

**INTERNATIONAL JOURNAL OF ADVANCES IN PHARMACY,
BIOLOGY AND CHEMISTRY****Review Article****Pharmacological Actions of *Ocimum sanctum*– Review
Article**

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ABSTRACT

In the present review, an attempt has been made to congregate the botanical, phytochemical, ethno medicinal, pharmacological and toxicological information on *Ocimum sanctum* Linn. (*OS*, *Tulsi*), a medicinal herb used in the indigenous system of medicine. *OS* has been adored in almost all ancient ayurvedic texts for its extraordinary medicinal properties. It is pungent and bitter in taste and hot, light and dry in effect. Its seeds are considered to be cold in effect. The roots, leaves and seeds of *Tulsi* possess several medicinal properties. Ayurvedic texts categorise *OS* as stimulant, aromatic and antipyretic. While alleviating kapha and vata, it aggravates pitta. It has a wide range of action on the human body mainly as a cough alleviator, a sweat-inducer and a mitigator of indigestion and anorexia. This review will definitely help for the researchers as well as clinicians dealing with *OS* to know its proper usage as this herb is seemed to be highly valuable, possessing many pharmacological / medicinal properties. Medicinal properties of *Tulsi* (*Ocimum sanctum* Linn) are known for thousand years to various civilizations of the world. This medicinal herb is considered as a sacred plant by the Hindus in the Indian subcontinent. Scientific explorations of traditional belief of medicinal properties of *Tulsi* have got momentum mostly after the middle of the 20th century. Most of these evidences are based on *in-vitro*, experimental and a few human studies.

Keywords: Medicinal properties, *Ocimum sanctum* (*OS*, *Tulsi*), Pharmacological activities.

INTRODUCTION

Tulsi is an important symbol of the Hindu religious tradition. Although the word '*Tulsi*' gives the connotation of the incomparable one, its other name, Vishnupriya means the one that pleases Lord Vishnu. Found in most of the Indian homes and worshipped, its legend has permeated Indian ethos down the ages. Known in English as Holy Basil and botanically called *Ocimum sanctum*, *Tulsi* belongs to plant family Lamiaceae. It has made important contribution to the field of science from ancient times as also to modern research due to its large number of medicinal properties. *Tulsi* has been described as of two types- vanya (wild) and gramya (grown in homes). Although having identical usage, the former has darker leaves. *Tulsi* is a popular home remedy for many ailments such as wound, bronchitis, liver diseases, Catarrhal fever, otalgia, lumbago, hiccough, ophthalmic, gastric disorders, genitourinary disorders, skin diseases, various forms of poisoning and psychosomatic stress disorders^{1,2}. It has also

aromatic, stomachic, carminative, demulcent, diaphoretic, diuretic, expectorant, alexiteric, vermifuge and febrifuge properties³. In view of these facts, an attempt has been made to review on the various pharmacological activities of *OS* based on the experimental and clinical studies reported in different literatures.

Tulsi grows wild in the tropics and warm regions. The plant is distributed and cultivated throughout India. It is an erect, much branched, fragrant and erected plant attaining a height of about 30-60 cm when mature. Its aromatic leaves are simple, opposite, elliptic, oblong, obtuse or acute with entire or sub serrate or dentate margins, growing up to 5 cm long. The *Tulsi* flowers are small, purplish in elongate racemes in close whorls. The fruits are small and the seeds are reddish-yellow in colour. The plant is bitter and acrid^{2,3}.

Tulsi is described as sacred and medicinal plant in ancient literature. The name *Tulsi* is derived from '*Sanskrit*', which means "matchless one". This plant belongs to the family *Labiatae*, characterized

by square stem and specific aroma. Botanical name of *Tulsi* is *Ocimum sanctum* (Linn). In India, the plant is grown throughout the country from Andaman and Nicobar islands to the Himalayas up to 1800 meters above the sea level. It is also abundantly found in Malaysia, Australia, West Africa and some of the Arab countries. *Ocimum sanctum* (Linn) is the most prominent species of the genera. The leaves of the plant are considered to be very holy and often form a consistent part of the Hindu spiritual rituals (*Tirtha* or *Prasada*). *Ocimum sanctum* has two varieties i.e. black (*Krishna Tulsi*) and green (*Rama Tulsi*), their chemical constituents are similar. Both the varieties also have common medicinal properties¹.

Traditional uses

Tulsi is also known as "the elixir of life" since it promotes longevity. Different parts of plant are used in Ayurveda and Siddha Systems of Medicine for prevention and cure of many illnesses and everyday ailments like common cold, headache, cough, flu, earache, fever, colic pain, sore throat, bronchitis, asthma, hepatic diseases, malaria fever, as an antidote for snake bite and scorpion sting, flatulence, migraine headaches, fatigue, skin diseases, wound, insomnia, arthritis, digestive disorders, night blindness, diarrhoea and influenza. The leaves are good for nerves and to sharpen memory. Chewing of *Tulsi* leaves also cures ulcers and infections of mouth².

Phytoconstituents

The leaves of *OS* contain 0.7% volatile oil comprising about 71% eugenol and 20% methyl eugenol. The oil also contains carvacrol and sesquiterpine hydrocarbon caryophyllene. Fresh leaves and stem of *OS* extract yielded some phenolic compounds (antioxidants) such as cirsilineol, circimaritin, isothymusin, apigenin and rosameric acid, and appreciable quantities of eugenol⁸. Two flavonoids, viz., orientin and vicenin from aqueous leaf extract of *OS* have been isolated³. Ursolic acid, apigenin, luteolin, apigenin-7-O-glucuronide, luteolin-7-O glucuronide, orientin and molludistin have also been isolated from the leaf extract. *OS* also contains a number of sesquiterpenes and monoterpenes viz., bornyl acetate, elemene, neral, - and-pinenes, camphene, campesterol, cholesterol, stigmasterol and \square -sitosterol⁹.

Tulsi as a prophylactic agent

Decoction of leaves is used against the gastritis and hepatic disorders. The juice of fresh leaves is also given to patients to treat dysentery. In a study, it has been found that methanol extract of *Ocimum suave* showed healing effect against chronic gastric ulcers induced in experimental rats. *Ocimum* sp. along with pepper, turmeric and onion is

prophylactic against malaria. Oil is insecticidal and larvicidal. It contains: b-bisabolene (13-20%), methyl chavicol (3-19%), 1,8-cineole (9-33%), eugenol (4-9%), (E)-a-bisabolene (4-7%) and a-terpineol (1.7-7%) are the main constituents of *tulsi* oil¹⁰. Often, *Tulsi* is planted in Indian gardens as a mosquito repellent. Essential oils of *Tulsi* possess 100 % larvicidal property. It has been found that *Tulsi* has excellent anti-malarial properties as well. Eugenol is the main constituent and it is responsible for its repellent property. Paste prepared from *Tulsi* leaves is used against the ringworm infection. *Tulsi* removes worms and parasites. *Tulsi* extract with honey is recommended so that the parasites may be excited, thus drawing them out of their hiding places. Paste of its leaves is applied on face to clear marks¹¹. Urosolic acid present in leaves returns elasticity and removes wrinkles. *Tulsi* helps skin stay healthy and supple. Use of *Tulsi* in the treatment of all kinds of cuts, wounds and ulcers is highly beneficial. The leaf juice of *tulsi* along with triphala is used as an eye tonic and is recommended for glaucoma, cataract, chronic conjunctivitis and other diseases associated with eyes. Chewing of leaves before a meal helps stimulating the appetite, and a tea taken after a meal promotes digestion by increasing the flow of gastric juices, while reducing gas and bloating. *Ocimum sanctum* also reduces the chances of ulcers. It is an active diaphoretic common cold. It removes excess cough from lungs and nasal passages. A decoction of *Tulsi* leaves is a popular remedy for common cold in India. It is also given for fever along with the clove. It also lowers the uric acid levels and hence is considered as a potential anti-inflammatory agent. The leaves of basil are specific for many fevers. During the rainy season, when malaria and dengue fever are widely prevalent, tender leaves, boiled with tea, act as preventive against these diseases. In case of acute fevers, a decoction of the leaves boiled with powdered cardamom brings down the temperature, thereby it has been considered as a potential antipyretic cocktail as a home remedy. *Tulsi* is an important constituent of many cough syrups and expectorants. It helps to mobilize mucus in bronchitis and asthma. Chewing *Tulsi* leaves relieves cold and flu. The leaves are nerve tonic and also sharpen memory. They promote the removal of the catarrhal matter and phlegm from the bronchial tube. It is useful in teeth disorders and is also recommended as a remedy against pyorrhoea. Also, it is used as a remedy for night blindness and conjunctivitis. Being nerve tonic the leaves are used to sharpen memory. It is a good source of antioxidants and offer substantial protection against free radical induced damage. Oxygen free radicals are natural physiological products, containing one or more unpaired electrons¹⁰. Reactive oxygen species (ROS) may

damage life important membrane lipids, proteins, DNA and carbohydrates. This damage has been implicated in the causation of several diseases such as liver cirrhosis, atherosclerosis, cancer, and diabetes etc^{11,12}. It has been well accepted that dietary antioxidants have great potential in ameliorating these disease processes. Antioxidants thus play important role in protecting the human body against damage by reacting oxygen species. It also decreases the lipid peroxidation and increases the activity of super-oxide dismutase¹³. Presence of eugenol attributes to its anti-oxidative property and is also thought to be responsible for inhibition of lipid per oxidation. This property helps in maintaining good health and in preventing the chances occurrence of heart diseases as well as most of the other biochemical diseases because oxidative stress is the hallmark of such diseases¹⁴.

Chemical properties

Ocimum sanctum has specific aromatic odour because of the presence of essential or volatile oil, mainly concentrated in the leaf. This aromatic volatile oil mainly contains phenols, terpenes and aldehydes. The oil extracted from seeds is called fixed oil and mainly composed of fatty acids. Besides oil, the plant also contains alkaloids, glycosides, saponins and tannins. The leaves contain ascorbic acid and carotene as well. The present day information about the chemical properties is based on the various studies that have been done in different parts of the world¹⁵ and it is likely that chemical constituents may be varying due to edaphic and geographic factors¹⁶.

Health Benefits of Basil (Tulsi)

The health benefits of holy basil or tulsi include oral care, relief from respiratory disorders, fever, asthma, lung disorders, heart diseases and stress. Holy Basil (scientific name is *Ocimum Sanctum*) or Tulsi is undoubtedly the best medicinal herb ever known. It has endless miraculous and medicinal values and is being worshipped in India since thousands of years. Even going closer to a Tulsi plant alone can protect you from many infections. A few leaves dropped in drinking water or food-stuff can purify it and can kill germs in it. Even smelling it or keeping it planted in a pot indoors can protect the whole family from infections, cough and cold and other viral infections. Holy Basil is so good for boosting up the immune system that cannot be explained in words. It protects from nearly all sorts of infections from viruses, bacteria, fungi and protozoa. Recent studies show that it is also helpful in inhibiting growth HIV and carcinogenic cells.

1. Healing Power

The tulsi plant has many medicinal properties. The leaves are a nerve tonic and also sharpen

memory. They promote the removal of the catarrhal matter and phlegm from the bronchial tube. The leaves strengthen the stomach and induce copious perspiration. The seed of the plant are mucilaginous.

2. Fever & Common Cold

The leaves of basil are specific for many fevers. During the rainy season, when malaria and dengue fever are widely prevalent, tender leaves, boiled with tea, act as preventive against these diseases. In case of acute fevers, a decoction of the leaves boiled with powdered cardamom in half a litre of water and mixed with sugar and milk brings down the temperature. The juice of tulsi leaves can be used to bring down fever. Extract of tulsi leaves in fresh water should be given every 2 to 3 hours. In between one can keep giving sips of cold water. In children, it is every effective in bringing down the temperature.

3. Coughs

Tulsi is an important constituent of many Ayurvedic cough syrups and expectorants. It helps to mobilize mucus in bronchitis and asthma. Chewing tulsi leaves relieves cold and flu.

4. Sore Throat

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

5. Respiratory Disorder

The herb is useful in the treatment of respiratory system disorder. A decoction of the leaves, with honey and ginger is an effective remedy for bronchitis, asthma, influenza, cough and cold. A decoction of the leaves, cloves and common salt also gives immediate relief in case of influenza. They should be boiled in half a litre of water till only half the water is left and add then taken.



Fig. 1: Tulsi (*Ocimum Sanctum*)

6. Kidney Stone

Basil has strengthening effect on the kidney. In case of renal stone the juice of basil leaves

and honey, if taken regularly for 6 months it will expel them via the urinary tract.

7. Heart Disorder

Basil has a beneficial effect in cardiac disease and the weakness resulting from them. It reduces the level of blood cholesterol.

8. Children's Ailments

Common paediatric problems like cough cold, fever, diarrhoea and vomiting respond favourably to the juice of basil leaves. If pustules of chicken pox delay their appearance, basil leaves taken with saffron will hasten them.

9. Stress

Basil leaves are regarded as an 'adaptogen' or anti-stress agent. Recent studies have shown that the leaves afford significant protection against stress. Even healthy persons can chew 12 leaves of basil, twice a day, to prevent stress. It purifies blood and helps prevent several common elements.

10. Mouth Infections

The leaves are quite effective for the ulcer and infections in the mouth. A few leaves chewed will cure these conditions.

11. Insect Bites

The herb is a prophylactic or preventive and curative for insect stings or bites. A teaspoonful of the juice of the leaves is taken and is repeated after a few hours. Fresh juice must also be applied to the affected parts. A paste of fresh roots is also effective in case of bites of insects and leeches.

12. Skin Disorders

Applied locally, basil juice is beneficial in the treatment of ringworm and other skin diseases. It has also been tried successfully by some naturopaths in the treatment of leucoderma.

13. Teeth Disorder

The herb is useful in teeth disorders. Its leaves, dried in the sun and powdered, can be used for brushing teeth. It can also be mixed with mustered oil to make a paste and used as toothpaste. This is very good for maintaining dental health, counteracting bad breath and for massaging the gums. It is also useful in pyorrhoea and other teeth disorders.

14. Headaches

Basil makes a good medicine for headache. A decoction of the leaves can be given for this disorder. Pounded leaves mixed with

sandalwood paste can also be applied on the forehead for getting relief from heat, headache, and for providing coolness in general.

15. Eye Disorders

Basil juice is an effective remedy for sore eyes and night-blindness, which is generally caused by deficiency of vitamin A. Two drops of black basil juice are put into the eyes daily at bedtime.



Fig. 2: Tulsi

EXPERIMENTAL AND CLINICAL STUDIES

All over the world scientific research is getting momentum to evaluate the pharmacological activities, side effects and medicinal uses of *OS* against different diseases. On the basis of various experimental and clinical researches, the following pharmacological activities or medicinal properties of *OS* have been reported.

Anticancer activity

The anticancer activity of *OS* has been proved and cited by several investigators¹⁷. The alcoholic extract (AIE) of leaves of *OS* has a modulatory influence on carcinogen metabolizing enzymes such as cytochrome P 450, cytochrome b5, aryl hydrocarbon hydroxylase and glutathione S-transferase (GST), which are important in detoxification of carcinogens and mutagens. The anticancer activity of *OS* has been reported against human fibro-sarcoma cells culture, wherein AIE of this drug induced cytotoxicity at 50 mg/ml and above. Morphologically, the cells showed shrunken cytoplasm and condensed nuclei. The DNA was found to be fragmented on observant on in agarose gel electrophoresis. *OS* significantly decreased the incidence of benzo(a)pyrene induced neoplasia of fore stomach of mice and 3'-methyl-4-dimethylaminoazobenzene induced hepatomas in rats. The AIE of the leaves of *OS* was shown to have an inhibitory effect on chemically induced skin papillomas in mice¹⁸. Topical treatment of Tulsi leaf extract in 7,12-dimethylbenz(a)anthracene (DMBA) induced

papilloma genesis significantly reduced the tumour incidence, average number of papillomas/mouse and cumulative number of papillomas in mice. Topical application of the extract significantly elevated reduced GSH content and GST activities. A similar activity was observed for eugenol, a flavonoid present in many plants, including *Tulsi*. Oral treatment of fresh leaves paste of *Tulsi* may have the ability to prevent the early events of DMBA induced buccal pouch carcinogenesis¹⁹. Leaf extract of *OS* blocks or suppresses the events associate with chemical carcinogenesis by inhibiting metabolic activation of the carcinogen. The anticancer activity of *OS* was observed in Swiss albino mice bearing Ehrlich ascites carcinoma (EAC) and S 180 tumours²⁰. The anti-carcinogenic properties have been evaluated in the experimental animals induced by different types of carcinogens. *Tulsi* leaves when fed to experimental rats with 600 mg/g diet for ten weeks, significantly reduced the 3,4-benzo(a)pyrene [B(a)P] and 3'-methyl-4-dimethylaminoazobenzene (3'MeDAB) induced squamous cell carcinoma and hematoma incidences. The anti-cancer activity of *Tulsi* has also been reported from Philippines where juice of fresh leaves was applied on the skin of experimental mice thrice a week for 20-minutes along with tumor promoter agents (dimethylbenzanthracene as initiator and croton oil as promoter of cancer). No incidences of tumor were found in 20 weeks follow up period in *Tulsi* treated group. The ethanolic extract of *Tulsi* leaves at a dose of 400 and 800 mg/kg, bw have found to modulate carcinogen metabolizing enzymes such as cytochrome P-450, cytochrome-b5 and aryl hydrocarbon hydroxylase of mice liver²¹.

Radioprotective activity

The radioprotective effect of *OS* was firstly reported in the year 1995. Two isolated flavonoids, viz., orientin and vicenin from *OS* leaves showed better radioprotective effect as compared with synthetic radio protectors. They have shown significant protection to the human lymphocytes against the clastogenic effect of radiation at low, nontoxic concentrations. The combination of *OS* leaf extract with WR-2721 (a synthetic radio protector) resulting in higher bone marrow cell protection and reduction in the toxicity of WR-2721 at higher doses, suggested that the combination would have promising radioprotection in humans²². The research on radioprotective properties of *Tulsi* extracts on experimental animals. They established that water extract of *Tulsi* is more radioprotective than the alcoholic extract. Optimum dose for water extract was found to be 10 mg/kg, bw and optimum radioprotection observed when the route of administration was intra-peritoneal.

Increase in the doses however did not increase the level of radio-protection. This was observed when experimental mice were given water extract at a dose of 10 mg/kg, bw for consecutive 5 days before whole body γ -radiation (11 Gy) and the survival of mice were observed for a period of 30 days. Among three plants extracts viz *Withania somnifera*, *Plumbago rosa* and *Ocimum sanctum*, tested on experimental mice bone marrow survival following 2 Gy γ -radiation, water extract of *Tulsi* provided highest radioprotection as measured by an exogenous spleen colony forming unit (CFU-S) assay. It was also observed that the *Tulsi* extract had no toxic effects compared to synthetic radio protector WR-2712. Radio-protection efficacy of two flavonoids, orientin and vicenin, isolated from leaves of *Tulsi* (administered i.p. 10 mg/kg, bw/day to mice for five days) were compared with synthetic radio-protectector aminothioli, 2-mercaptopropionyl-glycerine 'MPG' (20 mg/ kg, bw), WR-2721 (150 mg/kg, bw). The experimental mice were subjected to whole body exposure to 2 Gy γ -radiations for 30 minutes and bone marrow chromosomal aberrations were studied. It was observed that vicenin provided maximum protection from radiation induced chromosomal aberrations and MPG the least, while orientin and WR-2721 provided almost similar effects⁴³.

Antimicrobial activity

AqE of *OS* showed growth inhibition for *Klebsiella*, *E. coli*, *Proteus* and *Staphylococcus aureus*; while AIE of *OS* showed growth inhibition for *Vibrio cholerae*⁴⁴. The AIE of *OS* was also found to be active against multidrug-resistant strains of *S. aureus* that are also resistant to common beta lactam antibiotics⁴⁵. Similarly, *OS* was found to be active against resistant *Neisseria gonorrhoea* strains⁴⁶. *OS* fixed oil showed good antibacterial activity against *Bacillus pumilus*, *Pseudomonas aeruginosa* and *S. aureus*. Higher content of linolenic acid in *OS* fixed oil could contribute towards its antibacterial activity⁴⁷. Indian mythological book *Padmottara Purana* asserts that a house where a garden of *Tulsi* exists is itself a centre of pilgrimage; neither servants of *Yama* (The lord of death) nor disease can enter there and wherever fragrance of *Tulsi* goes, the air gets purified⁶. This statement seems to have some relevance because the essential oil, which forms the specific fragrance, is volatile in nature and can kill various types of microbes. The essential oil is reported to possess antibacterial and insecticidal properties. The oil has been shown to have inhibitory effects on growth of *Mycobacterium tuberculosis* and *Micrococcus pyogenes* var. *aureus*. It has one tenth anti-tubercular potency of streptomycin and one-fourth that of isoniazid⁴. Aqueous and acetone extracts of *Ocimum sanctum* were also found to be sensitive to many plant fungi,

Alternaria tenuis, *Helminthosporium spp*, and *Curvularia penniseli*. Essential oil of *Tulsi* was tested on plant pathogenic fungi as well e.g. *Alternaria solani*, *Candida guilliermondii*, *Colletotricum capsici*, *Curvularia spp*, *Fusarium solani*, *Helminthosporium oryzae* and the bacterial strains, *Anthrobacter globiformis*, *Bacillus megaterium*, *Escherichia coli*, *Pseudomonas spp*, *Staphylococcus aureus*, *Staphylococcus albus* and *Vibrio cholerae*. The essential oils of *Tulsi* have been effective against both Gram-positive and Gram-negative bacteria and the properties were comparable with the effectiveness of clove oil²⁵. Antimicrobial activity of *Ocimum sanctum* was found to be higher as compared to commonly available other species of *Ocimum* (i.e. *O. canum*, *O. gratissimum*, *O. basilicum*) in India more so, aqueous extract, alcoholic extract and seed oil of *Tulsi* shown antimicrobial properties against enteric pathogens²⁶. It also exhibited significant antimicrobial activities against some of the clinical isolates and multi-drug resistant *Neisseria gonorrhoeae*²⁷. The ethanolic extracts have ability to inhibit clinical isolates of β -lactamase producing methicillin-resistant *Staphylococcus aureus* (MRSA) and methicillin-sensitive *Staphylococcus aureus* [MSSA]. Essential oil of *Ocimum sanctum* reported to have shown antimicrobial activity against *Propionibacterium acnes* in *in-vitro* study and minimum inhibitory concentration (MIC) value found to be 3.0% v/v. Fresh leaves essential oil had shown more antibacterial properties compared to dried leaves essential oil of *Tulsi* and in case of fungus the property is just the reverse²⁸.

Immunomodulatory activity

Steam distilled extract from the fresh leaves of *OS* showed modification in the humoral immune response in albino rats which could be attributed to such mechanisms as antibody production, release of mediators of hypersensitivity reactions and tissues responses to these mediators in the target organs. *OS* seed oil appears to modulate both humoral and cell-mediated immune responsiveness and GABAergic pathways may mediate these immunomodulatory effects *Tulsi* strengthens the immune response by enhancing both cellular and humoral immunity²⁹.

Hepatoprotective activity

Oral administration of hydro-ethanolic extract of *OS* leaves at 200 mg/kg in male Wistar albino rats gave protection against liver injury induced by paracetamol. The cold water extract (3 g/100g, orally for 6 days) of *OS* was found to be effective against carbon tetrachloride (0.2 ml/100 g, subcutaneously) induced liver damage in albino rats. *Tulsi* offered liver protection against various experimentally induced damages.

Tulsi extract treated group showed no mortality while control group showed 60% mortality in carbon tetrachloride induced liver damage in rats. The ethanol extract of *Tulsi* can protect the liver damage from anti-tubercular drugs in experimental rats. The ethanol extract of *Tulsi* treatment prior to paracetamol induced liver damage, have shown to protect the liver. This has been evident by significantly enhanced levels of serum enzymes (aspartate, aminotransferase, alkaline and acid phosphatase) and liver glutathione in experimental rats. In a polyherbal formulation of four plants "Imu-21" including *Ocimum sanctum* tested for cytotoxicity by measuring splenic leukocyte natural killer (NK) cells activity against K-562 cell line, showed that pre-treatment with Imu-21, for seven days, can increase NK cell activity in mice. The possible mechanism is probably due to activation of mature NK cells or precursor cells which were previously not active³⁰.

Anti-inflammatory activity

Methanol extract (500 mg/kg) and aqueous suspension of *OS* showed analgesic, antipyretic and anti-inflammatory effects in acute (carrageenan-induced pedal oedema) and chronic (croton oil induced granuloma and exudate formation) inflammations in rats. The fixed oil and linolenic acid possess significant anti-inflammatory activity against PGE₂, leukotriene and arachidonic acid induced paw oedema in rats by virtue of their capacity to block both the cyclooxygenase and lipoxygenase pathways of arachidonic acid metabolism³¹.

The aqueous and methanol suspension of *Tulsi* has shown to inhibit acute as well as chronic inflammation in rats. This test was conducted by carrageenan induced paw edema, croton oil induced granuloma and exudates, at a dose of 500 mg/kg, bw/day. The oils extracted from fresh leaves (essential oil) and seeds (fixed oil) of *Tulsi* have shown anti-inflammatory effects on experimental animal's hind paw edema induced by carrageenan, serotonin, histamine and prostaglandin-E-2. These experimental rats were administered with essential oil (200 mg/kg, bw), and fixed oil (0.1ml/kg, bw) before injection of phlogistic agents and was compared with standard drug flurbiprofen. It was noted that *Tulsi* extracts could significantly reduce the edema when compared with the saline treated control. However, its effect was less than the standard drug³². The mechanism of action of the anti-inflammatory effects of *Tulsi* could be the cyclo-oxygenase and lipoxygenase pathways. In order to compare the anti-inflammatory effects of fixed oils of various species of *Ocimum viz O. sanctum*, *O. basilicum*, *O. americanum*, which possess varying proportions of unsaturated fatty acids (particularly linolenic acid) showed different response against phlogistic

agent induced paw edema. *Ocimum basilicum* possess highest percentage of linolenic acid (21.0%) and offered maximum inhibition of paw edema (72.42%), *O. sanctum* fixed oil containing 16.63% linolenic acid provided 68.97% inhibition while *O. americanum* offered least paw edema inhibition. Fixed oil of *Tulsi* can inhibit enhanced vascular permeability and leukocyte migration as evidenced by carrageenan induced inflammatory stimulus³³.

Adaptogenic activity/antistress activity

The immunostimulant capacity of *OS* may be responsible for the adaptogenic action of plant. The AIE of *OS* whole plant increased the physical endurance (survival time) of swimming mice, prevented stress induced ulcers and milk induced leucocytosis, respectively in rats and mice, indicating induction of non-specifically increased resistance against a variety of stress induced biological changes by *OS* in animals³⁴. Stress is a common phenomenon that is experienced by every individual. Stress is defined as “non specific result of any demand upon the body”. Stress can be either physical or psychological. When stress becomes extreme, it is harmful for the body and hence, needs to be treated. Stress is involved in the pathogenesis of a variety of diseases that includes psychiatric disorders such as depression and anxiety, immunosuppression, endocrine disorders including diabetes mellitus, male impotence, cognitive dysfunction, peptic ulcer, hypertension and ulcerative colitis. *Tulsi* is an excellent rejuvenator, which has been known to help reduce stress, relax the mind and assist the body in improving memory. *Tulsi* has antihypoxic effect and it increases the survival time during anoxic stress. A study conducted with rabbits has suggested that *Tulsi* decreased oxidative stress³⁵.

Antidiabetic activity

Oral administration of *OS* extract led to marked lowering of blood sugar in normal, glucose fed hyperglycemic and streptozotocin-induced diabetic rats. A randomized, placebo-controlled, cross over single blind human trial indicated a significant decrease in fasting and postprandial blood glucose levels by 17.6% and 7.3%, respectively. Urine glucose levels showed a similar trend. Further, *OS* has aldose reductase activity, which may help in reducing the complications of diabetes such as cataract, retinopathy, etc³⁶

Leaves of *O.sanctum* have been shown to possess hypoglycaemic effects in experimental animals³⁷. Decoction prepared with various parts of plant lowers the blood sugar level. A study conducted on rats has suggested that constituent of *O. sanctum* leaf extracts have stimulatory effects on physiological pathways of insulin secretion³⁸. Various studies have been performed on the

antiglycemic properties of *Ocimum* but its mechanism of action has not been elucidated as yet. Study conducted with *tulsi* plus neem has suggested that this combination is better for the diabetic patients in lowering the sugar level³⁹.

Antipyretic activity

The antipyretic activity of *OS* fixed oil was evaluated by testing it against typhoid-paratyphoid A/B vaccine-induced pyrexia in rats. The oil on ip administration considerably reduced the febrile response indicating its antipyretic activity. At a dose of 3 ml/kg, the antipyretic activity of the oil was comparable to aspirin. Further, the fixed oil possessed prostaglandin inhibitory activity and the same could explain its antipyretic activity⁴⁰

Antiarthritic activity

The antiarthritic activity of *OS* fixed oil was evaluated against formaldehyde-induced arthritis in rats. The fixed oil significantly reduced the diameter of inflamed paw. On intraperitoneal administration of the fixed oil daily for 10 days, there was marked improvement in the arthritic conditions in rats. The antiarthritic effect at 3 ml/kg dose was comparable to aspirin at 100 mg/kg, ip⁴⁰. The fixed oil inhibited carrageenan and inflammatory mediators (e.g., serotonin, histamine, bradykinin and PGE2) induced inflammation. It is natural that the oil could inhibit any inflammatory response involving these mediators. The result suggests potentially useful antiarthritic activity of the inflammation models, including adjuvant as well as turpentine oil-induced joint oedema in rats⁴¹.

Anticoagulant activity

The *OS* fixed oil (3 ml/kg, ip) prolonged blood clotting time and the response was comparable to that obtained with aspirin (100 mg/kg). The effect appears to be due to the anti-aggregator action of oil on platelets⁴².

Toxicity

The median lethal dose (LD50) of *OS* fixed oil was determined after ip administration in mice. The fixed oil was well tolerated up to 30 ml/kg, while 100% mortality was recorded with a dose of 55 ml/kg. The LD50 of oil was 42.5 ml/kg. There was found no untoward effect on Sub-acute toxicity study of *OS* fixed oil at a dose of 3 ml/kg/day, ip for 14 days in rats⁴⁰.

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