyl acetate, eugenol and beta-elemene as major constituents which show multiple biological effectiveness. Its EO is a well-known insect repellent due to presence of camphor, caryophyllene oxide, cineole, methyl-eugenol, limonene, myrcene, and thymol. *Tulsi* leaves are widely used in several ancient systems of

medicine including Ayurveda, Greek, Roman, Siddha, and Unani. *Tulsi* leaves are widely used in the preparation of Ayurvedic medicine for treatment of many diseases and disorders. Plant has vast number of therapeutic applications such as in cardiopathy, hemopathy, leukoderma, asthma bronchitis, catarrhal fever, otalgia, hepatopathy, vomiting, lumbago, hiccups, ophthalmia, gastropathy, genitourinary disorders, ringworm, verminosis and skin diseases etc., *Tulsi* is well known for treatment of bronchitis, bronchial asthma, malaria, diarrhea, dysentery, skin diseases, arthritis, painful eye diseases, chronic fever and insect bite. It is also used for preventing stomach disorders. OS plant parts and its chemical constituents showed various pharmacological activities. Plant possess strong anti-inflammatory, analgesic, antipyretic, antidiabetic, hepatoprotective, hypolipidemic, antistress, and immunomodulatory activities and is a plethora of biological and pharmacological activity. *Tulsi* plant and eugenol work upon immune system, reproductive system, central nervous system, cardiovascular system, gastric system, urinary system and blood biochemistry. *Tulsi* is highly beneficial in treating conditions such as heart disease, headaches, stomach disorders, hepatitis, malaria, tuberculosis, dengue, and swine flu. Leaf powder and EO is highly useful for dental health and for healthy gums. *Tulsi* plant serve as a fabulous repellent in fighting against flies, mosquitoes, and insects. Its EO can be used to abate the growth of mosquitoes and control malaria. *Tulsi* is used by local people for various herbal preparations such as concoctions, syrups, green tea, and sat. Daily usage of *Tulsi* leaves help in controlling diabetes and diabetes-associated pathologies. Phytochemicals, nutritional, and mineral constituents of different plant species will definitely assist clinicians and pharmacists to prepare antidiabetic drug formulation with an establishment of non-toxic herbal drugs. These could be used as sources of nutrients, and as replacements for synthetic antidiabetic drugs. No doubt indigenous medicinal plants can be used to maximize the production of economically feasible drugs as an alternative of synthetic drugs to treat diabetes. There is a need of natural plant products that can be used for preparation of anti-diabetic formulations which could do a significant reduction in blood glucose level in comparison to existing standard anti-diabetic drugs. Various herbal preparations are also used as ethnomedicines by local people in the form of crude extracts prepared from flowers, fruits, roots of endemic plant species.

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