

Tulsi: The Queen of Medicinal Herbs

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ABSTRACT

Tulsi has got the great medicinal value. Studies have also shown Tulsi to be effective for diabetes, by reducing blood glucose levels. The same study showed significant reduction in total cholesterol levels with Tulsi. Another study showed that Tulsi's beneficial effect on blood glucose levels is due to its antioxidant properties. The Rama Tulsi is the effective remedy for the severe acute Respiratory Syndrome. Juice of its leaves gives relief in cold, fever, bronchitis and cough. Tulsi oil is also used as the ear drop. Tulsi helps in curing malaria. It is very effective against indigestion, headache, hysteria, insomnia and cholera. The fresh leaves of Tulsi are taken by the millions of people every day. For over the centuries Tulsi (the queen of herbs) has been known for its remarkable healing properties. Modern scientific research offers impressive evidence that Tulsi reduces stress, enhances stamina, relieves inflammation, lowers cholesterol, eliminates toxins, protects against radiation, prevents gastric ulcers, lowers fevers, improves digestion and provides a rich supply of antioxidants and other nutrients. Tulsi is especially effective in supporting the heart, blood vessels, liver and lungs and also regulates blood pressure and blood sugar. Recent studies suggest that Tulsi may be a COX-2 inhibitor, like many modern painkillers, due to its high concentration of eugenol (1-hydroxy-2-methoxy-4-allylbenzene). The anti-flu property of Tulsi has been discovered by medical experts across the world quite recently. Tulsi improves the body's overall defence mechanism including its ability to fight viral diseases.

Keywords: Tulsi; Green medicines; Sacred; Basil; Medicinal herbs; *Ocimum sanctum*; Eugenol; Anti-oxidant; Antimicrobial; Anti-inflammatory

INTRODUCTION

Tulsi is a Sanskrit word which means "matchless one" [1]. Tulsi in Hindi or Tulsi in Sanskrit (holy basil in English) is a highly revered culinary and medicinal aromatic herb from the family Lamiaceae that is indigenous to the Indian subcontinent and been used within Ayurvedic medicine more than 3000 years. In the Ayurveda system tulsi is often referred to as an "Elixir of Life" for its healing powers and has been known to treat many different common health conditions. In the Indian Materia Medica *tulsi* leaf extracts are described for treatment of bronchitis, rheumatism, and pyrexia. Other reported therapeutic uses include treatment of epilepsy, asthma or dyspnea, hiccups, cough, skin and hematological diseases, parasitic infections, neuralgia, headache, wounds, and inflammation and oral conditions. The juice of the leaves has been applied as a drop for earache, while the tea infusion has been used for treatment of gastric and hepatic disorders. The roots and stems were also traditionally used to treat mosquito and snake bites and for malaria [2].

AIM AND OBJECTIVE

Tulsi has proved to be highly effective in protecting our body from various infections and diseases of heart, liver, skin, kidney etc. So, Tulsi is rightly called the 'Queen of Herbs'. Tulsi leaves are rich in vitamins A, C and K and minerals like calcium, magnesium, phosphorus, iron and potassium. It also has a good amount of protein and fiber. Tulsi is rich in Vitamin C and zinc. It thus acts as a natural immunity booster and keeps infections at bay. It has immense anti-bacterial, anti-viral and anti-fungal properties which protect us from a variety of infections. Tulsi leaves extract increases the T helper cells and natural killer cells activity, boosting the immune system.

LITERATURE REVIEW

Tulsi, also known as holy basil, is indigenous to the Indian continent and highly revered for its medicinal uses within the Ayurvedic and Siddha medical systems. Many *in vitro*, animal and human studies attest to tulsi having multiple therapeutic actions including apoptogenic, antimicrobial, anti-inflammatory,

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cardioprotective, and immunomodulatory effects, yet to date. There are no systematic reviews of human research on Tulsi's clinical efficacy and safety. Conducted a comprehensive literature review of human studies that reported on a clinical outcome after ingestion of tulsi. We searched for studies published in Google Scholar, Embase, Medline, PubMed, Science Direct, and Indian Medical databases. A total of 50 studies were identified that reported therapeutic effects on metabolic disorders, cardiovascular disease, immunity, and neurocognition. All studies reported favorable clinical outcomes with no studies reporting any significant adverse events. The reviewed studies reinforce traditional uses and suggest tulsi is an effective treatment for lifestyle related chronic diseases including diabetes, metabolic syndrome, and psychological stress. Further studies are required to explore mechanisms of action, clarify the dosage and dose form, and determine the populations most likely to benefit from tulsi's therapeutic effects.

Classification [3]

Kingdom: Plantae

Division: Magnoliophyte

Class: Magnoliopsida

Order: Lamiales

Family: Lamiaceae

Genus: *Ocimum*

Species: *sanctum*

Other names [3]

English name: Holy basil

Hindi: Tulsi

Sanskrit: Tulsi

Gujarati: Tulsi

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, diarrhea and influenza. The leaves are good for nerves and to sharpen memory. Chewing of Tulsi leaves also cures ulcers and infections of mouth [4].

ANTI-OXIDANTS

Extract protects against piroxicam-induced gastric ulceration in rats: involvement of antioxidant mechanisms

These present studies were aimed at evaluating whether an aqueous extract of Tulsi leaves is capable of ameliorating piroxicam-induced gastric injury in rats [5]. In which Male Wister rats were used for the present studies. The aqueous Tulsi leaf extract (TLE) [25, 50, 100 and 200 mg/kg bw] was administered orally to the fasted rats (water ad libitum), one hour prior to the piroxicam treatment. The aqueous leaf extract of Tulsi was found to protect the gastric mucosa from becoming ulcerated following piroxicam

treatment, in a dose-dependent manner. Pre-treatment of rats with increasing doses of TLE protected the rise in the level of lipid peroxidation, reduced glutathione from being decreased as well as protected the activities of the antioxidant enzymes indicating it may have protected the gastric tissue from piroxicam-induced injury. The results of the biochemical analyses were supported by macroscopic and microscopic studies of gastric tissue. It concluded from the results it may be concluded that aqueous leaf extract of Tulsi may be a safe gastro-protective agent and may find extensive pharmaceutical applications especially in situations where the use of NSAIDs is the only choice.

One more study was done in the present study, a hydroalcoholic extract of *Ocimum sanctum* leaves has been investigated for its antioxidant activity in animal models of peptic ulcer with the aim of exploring a possible correlation between its antioxidant and antiulcer activities. Gastric ulcers were produced in rats by ethanol treatment and pyloric ligation whereas duodenal ulcers were produced in guinea pigs by histamine treatment. The animals were divided into six groups of six animals each in all these three models of peptic ulcer. Group I served as disease control in which distilled water (10 ml/kg) orally was administered as placebo. Group II, III and IV received the test drug (*Ocimum sanctum* leaf extract) in doses of 50 mg/kg, 100 mg/kg and 200 mg/kg respectively orally once daily for 7 days. Group V was administered ranitidine (10 mg/kg orally) once daily for 7 days and served as standard for comparison. Group VI consisted of healthy control for baseline malondialdehyde (MDA) and superoxide dismutase (SOD) levels. The antioxidant activity was by evaluated estimating plasma MDA in ethanol treated rats and histamine treated guinea pigs and estimating SOD in pyloric ligated rats and histamine treated guinea pigs. In ethanol treated rats, *Ocimum sanctum* leaf extract (100 mg/kg & 200 mg/kg) significantly decreased the levels of MDA to 2.45 ± 0.29 nmole/ml and 2.40 ± 0.14 nmole/ml respectively in comparison to 4.87 ± 0.06 in the diseased control. Similarly, in the histamine treated guinea pig group, the same doses of the extract significantly lowered the levels of MDA to 2.45 ± 0.12 nmole/ml and 2.37 ± 0.16 nmole/ml respectively when compared to 4.66 ± 0.11 in the diseased control. The extract (100 mg/kg & 200 mg/kg) also increased the levels of SOD in pyloric ligated rats to 1.78 ± 0.12 U/ml and 1.89 ± 0.08 U/ml respectively when compared to 1.29 ± 0.06 U/ml in the diseased control. In the histamine treated guinea pig group also, the same doses of the extract produced a rise in the SOD levels to 2.10 ± 0.11 U/ml and 2.20 ± 0.14 U/ml respectively when compared to 1.32 ± 0.07 in the diseased control. Since lowered levels of MDA and increased levels of SOD signify antioxidant activity, the antiulcer activity of *Ocimum sanctum* might be due to this mechanism [6].

ANTI-MICROBIALS

Tulsi Leaf extract have great potential as antimicrobial agent for the treatment of water. The treatment is simple, cost-effective, ecofriendly, reachable for all and the components present in *Ocimum sanctum* leaves have no side effects to human compared to chemical treatment. More over the water treated with Tulsi extract serve not only as germ free but also as Medicinal water [1].

In recent years scientists worldwide have realized that the effective life span of any antimicrobial agent is limited, due to increasing development of resistance by microorganisms. Consequently,

numerous studies have been conducted to find new alternative sources of antimicrobial agents, especially from plants. The aims of this project were to examine the antimicrobial properties of essential oils distilled from Australian-grown *Ocimum tenuiflorum* (Tulsi), to quantify the volatile components present in flower spikes, leaves and the essential oil, and to investigate the compounds responsible for any activity. Broth micro-dilution was used to determine the minimum inhibitory concentration (MIC) of Tulsi essential oil against selected microbial pathogens. The oils, at concentrations of 4.5 and 2.25% completely inhibited the growth of *Staphylococcus aureus* (including MRSA) and *Escherichia coli*, while the same concentrations only partly inhibited the growth of *Pseudomonas aeruginosa*. Of 54 compounds identified in Tulsi leaves, flower spikes, or essential oil, three are proposed to be responsible for this activity; camphor, eucalyptol and eugenol. Since *S. aureus* (including MRSA), *P. aeruginosa* and *E. coli* are major pathogens causing skin and soft tissue infections, Tulsi essential oil could be a valuable topical antimicrobial agent for management of skin infections caused by these organisms [7].

Aqueous ethanolic extract of four medicinal plants were subjected to *in vitro* antibacterial assay against human pathogenic *Escherichia coli*, *Salmonella typhi*, *Salmonella paratyphi*, *Staphylococcus aureus*, *Klebsiella pneumoniae*, *Pseudomonas aeruginosa* employing cup diffusion method. Characterization of the novel phytochemicals in the treatment of infectious diffusion method. Characterization of the novel phytochemicals in the treatment of infectious disease especially in light of the emergence of drug-resistant microorganisms and the need to produce more effective antimicrobial agents [8].

The nutritional analysis of *Ocimum sanctum* shown high level of ascorbic acid and total carbohydrate i.e., 65.41 mg/100g and 39.58% in their leaves, Whereas the total phenol was found to be maximum (1.88 mg/g) in leaves. Leaves in present investigation, contains major nutrient like N (3.30%), P (1.10%), K (6.62%), S (1.55%) and Na (0.74%). Dry weight basis contains 20.64% total protein and 3.60% total fat. The oil of leaves also contains comparable amount of antioxidant as ascorbic acid, flavonoid and total phenol as well as linolenic acid, polyunsaturated fatty acid which was very good for health. According to our results, most of the identified compounds were biologically important. Further the *Ocimum sanctum* leaf possesses certain characteristics that can be ascribed to cultivation on a domestic plantation. Antimicrobial activity of Tulsi leaves extract was evaluated and the results shown that *E. coli*, *E. faecalis* were mostly susceptible to methanol extract than *S. aureus* and *A. hydrophila*. It can be suggested that *S. aureus* was the most resistant organisms to the concentrations of 20 and 40 mg/ml of the methanol extract of *Ocimum*. The results of this study indicated the possibility of using the leave extract of Tulsi (*Ocimum sanctum*) as a source of antibacterial compounds for treatment of infections caused by multi-drug resistant bacterial pathogens [9].

A study was carried out to isolate endophytic fungi from *Ocimum* species (Tulsi) and to assess their antimicrobial activity against *Pseudomonas aeruginosa*, *Mycobacterium smegmatis*, *Salmonella typhimurium*, *Candida albicans* and *Penicillium chrysogenum* and production of enzymes such as amylase, protease and tyrosinase. In this study forty endophytic fungi were isolated from leaves and branches of Tulsi. Out of forty endophytic fungal isolates, six isolates showed the inhibition activity against test microorganisms done by dual culture method. The isolate P14T1 exhibited a high

antimicrobial activity against *Candida albicans* (22 mm). The crude extract of P13T5 isolate showed highest zone of inhibition against *Pseudomonas aeruginosa* (21 mm) by well and disc diffusion method. 50% of fungal isolates found positive for amylase and protease enzymes production and 27.5% showed positive for tyrosinase. The results of the study suggest that endophytic fungi associated with Tulsi are potential agents for antimicrobial activity and production of enzyme [10].

One study was focused on to compare the antimicrobial activity of methanolic leaf extracts of tulsi and neem. They have chosen tulsi (*Ocimum sanctum*) and neem (*Azadirachta indica*) to compare their antimicrobial activity toward Gram-positive (*Staphylococcus aureus*) and Gram-negative (*Escherichia coli*) bacteria. Phytochemical extracts have been made by the use of methanol as solvent and dried leaf powder by the cold maceration extraction process. Phytochemical analysis for some secondary metabolites has been done using standard protocols. Nutrient agar plates were inoculated with the above-mentioned microorganisms by spreading bacterial inoculum on the surface of the media. Wells (6 mm in diameter) were punched in the agar. The phytochemical extracts of neem and tulsi were allowed to diffuse into the medium, and after incubation of 24 h at 37°C, the zones of inhibition were observed. Results was Statistical analysis showed that tulsi was more effective toward *S. aureus* while neem was more effective toward *E. coli*. Minimum inhibitory concentration (MIC) of tulsi for both the microorganisms was 0.4 g/ml, and the MIC of neem for both the microorganisms was 0.2 g/ml. When both the tulsi and neem extract were mixed with each other for every concentration at equal volume, they have shown better effects in comparison to individual neem or tulsi extract and also the MIC got reduced to 0.2 g/ml for both the bacteria. Conclusions: Leaf extracts of both the *A. indica* and *O. sanctum* have shown antimicrobial activity against *E. coli* and *S. aureus*. *A. indica* has higher antimicrobial activity against *S. aureus*, whereas the *O. sanctum* was found to be more effective against *E. coli* (indicated by the zone of inhibition). When both the extracts were mixed with each other, they have shown a better effect toward both bacteria [11].

Ocimum sanctum is well known for its antimicrobial properties in Indian traditional medicinal system in Ayurveda. Different preparations of *O. sanctum* plants and parts of it have been reported throughout the world for its medicinal properties including antiviral effects. Thus, in present study hot aqueous extract of *O. sanctum* leaves was used to study the antiviral activity against the New Castle Disease Virus of poultry chicken embryo fibroblast monolayer culture. Before performing the study nontoxic dose of the extract was also decided for the chicken fibroblast culture and the concentrations of 10mg/ml or less of hot aqueous extract of *O. sanctum* leaves in basal media (RPMI 1640) appeared to be non-toxic. As cytopathic effects of NCD virus on chicken embryo fibroblast monolayer culture are well established so these was used to detect the antiviral activity of *O. sanctum* along with Hemagglutination test to get an idea of viral concentration in culture. Absence of cytopathic effects in monolayer and lower the HA titer were considered as the indicative of antiviral activity of extract of *O. sanctum* leaves. The concentrations of 10mg/ml or less of hot aqueous extract of *O. sanctum* leaves prevented the cytopathic effects and growth of NCD virus in chicken fibroblast monolayer [12].

Antimicrobial activity of *Ocimum tenuiflorum* leaves on mechanical behavior of fabrics

Microbial activity causes serious damage to living as well as non-living organisms [13]. Many textile manufacturers are trying to provide better protection to their consumers against microbes and bacteria. Antibacterial finishing treatment is one of the latest achievements in this industry. There is a need to make use of natural herbs and plants rather than synthetic materials over the surface of fabrics to provide protection against certain physical, biological and chemical hazards. This study aimed at developing a textile finish by using leaves of natural plant named *Ocimum tenuiflorum* (tulsi). The effectiveness of developed finish was determined against its antimicrobial activity with *Staphylococcus aureus* and *Escherichia coli* on cotton, polyester, bamboo and a blend of polyester and cotton. The study was experimental in nature. Control and experimental groups of collected fabrics were formulated, where only experimental group was treated with the developed finish. Treated fabrics depicted their zone of inhibition from 35 mm to 56 mm and 28 mm to 52 mm for gram positive and gram-negative bacteria respectively. It shows better protection against the growth of *Staphylococcus aureus* and *Escherichia coli*. Four mechanical characteristics such as tear strength, tensile strength, elongation and stiffness were evaluated to see the difference between treated and untreated fabrics to judge the efficiency of developed finish. The collected data was analyzed through One-way Analysis of Variance (ANOVA). P-value less than 0.05 suggest that there is a significant difference between experimental and control groups for their tested mechanical characteristics. It was observed that finish encapsulated the fiber structure completely and provided satisfactory protection against bacterial activity. Moreover, tested mechanical characteristics were also improved with the application of finish.

ANTI-CANCER EFFECT

Anti-cancer effect of *Ocimum-sanctum* ethanolic extract in non-small cell lung carcinoma cell line

The present study was aimed to investigate the effects of alcoholic root extract of *Ocimum sanctum*, in human non-small cell lung carcinoma cell (NCI-H460) [14]. In which the effect of ethanolic extract of *O. sanctum* in NCI-H460 cell was investigated by the cell viability assay, generation of ROS in a cancer cell, apoptotic morphological changes and by mitochondrial membrane potential. The cytotoxicity was observed by MMT assay. NCI-H460 cell was treated with various concentrations (10-150 µg/ml) of extract for 24 hr and 150 µg/ml showed a maximum decrease in cell viability. The extract (25-100 µg/ml) showed significant increase ROS production in NCI-H460 cell. It greatly inhibits cell viability and colony forming capacity of NCI-H460 cell, possibly because of increased oxidative stress. An increased apoptotic cell in *Ocimum sanctum* further shows its anticancer nature. Loss of mitochondrial membrane potential is an early stage of apoptosis. Our results showed that extract treatment caused serve loss of in NCI-H460 cell. Concluded the present study suggests that *O. sanctum* extract act by increasing oxidative damage in NCI-H460 cells.

ANTI-ULCER ACTIVITY

Peptic Ulcer Disease (PUD) encompassing gastric and duodenal ulcer is the most prevalent gastrointestinal disorder. Non-Steroidal Anti-Inflammatory Drugs (NSAIDs) such as indomethacin are used in the treatment of inflammation, fever and pain. However,

NSAIDs cause gastric damage as a major adverse reaction. In this study, the gastro protective effect of *O. sanctum* was also studied and compared with omeprazole in model of indomethacin-induced ulceration. This study was conducted at Navodaya Medical College and Research Centre for a period of two years. The gastro protective effect of aqueous extract of *O. sanctum* was studied using model of indomethacin-induced gastric damage and compared with omeprazole. *O. sanctum* (200 mg/kg or 400 mg/kg) or omeprazole (10 mg/kg) were administered alone in separate group of rats. *O. sanctum* showed significant ($p < 0.05$) protective effect against indomethacin-induced gastric ulcer when compared to control. The gastro protective effect of *O. sanctum* was comparable with that of omeprazole, the standard drug. Conclusion: *O. sanctum* showed significant gastro protective effect against indomethacin-induced gastric damage possibly due to its 5-lipoxygenase inhibitory effect, mucoprotective activity and its antisecretory effect [15].

ANTI-VIRALS

Ocimum sanctum is well known for its antimicrobial properties in Indian traditional medicinal system in Ayurveda. Different preparations of *O. sanctum* plants and parts of it have been reported throughout the world for its medicinal properties including antiviral effects. Thus, in present study hot aqueous extract of *O. sanctum* leaves was used to study the antiviral activity against the New Castle Disease Virus of poultry chicken embryo fibroblast monolayer culture. Before performing the study nontoxic dose of the extract was also decided for the chicken fibroblast culture and the concentrations of 10mg/ml or less of hot aqueous extract of *O. sanctum* leaves in basal media (RPMI 1640) appeared to be non-toxic. As cytopathic effects of NCD virus on chicken embryo fibroblast monolayer culture are well established so these was used to detect the antiviral activity of *O. sanctum* along with Hemagglutination test to get an idea of viral concentration in culture. Absence of cytopathic effects in monolayer and lower the HA titer were considered as the indicative of antiviral activity of extract of *O. sanctum* leaves. The concentrations of 10mg/ml or less of hot aqueous extract of *O. sanctum* leaves prevented the cytopathic effects and growth of NCD virus in chicken fibroblast monolayer [16].

Tulsi, *Ocimum sanctum* is one of the most important medicinal plants mentioned in Ayurvedic literature for its medicinal and spiritual properties. The plant is a highly celebrated medicinal plant as "The incomparable one," "Mother medicine of nature" and "The queen of herbs". Tulsi, along with other health benefits is known to have anti-infective functions. Hence, antiviral activity of aqueous, ethanol, methanol and chloroform extract of powdered drugs was evaluated against economically important viruses of veterinary importance, Orthomyxovirus and Paramyxovirus. The *in vitro* cytotoxicity confirmed the safety of the extracts and aqueous extract showed no inhibition on paramyxovirus while showing moderate inhibitory activity on orthomyxovirus while ethanol extract showed moderate inhibitory activity on paramyxovirus and no activity on orthomyxoviruses. Methanol extract showed no inhibition on of paramyxovirus while showed significant inhibition of orthomyxovirus. Chloroform extract of the plant showed no inhibition paramyxovirus while significant inhibition was observed on orthomyxovirus. Results of the study suggest that the *O. sanctum* can be used as antiviral agent for effective control of viral infections of animal importance [17].

ANTI-HELMINTIC ACTIVITY

Anthelmintics derived from plant source can be an answer to this world-wide problem as they form secure and non-toxic with a modified site of action. *Ocimum sanctum* Linn known as Tulsi in India is a sacred plant for Hindus known from centuries and being used in Ayurveda for its varied healing properties belonging to the Labiateae family. To this purpose we have studied *in vitro* anthelmintic activity of osmium in comparison with albendazole. The leaves of *Ocimum sanctum* was taken from the Institute staff quarter's garden, which was endorsed by certified Taxonomist. The study was done using earth worms' adult type due to their anatomical resemblance with the intestinal roundworm parasites of humans. The suspension of aqueous extract of leaves of *Ocimum sanctum* Linn, concentration 100 mg/ml was prepared. Albendazole was used as standard reference drug and its 20 mg/ml concentration was prepared by as per the prescribed method. The anthelmintic activity was performed according to standard screening methods. Aqueous extract of *Ocimum sanctum* took 145 ± 14 minutes to paralyze and 223 ± 11 minutes to death of the worm, whereas Albendazole took 92 ± 18 minutes to paralyse and 165 ± 17 minutes to death of the worm with significant ($P < 0.05$) value. Aqueous extract is more potent than control (NS) and lesser anthelmintic activity than albendazole. Time to paralysis and consequent death were significantly higher in aqueous extract of *Ocimum* that of Albendazole at same concentrations. Aqueous extract of *Ocimum sanctum* Linn is more potent than control (NS) and lesser anthelmintic activity than albendazole. Time to paralysis and consequent death were significantly higher in aqueous extract of *Ocimum* that of Albendazole at same concentrations [18].

One study was designed to extract ursolic acid (UA) from *Ocimum sanctum* and to evaluate the anthelmintic activity and antimicrobial effects on the *E. coli*. Ursolic acid, an important bioactive compound, was isolated from ethanolic extract of *Ocimum tenuiflorum* plant also known as *Ocimum sanctum*. In which Ursolic acid was isolated from the ethanolic extract of plant *Ocimum sanctum*. It was evaluated for anthelmintic activity and antibacterial action on *E. coli* with disc diffusion and well diffusion method. Compare the anthelmintic activity and antibacterial action of ursolic acid with standard drug albendazole and tetracycline respectively. Results: The evident obtained from the experimental data, ursolic acid showed significant anthelmintic activity against earthworm *Pheretima postuma*. Screening of compound was performed for complete death and paralysis of worms. The results reveal a dose dependent increase in activity of the compound at 15, 20 and 25 mg/ml concentration. Results were comparable along the standard drug albendazole, in the same concentration. The results of antibacterial screening assay of ursolic acid by disk diffusion method and well diffusion method. The *in vitro* antimicrobial studies reveal that the ursolic acid was potentially active against microbial species and exhibit greater biocidal effect as compared to ligand fragments. Conclusion: The present study shows the potent anthelmintic as well as antibacterial activity of ursolic acid that was good in their action against the worms. The results indicated that ursolic acid have the potential to paralyze and kill the parasitic worms [19].

One study was done using earth worms' adult type due to their anatomical resemblance with the intestinal roundworm parasites of humans. The suspension of aqueous extract of leaves of *Ocimum sanctum* Linn, concentration 100 mg/ml was prepared.

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Burn wound healing property

Burns remain a major public health problem all over the world, especially in developing countries [21]. *Pseudomonas aeruginosa* is a major cause of infection and a contributing factor in the death of patients with burns. So, there is a growing need to develop drugs which will prevent infections and complications more effectively than the presently used drugs. *Ocimum sanctum* L. (Tulsi in Hindi) has been shown to have antioxidant properties, which may be responsible and favorable for faster wound healing. The present study was carried out to evaluate the wound healing property of *O. sanctum* by monitoring the period of re-epithelization in thermal burns with and without supportive treatment of ointment silver sulfadiazine. In which wound healing property of *O. sanctum* was evaluated by monitoring the period of re-epithelization. Result was the period of re-epithelization, in control group was 34 ± 1.26 days, in Standard group treated with ointment silver sulfadiazine was 30.33 ± 1.37 days, in group treated with *O. sanctum* was 30.50 ± 1.87 days and in group treated with ointment silver sulfadiazine + *O. sanctum* was 26 ± 1.41 days. Group treated with ointment silver sulfadiazine + *O. sanctum* showed minimum re-epithelization period. So, the most effective treatment for burn wound healing in this study was ointment silver sulfadiazine + *O. sanctum*.

ANTI-OXIDANT AND RADIO-PROTECTIVE ACTIVITY

The antioxidant activity of two polysaccharides isolated from the Indian medicinal plants, *Ocimum sanctum* and *Tinospora malabaricana*, was studied. Only the *O. sanctum* polysaccharide (OSP) showed significant activity. OSP could prevent oxidative damage to liposomal lipids and plasmid DNA induced by various oxidants such as iron, AAPH and γ -radiation, besides scavenging important ROS such as the superoxide radical and hydrogen peroxide and inhibiting xanthine oxidase. In addition, OSP could prevent γ -radiation-mediated cell deaths in mouse splenocytes. We report a new polysaccharide (OSP) from *O. sanctum* as an efficient WSA that can prevent oxidative damages to lipids, DNA and solenocytes caused by various oxidation inducers. The activity was specific for OSP and could be attributed to its ability to scavenge various ROS and chelate iron. The present study demonstrated that in addition to the two phenolic antioxidants earlier reported from the plant, 13 OSP also can be a potentially good water-soluble antioxidant and radioprotector [22].

ANTI-INFLAMMATORY ACTIVITY

The aim of this study was to establish the anti-inflammatory activity of the methanolic extract of *Ocimum sanctum* leaves (MEOS) with its fractions and to delineate the possible mechanism of action for MEOS. The anti-inflammatory activities of MEOS along with its petroleum ether and chloroform fractions were evaluated in a Carrageenan induced model of acute inflammation. The effect of MEOS on lipopolysaccharide induced production of nitric oxide (NO) in macrophages was also studied. Result was MEOS (100, 200 and 400 mg/kg body weight) significantly reduced Carrageenan induced paw edema; chloroform fraction was most potent (66%, $p < 0.001$). MEOS was non-toxic up to 125microgm/ml in mouse peritoneal macrophages wherein it (0–100microgm/ml) reduced lipopolysaccharide induced NO production. It was concluded MEOS possesses significant anti-inflammatory activity. Chloroform fraction of MEOS showed best anti-inflammatory activity [23].

IMMUNOMODULATORY ACTIVITY

Traditionally the aqueous and alcoholic extracts as well as seed oil of *Ocimum sanctum* is reported to modulate the immune response. So, the present study was undertaken to compare the immunomodulatory activity between alcoholic and aqueous extract of *Ocimum sanctum*. Alcoholic and aqueous extracts of *Ocimum sanctum* were administered orally at doses of 50, 100 and 200 mg/kg/day for 14 days to healthy albino Swiss mice. The assessment of immunomodulatory activity was carried by testing the humoral (hemagglutination antibody titer model) and cellular immunity (delayed type hypersensitivity reaction models).

As a result, on oral administration of aqueous and alcoholic extracts had stimulatory effect on delayed type hypersensitivity (DTH) and significantly ($p < 0.01$) improved humoral immunity. The study shown stimulatory effect on the humoral and delayed type hypersensitivity but the alcoholic extract was more potent in producing immune stimulation than aqueous extract[24].

Biochemical, hematological and Immunomodulatory effect of *Ocimum sanctum* in rat was studied. Aqueous extract of *Ocimum sanctum* were administered orally at doses of 100, 200 mg/kg/day for 45 days in waster albino rats. Immunomodulatory effect and biochemical and hematological changes were tested by standard methods. Aqueous extract of the *Ocimum sanctum* showed increasing antibody production in dose dependent manner. It enhances the production of RBC, WBC and hemoglobin. It does not affect the biochemical parameters. They concluded an oral administration of the aqueous extract of *O. sanctum* showed immunomodulatory effect in rat [25].

One more study was investigating the effect of *Ocimum sanctum* seed oil (OSSO) on some immunological parameters in both non-stressed and stressed animals. An attempt has also been made to explore the possible mechanism of immunomodulatory activity. OSSO (3 ml/kg, in) produced a significant increase in anti-sheep red blood cells (SRBC) antibody titer and a decrease in percentage histamine release from peritoneal mast cells of sensitized rats (humoral immune responses), and decrease in footpad thickness and percentage leucocyte migration inhibition (LMI) (cell-mediated immune responses). Restraint stress (RS) produced a significant reduction in the anti-SRBC antibody titer, foot pad thickness and percentage LMI (% LMI). The effects of RS on humoral as well

as cell-mediated immune responses were effectively attenuated by pretreating the animals with OSSO. Co-administration of diazepam (1 mg/kg, Sc), a benzodiazepine (BZD), with OSSO (1 ml/kg, in) enhanced the effect of OSSO on RS-induced changes in both humoral and cell-mediated immune responses. Further, flumazenil (5 mg/kg, in), a central BZD receptor antagonist inhibited the immunomodulatory action of OSSO on RS-induced immune responsiveness. Thus, OSSO appears to modulate both humoral and cell-mediated immune responsiveness and these immunomodulatory effects may be mediated by GABA argic pathways [26].

One more study was designed to evaluate the immunomodulatory effects of ethanolic extract of Tulsi leaves through a double-blinded randomized controlled cross-over trial on healthy volunteers. Three hundred milligrams capsules of ethanolic extracts of leaves of Tulsi or placebo were administered to 24 healthy volunteers on empty stomach and the results of 22 subjects who completed the study were analyzed. The primary objective was to study the levels of Th1 and Th2 cytokines (interferon- γ and interleukin-4) during both pre and post intervention period in blood culture supernatants following stimulation with lipopolysaccharide and phytohemagglutinin. Other immunological parameters such as T-helper and T-cytotoxic cells, B-cells and NK-cells also were analyzed using Flowcytometry. Result was statistically significant increase in the levels of IFN- γ ($p = 0.039$), IL-4 ($p = 0.001$) and percentages of T- helper cells ($p = 0.001$) and NK-cells ($p = 0.017$) were observed after 4 weeks in the Tulsi extract intervention group in contrast to the placebo group. Conclusions: These observations clearly ascertain the immunomodulatory role of Tulsi leaves extract on healthy volunteers [27].

BRONCHODILATOR ACTIVITY

Bronchial asthma is one of the commonest chronic inflammatory diseases. The drugs available to treat bronchial asthma such as, beta-2 agonists, though very effective are associated with adverse effects. Therefore, the *Ocimum sanctum* (Tulsi) which was shown to have antiasthma tic activity in Ayurveda, is evaluated in this study. This study was to evaluate the bronchodilator activity of *Ocimum sanctum* Linn. in mild and moderate asthma and compare its efficacy with the standard bronchodilator drug, Salbutamol. This is a single-blind cross-over study. Capsules of *Ocimum sanctum* Linn. (200 mg, twice daily) and Salbutamol sulphate (2 mg, twice daily) were administered in 41 patients. Each drug was administered for a period of one week with a washout period of one week between the two drug schedules. FEV1 and PEFr were recorded in these patients to assess the bronchodilator activity before the drug administration, on 4th and on 7th day of administration of *Ocimum sanctum* and the parameters obtained were compared with that of the standard drug, Salbutamol. *Ocimum sanctum* 200mg twice daily produced significant improvement in both FEV1 and PEFr values, on 4th and 7th day and also produced improvement in symptoms of asthma. On comparing the results with that of Salbutamol 2mg twice daily, the bronchodilator activity of *Ocimum sanctum* was found to be less efficacious, where Salbutamol produced very highly significant improvement in FEV1 and PEFr values on both 4th and 7th day. Their results suggest that *Ocimum sanctum* Linn. possesses significant bronchodilator activity in mild and moderate bronchial asthma[28].

RADIO PROTECTIVE EFFECTS

The use of compounds which can selectively protect normal tissues against radiation injury is of immense use because in addition to it protecting the normal tissue, will also permits use of higher doses of radiation to obtain better cancer control and possible cure [29]. However, most of the radio protective compounds investigated possess inadequate clinical application principally due to their inherent systemic toxicity at their optimal protective concentrations. Plants commonly used as medicinal and dietary agents have recently been the focus of attention and studies have shown that *Ocimum sanctum* Linn. commonly known as the Holy Basil and its water-soluble flavonoids, orientin and vicenin protects experimental animals against the radiation-induced sickness and mortality at nontoxic concentrations. Studies with tumor bearing mice have also shown that both Tulsi extract and its flavonoids selectively protect the normal tissues against the tumoricidal effects of radiation. Preclinical studies have also shown that the aqueous extract of the Tulsi leaves; its flavonoids orientin and vicenin, and eugenol, the principal nonpolar constituent present in Tulsi prevent radiation-induced clastogenesis. Mechanistic studies have indicated that free radical scavenging, antioxidant, metal chelating and anti-inflammatory effects may contribute toward the observed protection. In addition, clinical studies with a small number of patients have shown that Tulsi was effective as a radio protective agent. This review summarizes the results related to the radio protective properties of Tulsi and its phytochemicals and also emphasizes the aspects that warrant future research to establish its use as a radio protective agent.

DISCUSSION AND CONCLUSION

This review will definitely help for the researchers as well as clinicians dealing with *O. sanctum* to know its proper usage as this herb is seemed to be highly valuable, possessing many pharmacological/ medicinal properties. It has a variety of biological/pharmacological activities such as antibacterial, antiviral, antifungal, antiprotozoal, antimalarial, anthelmintic, antidiarrheal, analgesic, antipyretic, anti-inflammatory, antiallergic, antihypertensive, cardioprotective, central nervous system (CNS) depressant, memory enhancer, antihypercholesterolaemic, hepatoprotective, antidiabetic, antiasthmatic, antithyroid, antioxidant, anticancer, chemo preventive, radioprotective, immunomodulatory, antifertility, antiulcer, antiarthritic, apoptogenic/antistress, anticataract, antileukemia and anticoagulant activities. It has not only medicinal properties but also nutritional, spiritual properties which are only present in this plant; thus, it is regarded as "Queen of Green Medicines."

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