Antirhumatoid Activity Of Tulsi By Using In-Vitro Models

Rutuja Nitin Takawane [1], Dr. Vivek M. Satpute[2], Mr. Santosh A. Waghmare[3], Dr. Hemant V. Kamble[4]
Dept of Pharmaceutics
[1, 2] loknete Shri Dadapatil Pharate College of Pharmacy, Mandavgan Pharata .Tal-Shirur, Dist-Pune Maharashtra.
[3]CEO ,Loknete Shri Dadapatil Pharate College of Pharmacy, Mandavgan Pharata .Tal-Shirur, Dist-Pune Maharashtra
[4]Principal of loknete Shri Dadapatil Pharate College of Pharmacy, Mandavgan Pharata. Tal-Shirur, Dist-Pune Maharashtra.

Abstract- *Tulsi plant is called as tulsi in Sanskrit, holy basil in English. The scientific name of Tulsi is ocimum sanctum. It is called as mother of nature because it can cure variety of disease. Tulsi is anti-cancerous, anti-microbial, anti inflammatory, anti-diabetics, anti-fungal, anti-stress plant. The oil extracted from Tulsi plant is also beneficial for the treatment of various skin diseases. The hot solution prepared by extracting Tulsi leaves is helpful for the treatment of cold, cough, sneezing and so on. More than 300 years ago Tulsi is used for medical, pharmaceutical and as herbs by many people all around the world. Tulsi plant is I is greatly admired and followed by Indians. Tulsi is prestigious for Indians and others non-Muslims because they worship tulsi plant. Tulsi is considered as sign of " 50dn * epsilon " for most of the believers of India around the world. People around the world believes that Tulsi is sign of health, wealth and prosperity of their families, so they keep Tulsi plant outside of their house. Tulsi is avaible in variety of different types around 12 types are known to world but 3 types of Tulsi are most commonly known and used by the people for various purposes. Tulsi also contain many essential oil, vitamin, and minerals (Vitamin C, linoleic and linoleic acid)*
Synonyms - Ocimum Sanctum
family - Lamiaceae
plant part use - leaves.

Keywords- Tulsi (Ocimumtenuiflorum), essential oil, antimicrobial activity, headspace–solid phase micro extraction, gas chromatography–mass spectrometry

Tulsi has got the great medicinal Value Studies have Bhown Tulsi. To be effective drabities, by reducing level also for blood glucose

Tulsi is considered to be a iubiqutous plant in india ocimumtenuiPlonum (tulsi) is an aromatic plant in the family lamiaceae. Tulsi vital role in our everyday life is said to be the queen es a playes OR the herbal plants. It is the most commen household plant in india and it is Scared in hindu tradition...

Many hindu epics explain the importance, properties and uses of Tuls). Tusi. It is commonly grown in gardens and in the periphery of temples. It is the only plant that candbsorb carbon dio. o vide through -out its life. It release the oxygen in early morning which is beneficial for the people breathing disorders .

Tulsi leaves are In the preparation of Ayurvedic medicinal widely used

Tulsi is used for disease. Such as the Curing Common Various Cold, inflammation, malaria, heart disease. headche, stomach disorder, kidney stone heart disorders and many more.

The indian basil, tulsi also. in the purification of atmosphere. It is especially Valuable in combating malarial fever.

It said that at the time. of establishment OR Victon a in Bombay, the workers become gardens time of mosquito bites and Suffend from chronic malenia Tulsi plant Serves as the most effective remedy. to combat cardiac disease

I. MEDICINAL PROPERTIES

1. Tulsi has antioxidant properties & reduce blood glucose levels. Thus is useful for diabetics.
2. Tulsi reduce total cholestrol levels. Thus it is useful for heart diesease. patient
3. Tulsi reduce blood Pressure.
4. It helps in building up stamina.
5. It has been used orders, headache. for gastric dis cough + common cold, malaria, and headache.
6. It is also used. reducing tooth ache as mouth wash for
7. Tulsi oil shows larvicidal against malarial larva Activity.
8. It has immuno-modulatory properties. I It contains phyto-chemical which provide all these beneficial effects.
9. It has antiviral, antibacterial, anti tubercular, antifungal, anti-malarial, properties.

HEALTH BENEFITS DAILY LIFE OF TULSI IN OUR

HEALLING POWER :-

The Tulsi plant has many medicinal properties. The leaves. are a nerve tonic and memory stomach also sharp The leaves straight the and induce copious aspiration. The seed of the are mucilaginous per plant

FEVER AND COMMON COLD =

The leaves of basil are specimen for many fevers. puring the rainy for season. when malaria and dengue. Fever are widely prevent preventive against these disease

COUGH

Tulsi is an important constituents of many ayurvedic cough syrup. It helps to mobilize mucus bronchitis and asthma

SORE THROAT

water boiled with basil leaves can be taken as drink in case of Sore throat. This the can also used as a gargle

KIDNEY STONE.

Twasi has a 5 + reng effect on the kidney. In case of renal stone the juice of basil leaves. and honey, it taken regularly for 6 months .

RESPIRATORY DISORDER

The herb is useful in the treat-. of respirating system disorder.

HEART DISORDER

It reduces the level of blood cholestrol.

CHILDREN'S

ALIMENTS

common pediatric •problemes like cough, Cold, fever, diarrhea and Vomiting respond favorably to the of basil leaves.

STRESS

Even healthy person can show 12 leaves of tulsi help the prevent stress day to It helps purifies blood. It also used for prevent mouth infections, insect bites, skin disorders, Teeth disordesHeadche, eye, discreer etc

TULSI CAN HELP KEEP SHINE FLU AHAY This Can not only keep the at fast recovery. dreaded Swine flu or H_1N_1 flue. bay but also belp in of an afficted person. The antifluprop sty of twisi has been! discovered by world

Tulsi" improve the body's overall defence mechanisms including its ability to fight Viral disease was succesfully used in combating Japanese encephalitis and the Jame theory applies to swimeding DY. UK Tiwari, a herbal medicine -practitioner says Apart from a as a preventive mediare in case swine flu. Tulsi can faster of helps de cared Even when a person has |a|\ ready contracted Swine flue Tulsi can help in sta speeding up the and also help. Swine flue. Tulsi); leaves in water and the g_{i}*v * e_{m} to children and ale boiled essence adults who suffer from flu and Common cold recovery process in strengthning the immune system of the body.

Tulsi can Control Swine flu and it should be taken in fresh form. Juice or paste of at least 20-25 medium size leaves. Consumed twice a day on an empty stomach. Just effectiveness against

SHEETAHARAMTAKVAII (pills that end malaria) - 10 gm of tulsi leaves to grams of powder To gram of black paper gram of the leaves of bittergourd Or ceper. Regularly used this in seasons favouring malaria will prevent an attack of the discase

Taking one of these pills three times a day or two of them event morning and every evening is beneficial In fevers preceded by cold fevers prevalent in winter rigours Helps improve memory - Holy basil is excellent rejuvent for, which has been known to help. Reduces stress i relax the mind, and assist the body in imprising the just need to calm. pollutes the atmophere Holy basil (Tulsi) is considend to have some elements which help in purifying the environment. In addition it cleanses the polluted water as w Although regular fending and air .

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. 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 religions 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 Vallabna (beloved of Vishnu), 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 Tului). 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 plant.

Krishna, as its purple color is similar to Krishna's dark color (Photograph 1), OT, also known as Ocimum sanctum (OS). holy basil, or tulsi or Tulsi (also sometimes spelled Thulsi). 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, It is au creet, many-branched sub-shrub. 30-60 cm (12-24 in) tall with lariry 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. The two main morpholypes cultivated in India and Nepal are green-leaved (Sri er Lakshmi Tulsi) and purple-leaved (Krishna tulasi) 1 Ocimum basilicum L. Cvs. Vikarsudha and CIM-Soumya, OS L. Cvs. Green (CIM-Ayu) and Puplel

MEDICINAL USE :-

Tulsi (OSLinn), commonly known as holy basil has been used for the treatment of a wide range of ailments in many parts of the world." 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, ill, and chest congestion. Tulsi tea or Kars 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. Phyto-nutrients, 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, there by elimination risks of developing kidney stones.

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 , 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 conscentive months can oust these stones via the urinary tract. For maintaining healthy heart, Tuls: 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 asheart disease, headaches, stomach disorders, hepatitis, malaria, muberenlosis, dengue, and swine flu Leaf powder and EO are highly useful for dental health and for healthy gums. Tulsi plant serves as a fabulous repellant 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 entericaservar Typhi when provided. with chloramphenicol and trimethoprim " 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 Tulsiin management of various ailments Tulsi mixed in milk is provided to children during during measles attack. Lung. Tulsi leaves and Kishmish is the most common foodstull given with cow milk and khichdi is a special nutritional care during the attack of measles to their children.

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, asthuna, hiccups, ophthalmia, gastropathy, genitourinary. Different varieties of Tulsi plant found in bronchitis, catarrhal fever otalgia, hepatopathy vomiting.

Indian sub-tropical climate

International Journal of Green Pharmacy Jan-Mar-2017 (Suppl) 11

II. PHYTOCHEMISTRY

Ocimumbasilicum 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 Thaibasil

Linolool contains methyl chavicol (93.0%), eugenol (41.5%), gamma caryophyllene (23,76), and methyl engenal (11.8%) as major compounds [Figure 11 Hoary basil oil contained hight amounts of geraniol (32.0%) and neral (27 2%4) and small amounts of methyl chavicol (0.8%), Linumusitatissimum, oil contains high alpha-linolenic acid contents mainly eicosanoid precursor poly unsanurated fatty acids (PUFA) which are highly anti-inflammatory Figure 1]. Ocimum basilicum I EO contains engenol (67.4% and 72.8%) -elemene (11.0% and 10.9%). B-caryophyllene (7.3% and 8.4%), and germacrene D (2.4% and 2.2%), while the major components in O. basilicumevs. Vikarsudha" and "CIM Soumya" were methyl chuvicol (68.0% and 64.9%) and linalool (21.9% and 25.6%) , along with bicyclogermaerene (2.0% and 0.7%) and a-terpineol (1.2% and 0.1%). Eugenol (77.2%). 1,8-cineole (7.6%), germacrene D (2.7%), and. -caryophyllene (1.7%) were identified as the major of Ocimumgratissimum (OG) [Figure 1]

PHARMACEUTICAL ACTIVITY-

OS Lin, contains diverse category of phytochemicals which show diverse biological and pharmacological activities. Few important pharmaceutical activities noted are as follows.

1. ANTICANCER ACTIVITY-

OS L. or OT L. contains phyto- chemicals such as eugenol. rosmarinic acid, apigenin, myretenal. luteolin, B-sitosterol, and carnosic acid prevented chemical-induced skin, liver, oral, and lung cancers and tomediate these effects by increasing the antioxidant activity, altering the gene expressions, inducing apoptosis, and inhibiting angiogenesis and metastasis The aqueous extract of Tulsi and its bio-organic constituents, ie, flavanoids, orintin, and vicenin are shown to protect mice against y-radiation-induced sickness and reduced the mortality. It selectively protects the normal tissues against the tumoricidal effects of radiation. The other important phyto - chemicals such as eugenol. rosmarinic acid, apigenin, and carnosic acid are also shown to prevent radiation-induced DNA damage. Tulsi plant possesses both chemo preventive and radio protective effects and found highly effective in cancer prevention and treatment. OS is a dietary herb and well known for its multiple beneficial pharmacologic properties including anti-cancer activity. 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 hydrophile fractions (HB and HL) differentially inhibit breast cancer cell chemotaxis and chemomvasion 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 cancerons activity MMP inhibitory activity [Table 11.07

Tulsi (OS Linn) extract shows apoptosis-inducing ability. on INCAP prostate cancer cells. 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. Flavonoid vicemin-2 (VCN-2), isolated from OS when provided in combination with docetaxel (DTL) stop carcinoma of prostate (CaP). 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 p7056K pathway along with decreasing e-Mye, cyclin D1. cyclin B1. CDK4, PCNA, and hTERT in vitro Os Linn (Tulsi) extract also shows anti-ulcerogenic property in pyloric and aspirin treated rats.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. Oi retards breast cancer growth and its progression. It acts as a natural inhibitor of matric metalloproteases [Table 1].

2. ANTIOXIDANT ACTIVITY -

Leaves of different species of Tulsi (Ocimumbasilicum var. Purpurascéns, Ocimumhasilicum, O,Ocimummicranthum, and OT (syn. OS) showed variable yield of EO s and types of chemical constituents. These chemotypic variations also reflect variable antioxidant and free radical scavenging: capacity. The yield of oils obtained was greater in OG (3.5%) and least from Ocimumbasilicum 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 (T-0.77, P 0.1) with other major volatiles was observed. 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 anti- hyperlipidemic and anti-oxidative actions against hypercholesterolemia. Tulsi EO suppressed the high serum lipid profile and atherogenie index as well as serum lactate dehydrogenase and creatine kinase MB subunit without significant effect on high senum 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 thiobarbitric. acid reactive substances (TBARS), glutathione peroxidase (GPx), and superoxide dismutase (SOD) without impacting. catalase (CAT) in the cardine tissue while in the liver, it decreased high level of TBARS without significantly effecting GPx, SOD and CAT Ocimumcanum a Thai plant shows anti-tyrosinase and antioxidant activities. The EO of Os had the highest level of antioxidant activity, followed by the FO of OG, 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. EO of OG showed comparative antioxidant activity with IC values 23.66 0.55 and 23.91 0.49 ug/ml in 2.2-diphenyl-1-picrylhydrazyl and.

International Journal of Green Pharmacy Jan-Mar 2017 (Suppl) 11 (1) | 84
Upadhyay Medicinal value of Tulsi plant

MAJOR AND MINOR BIOCHEMICAL INGREDIENTS FOUND IN TULSI PLANT WITH THEIR BIOLOGICAL ACTIVITY

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

Tulsi species	Biochemical component/s	Characteristics	Biological activity
O. basilicum 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 *in vitro* as an antifungal against dermatophytes
	Camphor	Terpenoid	Topically 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 monoterpenoid	Used in flavorings, fragrances, and cosmetics
	Methyleugenol	Phenylpropene	Used in insect traps and lure products to attract certain fruit flie
	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 *H. pylori*
	Neral	Geranial and citral B	Cure of skin and hair problems
O. basilicum	((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	Sesquiterpenes	Anti-proliferative effect
	α-terpineol		
	Germacrene D	Sesquiterpene	Hyperglycemia, obesity

(Contd...)

Table 1: (*Continued*)...

Tulsi species	Biochemical component/s	Characteristics	Biological activity
	Cinnamyl acetate	3-phenyl-2-propenyl acetate	Antipyretic and larvicidal against Anopheles gambiae larvae
	α- linolenic acid	Fatty acid	Highly anti-inflammatory
O. tenuiflorum	Methyl eugenol rich sacred/holy basil	Essential oil	Used as a holistic and alternative medicine
O. gratissimum	Eugenol, 1,8-cineole, germacrene D and β-caryophyllene	Multiple components	Multiple biological activity, highly therapeutic
O. kilimandscharicum	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

3. Tulsi species O. basilicum L.
4. Bloohemical component/s
5. Linalool (30-40%)

Characteristics Terpene alcohol

Phenylpropene, an allyl chain-subatitutedauaiacal

BIOLOGICAL ACTIVITY

1.ANTIDIABETIC-

OS L. or OT L. shows anti-dibetic. Aqueous extract of OT decreases levels of blood glucose in induced hyperglycemic tilapia (Oreochromisniloticus) Extracts/fractions of AM and MC were found to inhibit significantly (P<0.05) a-glucosidase activity, with IC comparable to the drug 1-deoxynojirimycin. When same treatment was given in vivo on glycogen-londed 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, Similar anti-diabetic activity is reported in tetracyclic triterpenoid ([16-hydroxy- 4.4.10.13-tetramethyl-17-(4-methyl-pentyl-hexadecahydro- cyclopental alphenanthren-3-one] isolated from aerial parts of OS 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. 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. Similarly, aqueous extractOS L is sued for management of diabetes and related complications (while methanolic extract of OS Linn. reverses dyslipidemia and oxidative stress in alloxan induced. type 1 diabetic rat model OS has a therapeutic role in

OS is used in diabetes related treatment of diabetes-related metabolic disorders, and act both in hypoglycemic and hyperglycemic activity and restore glucose level OT (L) showed the ability to inhibit glucosidase and a-amylase inhibitory property. The three extracts of OT showed good inhibition of murine pancreatic and intestinal glucosidases as compared with acarbose, a known glucosidase inhibitor Plant extract also normalize the damage induced by free radicals and show antioxidant properties. Os leaf extracts stimulate insulin secretion from perfused pancreas, isolated islets, and clonal pancreatic beta-cells hypoglycemic effect. Ethanolic extract of OS leaves partially attenuates streptozotocin-induced alterations in glycogen content and carbohydrate metabolisin in rats. Os decreased the serum concentration of both cortisol and glucose OS shows significant aldose reductase inhibiting potential and slow down cataractogenesis an important role in sugar induced cataract ethanolic extract of OS showed STZ induced significant hyperglycemia and a concomitant decrease in islet cell SOD activity: hypoglycemic effect of indigenous hypoglycemic herbs (in crude ethanolic extract) [Table 11.

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 infasting 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 Tulsi leaf powder shows. hypoglycemic and hypolipidemic effect in animal model.

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 21.0mg / d * l , confidence interval of difference- \$1.4-(-)11.2 P<0.001) , and postprandial blood glucose fell by 5.8 mg/d1 , 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]

2. IMMUNOMODULATORY-

Consumption of Tulsi leaf (OS Linn.) on empty stomach increases immunity. [61] Its alcoholic leaf extract shows immuno modulatory effect611 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, phagocytosis.[6] Tulsi is leaf extract (DTLE) is protective against genotoxicants [Table 1].[63]

3. ANTIMICROBIAL ACTIVITY

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 mu g/ml) .[56] The colloidal solution of silver nanoparticles exhibits high antibacterial activity against three different strains of bacteria E. coli (Gram-negative), Corney bacterium (Gram-positive), Bacillus subtilis (spore forming).[57] Ocimum species EO showed antibacterial activity against 5 Gram-positive and 7 Gram-negative bacteria and antifungal

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. entericaserovarTyphi (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. Solvents and water extracts of Tulsi have shown antibacterial activity multi-drug resistant S. aureus[52] and MIC was noted .25 mg/ml, whereas higher values (25-25 mg/ml) were obtained against the multi-drug resistant isolates Klebsiellapneumoniae and Escherichia coli.[521 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]

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 mu*g / m * L) showed significant anti inflammatory activity anti-inflammatory effect [Table 1].[66]

4. ANTI-INFLAMMATORY

Methanolic extract of OS (Tulsi) leaves showed anti inflammation effect in isoproterenol (ISP) induced MI in rats. [64] The activities of 5-lipoxygenase and cycloxygenase-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 cardio protective effect which may be due to the high phenolic content of methanolic extract of OS leaves [Table 1],[64]

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. Lipoxygenase inhibitory, histamine antagonistic and antisecretory activities of the oil contribute toward antiulcer activity. The oil contains a-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]

5. 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]

6. 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 peroxidae 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), ß-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]

7. ANALGESIC

OS L. or OT L is analgesic. 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." 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]

8. 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].

9. 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. 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]

10. 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]

11. ANTHELMINTIC ACTIVITY

The EO of OS and eugenol, tested showed potent anthelmintic activity in the Caenorhabditiselegans 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].^ Box74 OS leaf also shows anthelmintic activity against ovine gastrointestinal nematodes.[75]

12. 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]

13. LARVICIDAL ACTIVITY

Ocimum is a genus of aromatic herbs, undershurbs or shrubs distributed in the tropical and warm temperate regions of the world. [76] The L*D_{50} 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 Ocimumamericanum, O. basilicum, O. basilicum fa. Citratum, OG and OT have shown repellent and larvicidal activities mosquito 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. Leaf ethyl acetate extracts of O. canum and OS were found larvicidal against fourth instar larvae of malaria vector, Anopheles subpictusGrassi, Japanese encephalitis vector, Culextritaeniorhynchus 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 Aedesaegypti and Culexquinquefasciatus. The highest larval mortality was found in leaf extract of OS against the larvae of A. aegypti and C. quinquefasciatus. The L*C_{5} , 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, Ocimumcanum, OS were found active against fourth instar larvae of gram pod borer Helicoverpaarmigera (Lepidoptera: Noctuidae), cotton leaf roller Syleptaderogata (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 (LC 50 =20.27 ppm), and A. Stephensi respectively [Table 1],[80] (LC 50 =28.96 ppm).

Popular tulsi tablets and capsules and the number of units per pack

Tulsi tablets and capsules	Units per pack
Himalaya Wellness Pure Herbs Tulasi Respiratory Wellness	60 tablets
Neuherbs Triple Tulsi - Giloy Plus	60 tablets
DABUR Tulsi Tablets	80 tablets
ORGANIC INDIA Tulsi Capsules	60 capsules
Amway Nutrilite Tulsi Tablets	60 tablets
Fast&Up Zinc + Tulsi Effervescent Tablets	30 effervescent tablets

.

Himalaya Wellness Pure Herbs Tulsi Respiratory Wellness

When it comes to healthcare products, Himalaya Wellness has been a trusted name in India. As the name suggests, these tablets are apt for maintaining respiratory wellness and giving you relief from cold, cough and minor respiratory infections. These tablets are known for their anti inflammatory and anti-microbial properties to maintain your overall health.

You can take 1 or 2 tablets every day as directed by your physician.

2. Neuherbs Triple Tulsi - Giloy Plus

If you want to go for tablets that have a combination of the extracts of tulsi and giloy, here is a good option to consider. These tablets work as natural immunity boosters and even make your respiratory tract stronger. So, the risk of cold, cough and other minor infections gets reduced with regular consumption of these tablets.

Besides the essential nutrients of tulsi and giloy, these tablets even contain the extracts of zinc and vitamins. So, you can take them for improving your immunity.

III. MATERIALS AND METHODS

- **Source of Tulsi**

Tulsi (*Ocimumtenuiflorum*), Voucher number PHARM-14-0028 obtained from the Medicinal Plant Herbarium at Southern Cross University, NSW, Australia, was used in this experiment. Fresh leaves and inflorescence (350 gm) were steam-distilled for 6 h in an essential oil Steam Distiller (Modified Clevenger apparatus) (Steam Distillation Apparatus, Crucible, Sacramento, CA, USA). The yield of volatile oil (weight of oil/weight of leaves made into a percentage) obtained was 0.57% v/w. The yellow colored volatile oil was stored in a sealed container at <4°C in the dark until needed.

- **Antimicrobial Activity of Tulsi Essential Oil**

The bacterial strains used in this study were *S. aureus* ATCC 25923, clinical isolate of methicillin-resistant *S. aureus* (MRSA) NCTC 6571 "Oxford Strain", *E. coli* ATCC 25922 and *P. aeruginosa* ATCC 27853.

The extracted oil was emulsified in Mueller–Hinton Broth (MHB, Oxoid, Adelaide, SA, Australia) by the following method: 90 µl of the essential oil and 10 µl of DMSO were added to a sterile Eppendorf tube (Sarstedt, Technology Park, SA, Australia). The solution was mixed by vortexing then 900 µl of the MHB was added in 30 µL aliquots, with brief vortexing between each addition. The broth dilution method was used to determine the minimal inhibitory concentration (MIC) of the Tulsi essential oil for each bacterial species (Wiegand et al., 2008). Two-fold dilutions of essential oil, diluted, and solubilized as described above, beginning at 9% (undiluted), in volumes of 50 µl were prepared in MHB in a 96-well sterile flat bottomed microtiter plate (Corning, Hickory, USA), then 50 µl of bacterial suspension was added to each well, such that the final concentration was 5×10^5 cfu in each well. The oil mixture was further diluted in the test (1:2) by the bacterial suspension, resulting in a solution containing of 4.5% essential oil in the

first well. Plates were incubated for 24 h at 37°C in the dark on an orbital shaker at 100 rpm to prevent adherence and clumping. After incubation, theoptical density of the contents of each well was determined using a spectrophotometer at 620 nm (Omega BMG LabTech, Ortenberg, Germany). For the minimal bactericidal concentration (MBC), 100 µl aliquots from each well were plated onto MHB agar and viable counts were determined after incubation for 24 h at 37°C (Clinical and Laboratory Standards Institute, 2012).

IBM SPSS (Statistical Package for the Social Sciences) (v.22, IBM Corporation, New York, NY, USA) was used for the statistical analysis of the amount of bacterial growth when treated with different concentrations of Tulsi essential oil. An alpha level of 0.05 was assumed for the determination of statistical significance. Analysis of variance (ANOVA) was followed by *post hoc* Tukey test to compare the amount of bacterial growth in wells containing different concentrations of essential oil. Data was calculated from two different experiments each conducted in triplicate.

- **Isolation and Identification of Volatile Compounds from Leaves, Flower Spikes, and Oil**

Fresh leaves, and flower spikes of Tulsi *Ocimumtenuiflorum* from the same source as the essential oil (distilled as described above) were collected from the Chinese medicinal garden at RMIT University, Bundoora Campus (Melbourne, VIC, Australia) in the summer of 2012; the temperature range during the growing season was 22–35°C. The samples were kept on ice after collection and during transportation to the laboratory, where 0.15 g of the inflorescence, fresh leaf material ground in a mortar and pestle unit, or essential oil was placed in a 4-ml clear, screw-top vial and sealed with a black polypropylene open-top cap and a PTFE (polytetrafluoroethylene)/silicone septum (Agilent Technologies, Santa Clara, CA, USA) and used immediately

- **Extraction of Volatile Compounds by HS-SPME**

Extraction of the volatile compounds from the ground leaf material, flower spikes and oil was performed by headspace–solid phase micro-extraction (HS–SPME) using modified protocol of Yamani et al. (2014). A 85-mm polyacrylate (PA) fiber fitted to a manual sampling fiber holder (Supelco, Bellefonte, PA, USA) was conditioned according to the manufacturer's instructions by placing into the gas chromatograph (GC) injection port at 250°C for 30 min before use. The preconditioned PA fiber was allowed to cool then inserted into the headspace of the vial containing the sample, and then the whole system was placed in a heating block at 40°C for 50 min. The volatiles were then desorbed by placing the fiber in the GC injection port for 5 min. The equilibrium time profile was developed using the method of Da Porto and Decorti (2008) with slight modifications; vials were placed in the heating block at 40°C instead of 30°C in order to extract all the compounds that might be present under hot conditions on summer days in Melbourne. Moreover, heating at 40°C resulted in an increased amount of volatile compounds on the fiber and a higher number of resulting peaks compared to heating at 30°C

IV. RESULTS

- **The Antimicrobial Activity of Tulsi Essential Oil**

Tulsi oil at concentrations of 4.5 and 2.25% completely inhibited the growth of *S. aureus*, including MRSA and *E. coli*, while the same concentrations only partly inhibited the growth of *P. aeruginosa* (**Figure** **Figure11**). The MBC results showed that Tulsi essential oil had only bacteriostatic activity against the examined bacterial strains. Viable bacterial counts were not measured because the plates were confluent indicating bacteriostatic activity. Statistical analysis of the spectrophotometric results showed that both the concentration of Tulsi oil and bacterial species used significantly affected the amount of growth ($P < 0.05$) (**Table** **Table11**). The percentage of bacterial growth was lower overall when bacteria were treated with Tulsi oil at a concentration of 4.50% (17.29) and 2.23% (15.07) in comparison to 1.13% concentration (56.62). The main effect on the bacterial species growth for all essential oil concentrations was significant as well. The percentage of bacterial growth was lower for *S. aureus* (13.03), MRSA (18.58), and *E. coli* (17.99) than for *P. aeruginosa* (68.78). Overall, *P. aeruginosa* showed higher resistance to the antibacterial treatment with Tulsi oil, compared to three other bacteria used in the test. On the other hand, the mean difference of the percentage of bacterial growth between *S. aureus*, MRSA and *E. coli* was not significant $p > 0.05$.

- **Reesistance to valuable antibiotics.Conclusion**

In summary, the essential oil extracted from *Ocimumtenuiflorum* showed antimicrobial activity against *S. aureus* (including MRSA) and *E. coli*, but was less active against *P. aeruginosa*. Responses of *P. aeruginosa* to antimicrobial compounds was recently reviewed (Morita et al., 2014) and some compounds were found to interact with RND efflux pumps of the bacteria (Dreier and Ruggerone, 2015). In some other studies, *P. aeruginosa* has been shown to be more resistant than other most Gram negative bacteria to the action of the essential oils (Prabuseenivasan et al., 2006; Mahmood et al., 2008), but others have shown either increased sensitivity

(Mishra and Mishra, 2011) or no difference in activity (Helen et al., 2011). A detailed analysis of the volatile compounds found in the essential oil and extracts from leaves and inflorescence revealed 54 different components that varied in presence and concentration in the three different sample types. A review of the literature suggested that the main components responsible for the antimicrobial activity of Tulsi oil were likely to be camphor, eucalyptol, and eugenol. β-caryophyllene may also have contributed to the antimicrobial activity of the oil but was present in smaller amounts. Since *S. aureus*, including MRSA, *P. aeruginosa*, and *E. coli* are major pathogens causing SSTIs, Tulsi essential oil could be a valuable topical antimicrobial agent for management of skin infections caused by these organisms or as a wound dressing to prevent infection. Early treatment or preventative measures may halt progression to more serious infection requiring systematic antibiotic therapy, and reduce the risk of development of resistance to valuable antibiotics.

- **Bioactive Volatile Compounds Present in Tulsi-**

Camphor was the most abundant volatile compound present in essential oil (31.52%), leaves (24.15%), and flower spikes (22.55%) of the Australian-grown Tulsi (**Table Table22**). Eucalyptol was the second most abundant volatile compound present in both essential oil and the leaves (18.85 and 13.47%, respectively). Camphor and eucalyptol are major components of the essential oils of three Greek *Achillea* species (*A. taygetea*, 26.6%; *A. holosericea*, 20.9%; *A. fraasii*, 16.3%). Furthermore, eucalyptol is the major constituent of the essential oil of *A. taygetea* and *A. fraasii* (25.7 and 11.9%, respectively), but was detected only in trace amounts (0.7%) in the oil of *A. holosericea*. The antimicrobial activity of these essential oils was assessed against six bacterial species; *S. aureus*, *S. epidermidis*, *E. coli*, *Enterobacter cloacae*, *Klebsiellapneumoniae*, and *P. aeruginosa* using the broth dilution technique. The oils of *A. taygetea* and *A. fraasii* showed strong to moderate activity against all six bacterial species, but the oil of *A. holosericea* was shown to have no antibacterial activity. In the same study, camphor was shown to be more effective than eucalyptol against the same bacterial species. It was proposed that the antibacterial properties of the essential oils of *A. taygetea* and *A. fraasii* are associated with their high content of camphor and eucalyptol (Magiatis et al., 2002). Both camphor and eucalyptol, identified as the abundant volatile compounds present in the essential oils of five taxa of *Sideritis* from Greece, were shown to possess some antimicrobial activity (Aligiannis et al., 2001). Moreover, camphor and eucalyptol standards obtained from Merck showed activity against *E. coli* and *S. aureus*, *Bacillus cereus*, *P. aeruginosa*, with camphor being more effective than eucalyptol (Mahboubi and Kazempour, 2009). Since both these compounds were identified as major components of Australian-grown Tulsi, we suggest that these substances may be responsible for the antimicrobial activity

V. CONCLUSION

In summary, the essential oil extracted from Ocimumtenuiflorum showed antimicrobial activity against S. aureus (including MRSA) and E. coli, but was less active against P. aeruginosa. Responses of P. aeruginosa to antimicrobial compounds was recently reviewed (*Morita et al., 2014*) and some compounds were found to interact with RND efflux pumps of the bacteria (*Dreier and Ruggerone, 2015*). In some other studies, P. aeruginosa has been shown to be more resistant than other most Gram negative bacteria to the action of the essential oils (*Prabuseenivasan et al., 2006*; *Mahmood et al., 2008*), but others have shown either increased sensitivity (*Mishra and Mishra, 2011*) or no difference in activity (*Helen et al., 2011*). A detailed analysis of the volatile compounds found in the essential oil and extracts from leaves and inflorescence revealed 54 different components that varied in presence and concentration in the three different sample types. A review of the literature suggested that the main components responsible for the antimicrobial activity of Tulsi oil were likely to be camphor, eucalyptol, and eugenol. β-caryophyllene may also have contributed to the antimicrobial activity of the oil but was present in smaller amounts. Since S. aureus, including MRSA, P. aeruginosa, and E. coli are major pathogens causing SSTIs, Tulsi essential oil could be a valuable topical antimicrobial agent for management of skin infections caused by these organisms or as a wound dressing to prevent infection. Early treatment or preventative measures may halt progression to more serious infection requiring systematic antibiotic therapy, and reduce the risk of development of resistance to valuable antibiotics.

REFERENCES

[1] Aligiannis N., Kalpoutzakis E., Chinou I., Mitakou S., Gikas E., Tsarbopoulos A. (2001). Composition and antimicrobial activity of the essential oils of five taxa of *Sideritis* from

[2] Greece. *J. Agric. Food. Chem.* 49 811–815. 10.1021/jf001018w [PubMed] [CrossRef] [Google Scholar]

[3] Alma M. H., Mavi A., Yildirim A., Digrak M., Hirata T. (2003). Screening chemical composition and in vitro antioxidant and antimicrobial activities of the essential oils from *Origanumsyriacum* L. growing in Turkey. *Biol.*

Pharm. Bull. 26 1725–1729. 10.1248/bpb.26.1725 [PubMed] [CrossRef] [Google Scholar]

[4] Brophy J. J., Goldsack R. J., Clarkson J. R. (1993). The essential oil of *Ocimumtenuiflorum* L.(Lamiaceae) growing in Northern Australia. *J. Essent. Oil. Res.* 5 459–461. 10.1080/10412905.1993.9698260 [CrossRef] [Google Scholar]

[5] Burt S. (2004). Essential oils: their antibacterial properties and potential applications in foods—a review. *Int. J. Food. Microbil.* 94 223–253. 10.1016/j.ijfoodmicro.2004.03.022 [PubMed] [CrossRef] [Google Scholar]

[6] Chang J. D., Mantri N., Sun B., Jiang L., Chen P., Jiang B., et al. (2016). Effects of elevated CO2 and temperature on *Gynostemmapentaphyllum* physiology and bioactive compounds. *J. Plant Physiol.* 19 41–52.

[7] Clinical and Laboratory Standards Institute (2012). Methods for Dilution Antimicrobial Susceptibility Tests for Bacteria That Grow Aerobically, Approved standard M7-A9, 9th Edn Wayne, PA: Clinical and Laboratory Standards Institute. *[**Google Scholar**]*

[8] Cutler H. G., Cutler S. J. (1999). Biologically Active Natural Products: Agrochemicals. Boca Raton, FL: CRC Press. *[**Google Scholar**]*

[9] Da Porto C., Decorti D. (2008). Analysis of the volatile compounds of flowers and essential oils from Lavandulaangustifolia cultivated in Northeastern Italy by headspace solid-phase microextraction coupled to gas chromatography-mass spectrometry. Planta Med. 74 182–187. 10.1055/s-2008-1034295 [**PubMed**] [**CrossRef**] *[**Google Scholar**]*

[10] Dreier J., Ruggerone P. (2015). Interaction of antibacterial compounds with RND efflux pumps in Pseudomonas aeruginosa. Front. Microbiol. 6:660 10.3389/fmicb.2015.00660 *[**PMC free article**]* [**PubMed**] [**CrossRef**] *[**Google Scholar**]*

[11] Dryden M. S. (2009). Skin and soft tissue infection: microbiology and epidemiology. Int. J. Antimicrob. Agents 34 S2–S7. 10.1016/S0924-8579(09)70541-2 [**PubMed**] [**CrossRef**] *[**Google Scholar**]*

[12] Dryden M. S. (2010). Complicated skin and soft tissue infection. J. Antimicrob. Chemother. 65(Suppl. 3), iii35–iii44. 10.1093/jac/dkq302 [**PubMed**] [**CrossRef**] *[**Google Scholar**]*

[13] Eron L., Lipsky B., Low D., Nathwani D., Tice A., Volturo G. (2003). Expert panel on managing skin and soft tissue infections. Managing skin and soft tissue infections: expert panel recommendations on key decision points. J. Antimicrob. Chemother. 52 i3–i17. 10.1093/jac/dkg466 [**PubMed**] [**CrossRef**] *[**Google**