Sys Rev Pharm 2024; 15(5): 176-182
A multifaceted review journal in the field of pharmacy
E-ISSN 0976-2779 P-ISSN 0975-8453/DOI: 10.31858/0975-8453.15.5.176-182

Review Article

A Review on Indian Plant Tulsi (*Ocimum sanctum*) and its Medicinal Uses

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Article History: *Submitted: 03.05.2024* *Accepted: 20.05.2024* *Published: 27.05.2024*

ABSTRACT

Tulsi, which is also known as *Ocimum sanctum* and basil, belongs to the family Lamiaceae. It is a widely known as a medicinal plant in India which has various medicinal and religious properties. It has been used for centuries and has lot of uses, mainly because of its wide range of action on human body. This sacred herb can be recommended for the treatment of skin diseases, arthritis, inflammation and can lower the risk of cancer. Tulsi, also called as the queen of herbs, is known for its ability to relieve stress, anxiety and induce relaxation. It is commonly used for its antioxidant, antidiabetic, antimicrobial and anti-inflammatory pharmacological actions. It is one of the most important Ayurvedic plants which consists of phytochemicals like tannins, glycosides, saponins and phenol. This holy plant is also found in China, Sri Lanka, Malaysia and Thailand. It can also be used to cure back pain, hiccup, viral infections, stomach and urinary disorders. Hence it is a renowned traditional plant which makes it more beneficial to use because of its popularity and various uses.

Keywords: *Ocimum sanctum*, Cancer, Anti-inflammatory, Arthritis

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INTRODUCTION

Tulsi (*Ocimum sanctum* L.), also known as Tulasi in Sanskrit, holy basil in English is a highly prized culinary and medicinal herb belonging to the Lamiaceae family. It is native to the Indian subcontinent and has been used in Ayurvedic medicine for more than three millennia. Traditionally known for its medicinal benefits, tulsi is available in two types, black tulsi (Krishna tulsi) and green tulsi (Ram tulsi) (*Figure 1*). Eugenol is an essential oil found in tulsi, as well as compounds such as thymol, ursolic acid, etc., (Ghosh T, 2021). Tulsi plant is very important for humanity. Due to the complex restorative benefits it provides, tulsi leaves are widely used in the preparation of Ayurveda recipes. It has been proven to prolong life span. Extricates obtained from the plant are commonly used in the treatment of various diseases, such as the common cold, irritation, indigestion, coronary disease, migraine, stomach problem, kidney stone and heart problem, etc. Indian basil, tulsi helps in decontamination of the environment. Phytochemicals found in this medicinal plant are a rich source of secondary metabolites. Chemical and taxonomic diversity of these compounds are very high and their function is unclear. There are a large number of phytochemicals that are widely used in human therapy, in agriculture, veterinary medicine, various scientific researches and in various fields, as well as inhibitory effects *in vitro* on all species of microorganisms (*Table 1*).

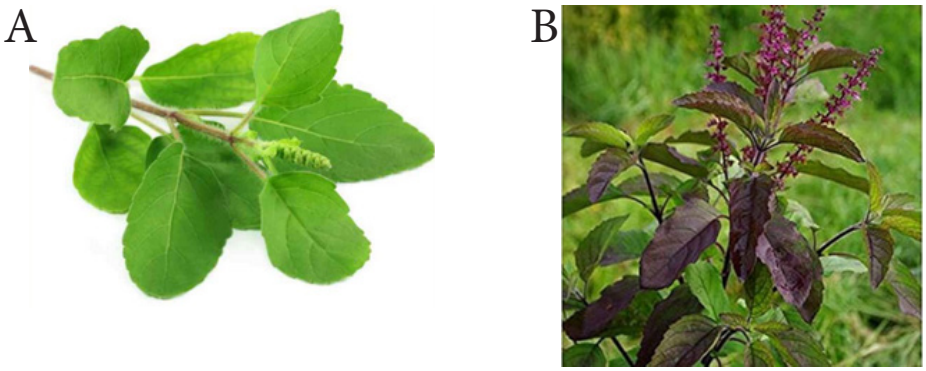

Figure 1: A) Ram tulsi (green tulsi); B) Krishna tulsi (black tulsi)

Table 1: Botanical classification of *Ocimum* species

Taxonomic rank	Taxon
Class	Magnoliopsida
Kindgdom	Plantae
Genus	*Ocimum*
Species	*Ocimum basilicum*
Order	Lamiales
Family	Lamiaceae
Division	Magnoliophyta

Tulsi leaves are utilized extensively due to their capacity to promote wellness. It greatly helps with memory as it stimulates the senses; tulsi is known to help with respiratory issues. The mixture of honey, ginger and tulsi leaves is a very good remedy for bronchitis, flu and asthma. Tulsi also lowers cholesterol in the blood and maintains heart in healthy manner (Kumar KP, *et al*., 2010). Eugenol possesses antioxidant properties and inhibits lipid peroxidation (Sethi J, *et al*., 2004).

Tulsi was acknowledged by ancient sages as a rejuvenating adaptogen and anti-stress agent, having the potential to improve longevity and overall health. The leaves, seeds and roots of tulsi plant have been used for their medicinal qualities in traditional Ayurvedic medicine. The leaves of this medicinal plant are extremely beneficial for sore throats. Simply by heating water immersed tulsi leaves can be beneficial for the patient to treat throat diseases through this decoction; tulsi can help to strengthen the kidneys. Additionally extracts of tulsi leaves with 70% ethanol have demonstrated substantial drops in blood glucose levels in rats that are healthy with diabetic rats and elevated blood glucose from glucose feeding brought on by Streptozotocin (STZ) (Chattopadhyay RR, 1993; Grover JK, *et al*., 2002). For those suffering from renal kidney stones, a decoction prepared by combining the juice of tulsi leaves with nectar, when taken consistently for six months, can remove stones from the urinary tract.

Tulsi has a huge range of therapeutic qualities (Cragg GM and Newman DJ, 2001; Naquvi KJ, *et al*., 2012). In the past 20 years, numerous studies, particularly by Indian scientists and researchers, have been conducted to demonstrate this plant's adaptable benefits for the general public (Sarkar A, *et al*., 1990; Kumar A, *et al*., 2011; Surkar A, *et al*., 1994; Mandal S, *et al*., 1993).

Over the past few decades, a number of studies conducted by Indian scientists and researchers have suggested the potential therapeutic benefits of *Ocimum sanctum* L. and the role of essential oils and eugenol. Numerous pharmacological studies using eugenol and steam-distilled, petroleum ether and benzene extracts of various tulsi plant parts have established the plant's therapeutic potential. Tulsi's well-established medicinal properties have led to its descriptions in Ayurveda as Kaphaghna (suppressant herb) and Sashemani Shwasaharani (antiasthmatic) (Shah CS and Qadry JS, 1971; Khanna N and Bhatia J, 2003; Singh E, *et al*., 2012).

Tulsi is beneficial to heart, aids in digestion, eases coughing and reduces breathing problems. According to the ancient writings by Charaka and Susruta, it has also been used to treat scorpion stings and snake bites. As a result, every portion of the plant has a purpose. Based on conventional wisdom, people continue to use various parts of this plant to treat variety of illnesses. But in the world of modern science, such claims need to be supported by evidence.

While scientific research is being done on the ancient traditional claims regarding the medicinal properties of tulsi, most of the studies are restricted to *in vitro* and experimental animal models. Human subjects are used in very few studies. Consequently, an attempt has been made to review it.

LITERATURE REVIEW

Tulsi history

Tulsi means one that is incomparable or matchless in Sanskrit and was recognized as one of the most exceptional medicinal herbs a millennium ago. They discovered that the plant was deemed to be beneficial to health and healing (Bhateja S and Arora G, 2012).

Synonyms of tulsi

Sanskrit-Surasa, Krishna tulasi and bana tulasi, Hindi-Tulasii, Assamese-Tulasii, English-Holy basil, Marathi-Tulase, Bengali-Tulasai, Gujarati-Tulasei, tulsi lip, Kannada-Tulaseii, shri tulsi, vishanu tulsi, Punjabi-Tulsi, Malayalam-Tulsii, tulasae, Tamil-Tulaesi, thulasii, theiru theezaei, Telugu-Tulasii, Armenia-Shahasbram, rehan, Urdu-Raihana, Tulss, Bulgaria-Bosilek, Denmark, Greenland-Basilikum, Netherlands and South Africa-Baziel koningskruid, Finland, Sweden and Norway-Basilika, England-Basilie, sweet basil, France-Basilic sacre, herbe royale, Germany-Indisches basilikum

Morphology

Tulsi plant yields long flowering racemes that are grouped closely in whorls. The hue of these flowers is purple, giving the plant a splash of color. Tulsi seeds are tiny and have reddish yellow-like color. Additionally, the plant yields small-sized fruits. Tulsi is usually planted in the rainy season because it needs moisture to grow. It takes several months to cultivate and care for it before it is ready for harvest.

Tulsi is a small shrub that spreads out and grows upright. At maturity, it usually grows to a height of between 30 cm and 60 cm. The plant's leaves have a pleasing aroma with straightforward structure. The leaves are shaped like ellipses with rounded tips which are arranged in an opposite pattern along the branches. The leaf margins are dentate or toothed. The leaves range in length from 1 cm-5 cm on average. In India and Nepal, two morphotypes are mainly cultivated-green leaved and purple leaved (Gudi SK, *et al*., 2014).

Chemical constituents

Tulsi has a very complex chemical makeup that includes numerous nutrients and substances that are biologically active. Standardisation of tulsi's active ingredient is a complex process because of its botanical origins and intrinsic biochemical complexity. Eugenol and ursolic acid, the two most well-known active ingredients in tulsi leaves are the source of essential oil. Other than ursolic acid, the main components found and extracted from tulsi are non-existent. Both male and female rats and mice are susceptible to the compound's antifertility effects. Ursolic acid inhibits spermatogenesis, lowers sperm count and has anti-estrogenic properties. Eugenol is a phenolic compound that is extracted from the various parts of tulsi plant and is a major component of the essential oil (*Figure 2*).

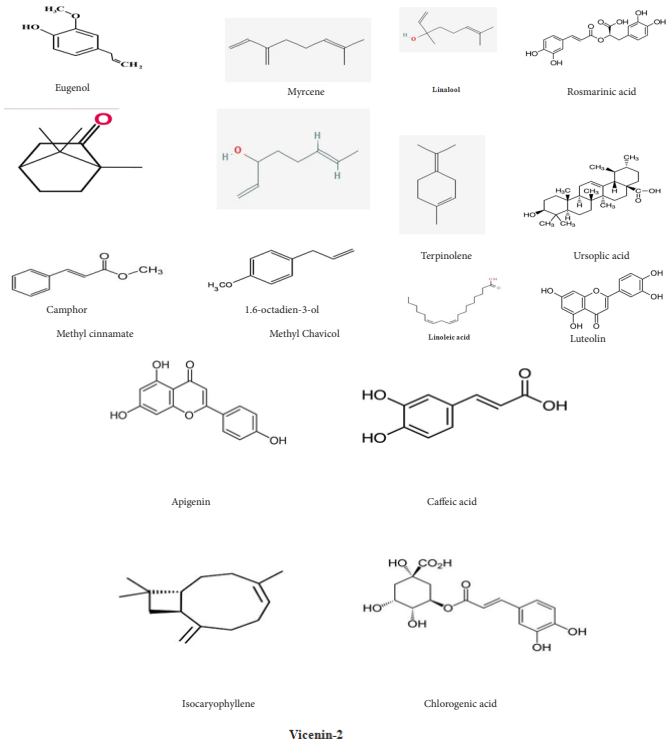

Figure 2: Structural representations of chemical constituents

Eugenol, one of the major components of the essential oils extracted from fresh *Ocimum sanctum* leaves and is primarily responsible for the therapeutic potential of these oils (Gulati D, *et al*., 2015). Tulsi consists of other components like alpha-pinene, alpha-thujene, toluene, eugenol, methyl eugenol, isoeugenol, β-caryophyllene, 4,11-carvacrol, seinadiene, β-selinene, caryophyllene oxide, ursolic acid, luteolin, apigenin, apigenin-7-oglucuronide, vicenin-2, luteolin-7-O-glucuronide, stigmasterol, aesculin, gallic acid, β-stigmasterol, phenylpropane glucosides, palmitic acid, linoleic acid, stearic acid, sitosterol, oleic acid, dilinoleno-linolins, linodilinolin and hexourenic acid (Sah AK, *et al*., 2018).

Tulsi contains about 45 different compounds and oils in a study scenario. The primary ingredients include volatile oils are eugenol,1,6-octadien-3-ol, 1,7-dimethyl, methyl cinnamate, methyl chavicol, linalool and rosmarinic acid which is a strong antioxidant. The main components of tulsi that have medicinal properties are camphor, eugenol and rhymol. Polysaccharides, xylose and sugars make up the mucilage. The seeds contain oils that are made up of sitosterol and fatty acids. One of the medicinal herbs that can help prevent cell damage that can result in cancerous conditions is basil. It also contains vitamins C and A, which can increase the production of antibodies that fight disease by up to 20% (*Table 2*).

Table 2: Nutritional quantities in tulsi plant

Nutrients	Value/quantity
Dietary fibre	1.60 g
Cholestrol	0 mg
Total fat	0.64 g
Carbohydrate	2.65 g
Protein	3.15 g
Energy	23 k/cal
Minerals	
Copper	3.85 mg
Zinc	0.81 mg
Calcium	177 mg
Iron	3.17 mg
Manganese	1.15 mg
Magnesium	64 mg
Vitamins	
Vitamin C	18 mg
Vitamin E	0.80 mg
Vitamin A	5275 IU
Vitamin K	414.8 µg
Thiamin	0.034 mg
Folates	64 µg

Medicinal properties

- Ginger juice, honey and pepper along with tulsi are used to treat cold and cough.
- As tulsi has antibacterial properties, it is utilized in the production of numerous skin ointments and cosmetics.
- Tulsi has antibacterial, antiviral and antiseptic properties.
- Tulsi has antioxidant properties and reduces blood glucose levels.
- Stomach poisoning against malarial larvae is demonstrated by the oil of tulsi.
- It is also used to treat headaches, malaria, common colds, coughs and stomach problems.
- According to Ayurveda, tulsi's arrangements can be used for indigestion, intestinal parasites and constipation (Singh S, *et al*., 2007).
- It possesses immunomodulatory qualities and serves as an insect repellent. Thus, grains are frequently stored in it.
- Beta-ursolic acid, a substance found in tulsi may be utilized as an anti-fertility medication.

Mechanism of action of tulsi

Tulsi plant contains variety of constituents in its different parts, including flavonoids, triterpenoids, saponins and tannins. Eugenol is found as the volatile oil in its leaves. Certain constituents have demonstrated a pivotal role in the management and cure of diseases by modulating various biological activities. The following is a description of tulsi's mode of action for managing illness curing; greater concentration of reactive oxygen produces oxidative stress and damages macromolecules, which leads to pathogenesis. Tulsi plant's antioxidant activity, on the other hand, neutralizes free radical potentiality. The plant also scavenges free radicals and protects against cellular damage.

Furthermore, extracts with concentrations of 100 µg/ml exhibited hydrogen peroxide (20.12%), hydroxyl radicals (12.68%) and superoxide radicals (21.68%) scavenging activity, according to methods for scavenging these three types of radicals.

Tulsi functions as anti-inflammatory agent and may help lower inflammation by modifying different genes. Antibacterial drug resistance is a serious health issue that requires a solution. A natural compound has a major part in stopping the growth of bacteria or killing them by breaking their cell walls.

Tulsi plant has demonstrated anti-gonorrheal efficacy against clinical isolates of methicillin-resistant *Staphylococcus aureus* that produces beta-lactamase and against multi-resistant strains of *Neisseria gonorrhea* (Almatroodi SA, *et al*., 2020).

Uses of tulsi

Tulsi as traditional Ayurvedic medicine: Stress-reduction is one of the qualities that make tulsi plant as a powerful medicinal herb, according to organic India, an organization devoted to organic agriculture and sustainable development. Antioxidants and essential oils found in abundance in tulsi are highly effective in reducing the effects of stress; tulsi has variety of therapeutic benefits. Tulsi plant has the ability to function as an adaptogen which helps in stress management and balances various bodily processes. The experts of the traditional Indian Ayurvedic medical system make use of turmeric which is employed in the Unani system as well.

Physicians practicing Ayurveda advise using tulsi (*Ocimum sanctum*) in all of its plant parts. To arrange its juice, it is suggested to gather the leaves, tender branches, tender roots, seeds and flowers-virtually every aerial part of tulsi plant. Use clean, flowing water to properly clean them and prepare a soft paste, chop them into small pieces and crush them in a mortar and pestle. To extract pure tulsi fluid, the prepared paste is placed and arrangement on a slender cotton cloth and allowed to press it. As an Ayurveda medication, tulsi plant extracts are used in Ayurvedic treatments for heart disease, inflammation, headaches, stomach problems, common colds, poisonings, and malaria. Tulsi is traditionally consumed in a variety of ways, such as a dried powder, fresh leaf, herbal tea or combined with honey or ghee.

Tulsi is used in Ayurvedic treatments for a variety of conditions, including malaria, headaches, stomach problems, inflammation, infections, heart disease, poisoning and cataracts. The nervous system is strengthened by the action of tulsi; it fortifies the heart. Tulsi acts as a preventive antibacterial agent (Kumar KP, *et al*., 2010) and it aids in digestion, serving as an ap-

petizer. It makes the digestion-related enzyme secretion and reduces flatu lence. Tulsi's detoxifying qualities help to cleanse blood of any potential poisons that could be in it. It is possible that tulsi can guard against radiation poisoning. Tulsi leaves prevent bacterial growth during the eclipses if it is sprinkled over food in the stored water. Additionally, tulsi has been shown to have anti-cancerous properties. A myth has emerged suggesting that a tulsi leaf taken on a daily basis will guarantee in prevention of cancer. Its religious significance notwithstanding, it is extremely significant medicinal value and is a key herb in Ayurvedic medicine.

Tulsi in modern medicine: According to the research in contemporary medicine, tulsi may have been a useful remedy for ailments like ulcers, high cholesterol, type II diabetes, obesity and weakened or suppressed immune systems (caused by illnesses like cancer and Acquired Immune Deficiency Syndrome (AIDS)). According to plant cultures, varieties of tulsi have intrinsic properties that may account for their traditional uses in Ayurveda. These properties include essential oils that contain the anti-inflammatory compound eugenol and various acids that have anti-inflammatory and antioxidant qualities, which may help to explain the ability of tulsi to treat wide range of ailments with Ayurveda.

Diabetes in Western medicine: According to Diabeteshealth.com, researchers have theorized that holy basil (tulsi) leaves may improve pancreatic beta cell function and thus enhance insulin secretion. According to the website, a small study of type II diabetic patients revealed that those who took 2.5 g of powdered tulsi had lower blood glucose fasting levels than those who took placebo. Drug interactions with tulsi have not been documented, according to Diabeteshealth.com; however, in diabetics treated with insulin or insulin secretagogues such as sulfonylurea (glyburide, glipizide, Prandial or Starlix), some interactions may be possible. As a result, those with diabetes who are thinking about taking tulsi should consult their physicians and then proceed accordingly.

Uses of natural medicines

Tulsi is used in Siddha, Unani and Ayurvedic medicine to treat a broad range of skin disorders, fever, cough and internal illnesses. Indians combine cardamom or lemon juice with tulsi leaves to make a liquid tonic that is used in Ayurvedic medicine to treat bronchitis. All the three medical systems are all dated back to ancient times and are based on herbal and plant-based natural remedies and treatments.

Insect bites: The herb (tulsi) is a preventive, curative and prophylactic measure for insect bites or stings. After several hours, another teaspoonful of the leaf juice is taken. Applying fresh juice of this herb to the affected areas is also necessary. In the event of insect and leech bites a paste made of fresh roots is also useful (Sharma P, *et al*., 1998).

Teeth disorders: The leaves are beneficial for tooth disorders where paste prepared form the leaves can be used to brush teeth after being sun-dried and powdered. It can also be used as toothpaste by combining it with mustered oil to form a paste. This works wonders for massaging the gums, preventing bad breath and preserving dental health. Additionally, it helps against pyorrhea and other dental conditions.

Skin disorders: When applied locally, ringworm and other skin conditions can be effectively treated with basil juice. Several naturopaths have also successfully treated leukoderma.

Eye disorders: Vitamin A deficiency is typically the cause of night blindness, which can be effectively treated with basil juice. Every night before bed, two drops of black basil juice are applied to the eyes.

Mouth infections: When it comes to mouth infections and ulcers, the leaves are quite effective. Chewing a few leaves can treat these ailments.

Stress and headaches: Basil leaves are thought to be an anti-stress or adaptogen. According to recent research, the leaves provide considerable level of stress protection. Chewing 12 leaves of basil twice/day can help to reduce stress even among healthy individuals. It helps to prevent several common elements and purify the blood; headache medication is made from basil. For this disorder, a decoction of the leaves may be administered. Applying a mixture of grounded leaves with sandalwood powder to the forehead can relieve heat, headaches by inducing cooling sensation.

Respiratory disorders: An essential ingredient in lot of Ayurvedic cough syrups and expectorants is tulsi. It aids in the mobilization of mucus in asthma and bronchitis. Tulsi leaves can be chewed to relieve the flu and cold. For sore throat, it is recommended to drink boiling water with basil leaves and gargle with this water. The herb can be used to treat disorders of the respiratory system. Bronchitis, asthma, influenza, coughing and cold can all be effectively treated with the decoction of the leaves made with honey and ginger. When someone has flu, a decoction made of the leaves, cloves and regular salt provides quick relief. The leaves need to be boiled in half liter of water until water becomes half and then consuming it would be beneficial (Puri HS, 2002).

Heart conditions and health: Basil can help to treat heart disease and weakness that comes with it. It lowers blood cholesterol levels (Sethi J, *et al*., 2004).

Illnesses in children: Basil leaf juice works well for common pediatric issues like fever, diarrhea, vomiting, cough and cold. Taking basil leaves with saffron would speed up the appearance of chicken pox pustules if they are delayed (Devi PU and Ganasoundari A, 1999).

Kidney stone: Kidneys are strengthened by the effect of basil. If taken consistently for six months, the juice of basil leaves and honey will help the urinary tract expel kidney stones.

DISCUSSION

Pharmacological activities

Anti-stress activity: Stress is a widespread disorder that most people experience on a regular basis. It is defined as people's physiological, psychological, and behavioral reactions when they experience an imbalance between their capacity to satisfy their deficiencies and their own shortcomings. Lack of neurotransmitters like dopamine, norepinephrine and serotonin causes stress reactions. According to earlier research, *Ocimum sanctum* leaves increase serotonin levels in the brain, which has a protective effect against stress-related behaviors.

Tulsi is a calming herb that works well, especially when taken twice a day. The stress hormone cortisone, which is inhibited by tulsi leaf extraction, stimulates both acute and chronic noise stress. Additionally, this effect is verified by using animals in experiments or by investigation. High levels of stress damage the body and increase the risk of many illnesses, including immune suppression, peptic ulcers, ulcerative colitis, hypertension and psychiatric disorders; for these reasons, stress needs to be treated. Stress can have physiological or physical effects. Tulsi enhances memory, lengthens anoxic stress tolerance and lowers hypoxia.

Antioxidant activity: The antioxidant activities were compared with standard antioxidant ascorbic acid. It simply means not allowing oxidizing chain reactions to occur, which inhibits other molecules' ability to oxidize and release energy to power biological processes. Numerous living things require oxidation. A number of diseases can be caused by free radicals, which are molecules with one or more unpaired electrons that react with other molecules by donating or stealing electrons. These chemicals are extremely reactive, unstable and they harm cells irreversibly. According to earlier research, the body's free radicals cause a variety of disorders by altering and developing cells. Antioxidants found in a variety of herbal medicinal plants, however may be able to control this.

Around 80% of people on the planet rely on medicinal plants to supplement their current medical needs. The primary components of life are membrane lipids, proteins, Deoxyribonucleic Acid (DNA) and carbohy-

drates; reactive oxygen species have the ability to destroy these. For this reason, number of illnesses including diabetes, atherosclerosis, cancer and liver cirrhosis are treated using the holy herb (tulsi).

Antioxidants, therefore shield the human body from free radicals that damage liver microsomes, increase the activity of superoxide dismutase and inhibit lipid peroxidation by preventing the destruction of reactive oxygen species. The standard antioxidant ascorbic acid is used to compare the antioxidant activities primarily. Some of the studies used qualitative preliminary phytochemical analysis to identify tannin, steroids, alkaloids, flavonoids and phenols (Bhooshitha AN, *et al*., 2020).

Anti-bacterial activity: Tulsi contains two antibacterial agents namely, terpene and carvacrol. The same purpose is likewise severed by sesquiterpene called β-caryophyllene. This ingredient, which is found naturally in tulsi is a food additive approved by the Food and Drug Administration (FDA). It aids in protecting the body against disease-causing bacteria.

Apart from being an antioxidant, rosmarinic acid is also a good source of anti-inflammatory properties. Another substance in the mixture that has the same purpose is apegenin. Other than these two, eugenol is the primary anti-inflammatory component of tulsi. Its primary component is responsible for controlling blood sugar in the body. It manipulates the pancreatic beta cell function and increases the release of insulin as a result.

Adaptogenic agent: Tulsi's adaptogenic qualities make it an ideal remedy for lowering volatile emotions and encouraging mental clarity and calmness. Eugenol and beta caryophyllene are the two most inactive adaptogens found in tulsi's chemical composition. These are incredibly effective at lowering corticosterone levels, which are the primary cause of stress.

It also enhances memory and reduces the chance of age-related mental health problems. As adaptogens, ursolic acid and oleanolic acid are very good at lowering stress levels (Flood G, 2008).

Immunomodulator: The immune system must have an immune-modulator in order to stabilize, replenish, maintain healthy and balanced immune system of the body. Tulsi's potent immune-boosting properties protect the body from foreign invaders such as viruses, bacteria, allergies and pathogens while preserving the body's overall balance (Chatterjee G, 2001).

Anti-diabetic activity: In *streptozotocin*-induced diabetic rats, ethanolic extract of *O. sanctum* Linn decreased the blood glucose, glycosylated haemoglobin and urea with a concomitant increase in glycogen, haemoglobin and protein, respectively. The extensive spectroscopic data analysis reveals that the isolated bioactive compound is elucidated as a tetracyclic triterpenoid. Various species of *Ocimum* were explored and compared for antidiabetic activity. All extracts were able to show antidiabetic activity at 0.5 mg/kg concentration. The activities are well comparable with the standard drug, glibenclamide. The methanolic extract of *O. sanctum* showed better antidiabetic activity than other species of *Ocimum* and standard drugs. The data were verified as statistically significant using one-way Analysis of Variance (ANOVA) at a 5% significance level ($p<0.05$) (Amarah U, *et al*., 2017). A randomized, placebo-controlled cross-over single-blind trial was performed on 40 patients having type II steroid induced diabetes. During the 4 week trial, all the patients alternately received daily dose of 2.5 g of tulsi leaves powder or a placebo dose for 2 weeks of period. The results showed a 17.6% reduction in fasting blood glucose and 7.3% decline in postprandial blood glucose on treatment with tulsi as compared to the blood glucose levels during treatment with placebo.

Anti-Alzheimer's activity: Alzheimer's disease is a neurodegenerative condition that primarily results in mood swings, behavioral abnormalities and cognitive impairment. Alzheimer's disease typically involves dementia; globally, 25 million people are estimated to be affected by dementia, which affects 70% of people living in industrialized nations. While there is no known cure for Alzheimer's disease, there are treatments that can reduce some of its symptoms and restore cholinergic function.

According to the review literature, memantine and donepezil medications worsen cognitive impairment in patients with Alzheimer's disease and they do not improve memory after two clinical trials. As a result, nootropic herbal remedies can strengthen the effects of another anti-Alzheimer's medication. Inducing neuronal death and oxidative stress is another major factor contributing to Alzheimer's disease. Majority of nootropics have an antioxidant effect against Alzheimer's disease.

The primary component of *Ocimum sanctum*, eugenol has antioxidant activity. Other secondary components include flavones with pharmacological qualities and fixed oils. The main active ingredient in *O. bascilicum* that gives tulsi its medicinal properties is eugenol. Additionally, in rodents the standardized extract of *O. sanctum* has statistically alleviated the ischemia reperfusion-enhanced oxidative stress and chronic hypoperfusion-enhanced cognitive impairment. Holy basil has been shown in models of cerebro-degenerative diseases to have memory-enhancing and antioxidant properties. As was already mentioned, oxidative stress and cognitive impairment are linked to Alzheimer's disease. Utilizing neurotoxins like colchicine and ibotenic acid as models, the effect of *O. sanctum* in Alzheimer's disease was evaluated. Ibotenic acid which is a structural analogue of glutamate excites glutamate receptors excitatoryly, thereby enhancing neuronal necrosis.

Anti-epileptic activity: The word seizures refer to the brain's neurons firing, which results in uncontrollable electrical activity in the brain. Epilepsy is a common chronic neurological disease that is 2nd only to stroke in terms of prevalence. This disease affects 40-60 persons per million annually. 30% of the population did not significantly respond to treatment, while between 60%-70% of the population responded favorably to antiepileptic medication. Investigating medications with the best antiepileptic properties and fewest side effects is crucial, though.

The ethanolic extract of holy basil leaves improves brain neuronal functions, which helps to reduce epilepsy symptoms. In order to reduce the Transient opening Calcium (T-type $Ca2^{+}$) channels in the thalamus, *Ocimum sanctum* extract acts by blocking N-methyl-D-aspartate receptors, which in turn blocks voltage-gated Sodium (Na^{+}) channels. Additionally, the medication affects Gamma-Aminobutyric Acid (GABA) agonistic potential. Furthermore, *Ocimum sanctum* prolongs the duration of phenobarbitone-enhanced sleep.

The drug has an effective antiepileptic property, as evidenced by the positive reactions against disease and the defensive action that ethanol and chloroform extractives of basil's stem, leaf and stem calli hold against Tonic Hind Limb Extension (THLE), according to the databases that are currently in place.

Antiplasmodial activity: In a 2012 study on three different species of *Ocimum*, Inbaneson SJ, *et al*., 2012 found that extracts from the leaves, roots, stem, and flowers of *Ocimum sanctum* exhibited good anti-plasmodial activity. The ethanolic extracts of the tested plants may contain alkaloids, glycosides, flavonoids, phenols, saponins, triterpenoids, proteins, resins, steroids and tannins, which could account for the *in vitro* anti-plasmodial activity.

Analgesic activity: In a study, Singh S and Majumdar DK, 1995 investigated the analgesic properties of fixed oil derived from the seeds of *Ocimum sanctum* in mice and rats. The study employed various techniques such as tail flicking, tail clipping, tail immersion, and acetic acid-induced writhing. It was discovered to be efficacious in a dose-dependent manner against writhing induced by acetic acid, indicating that the oil's ability to inhibit writhing is peripherally mediated by the combined inhibitory effects of prostaglandins, histamine, and acetylcholine.

Antiasthmatic activity: 50% of aqueous ethanolic extract of both fresh and dried tulsi leaves, along with the volatile and fixed oils of *Ocimum sanctum*, were tested against Preconvulsive Dyspnea (PCD) in guinea pigs

which were induced by histamine and acetylcholine. The guinea pigs were considerably shielded from histamine and acetylcholine-induced pre-convulsive dyspnea by the 50% ethanol extract, volatile oil extracted from fresh leaves and fixed oil from the seeds. Nevertheless, the guinea pigs' resistance to histamine-induced pre-convulsive dyspnea was not maintained by the 50% ethanol extract of dried leaves (Singh S and Agrawal SS, 1991).

Anti-ulcer activity: In Wistar rats, the aqueous extract of *Ocimum sanctum* (100 mg/kg and 200 mg/kg orally) showed a noteworthy protective effect against ethanol-induced gastric ulceration. By increasing the gastric mucosa's antioxidant potential and thereby lowering mucosal damage, *Ocimum sanctum* demonstrates antiulcer activity (Ghangale GR, *et al*., 2009). When given intraperitoneally, fixed oils of *Ocimum sanctum* exhibit strong antiulcer activity against rats' ulcers caused by stress, aspirin, indomethacin, alcohol (ethanol 50%), histamine, reserpine and serotonin. The antiulcer activity of the fixed oil was attributed to its lipoxygenase inhibitory, histamine antagonistic and antisecretory properties (Pandey G and Madhuri S, *et al*., 2010).

Anti-fertility activity: The total sperm count, sperm motility, and forward velocity of Albino rats treated with benzene extract of *Ocimum sanctum* leaves (250 mg/kg body weight) for 48 days were all reduced. The findings imply that these effects are the result of androgen deprivation brought on by *Ocimum sanctum* leaves' anti-androgenic characteristics. Two weeks after the treatment was stopped, all the parameters went back to normal, indicating that this effect was reversible.

The number of sperms in rabbits was observed to have significantly decreased. When *Ocimum sanctum* treated rabbits received 2 g fresh leaves/rabbit for 30 days, their serum testosterone levels increased significantly and their Follicle Stimulating Hormone (FSH) and Luteinizing Hormone (LH) levels decreased significantly. The findings point to *Ocimum sanctum*'s possible application as a reliable male contraceptive method (Sethi J, *et al*., 2010).

Anti-viral activity: The antiviral activity of *O. sanctum* was evaluated against a variety of significant viral agents, including fish pathogenic viruses such as Infectious Hematopoietic Necrosis Virus (IHNV), *Oncorhynchus masou* Virus (OMV), Infectious Pancreatic Necrosis Virus (IPNV), poliovirus type-3, Herpes Viruses (HSV), Adenoviruses (ADV), *Hepatitis B Virus* (HBV) and Ribonucleic Acid (RNA) viruses such as Coxsackievirus B1 (CVB1), Enterovirus 71 (EV71), *Buffalopox Virus* (BPXV), Virulent Newcastle Disease (VND) virus and infectious *Bovine Rhinotracheitis-1* (BoHV-1) virus.

Using the plaque reduction method on CHSE-214 cells, extracts of various traditional Thai herbs such as tulsi, demonstrated virucidal activity against fish pathogenic viruses, such as IHNV, OMV and IPNV. In Vero cells, poliovirus type-3 was inhibited by an ethanolic extract of basil leaves at a nontoxic range of 22.5-0.175 mg/ml, while an aqueous extract showed a nontoxic effective range of 2.25-1.75 mg/ml. By using a virus inhibition assay, the percentage of poliovirus type-3 that was inhibited by ethanolic and aqueous extracts of basil was found to be 99.9% and 99.68%, respectively (Parida MM, *et al*., 1997).

Anti-carcinogenic activity: Research indicates that tulsi, also referred to as holy basil, has promising anti-carcinogenic properties (Santwani S, 2023). One of the tulsi's main characteristics is its antioxidant content, which aids in scavenging free radicals that are known to damage cells and possibly hasten the onset of cancer. It has been discovered that tulsi extracts have anti-tumor properties by preventing the growth of cancer cells and causing different cancer cell types to undergo programmed cell death, or apoptosis. Tulsi also helps to protect DNA from mutations that can cause cancer by regulating the immune system and boosting the activity of immune cells against cancer cells.

Eugenol and rosmarinic acid, among other compounds, are what give tulsi its anti-carcinogenic properties. Research has indicated tulsi's ability to prevent the development of lung, breast, liver and oral cancer (*Table 3*).

Table 3: Parts and type of extract of tulsi plant used for different pharmacological activities

Pharmacological activity	Part of plant	Extract used
Anti-depressant activity	Leaves	Alcoholic extract
Anti-anixiety activity	Leaves	Alcoholic extract
Anti-plasmodial activity	Leaves	Alcoholic extract
Anti-fertility activity	Leaves	Benzene extract
Anti-fungal activity	Leaves	Essential oil
Anti-helminthic activity	Leaves	Essential oil
Anti-convulsant activity	Stem	Chloroform extract
Eye diseases	Leaves	Leaf juice
Stimulant/expectorant	Leaves	Leaf juice
Piles	Seeds	Fixed oil
Anti-ulcer	Seeds	Fixed oil
Anti-inflammatory activity	Whole plant	Alcoholic extract
Anti-oxidant activity	Whole plant	Alcoholic extract
Anti-tussive	Areal parts	Aqueous extract
Cardio-protective	Whole plant	Fixed oil
Anti-stress	Whole plant	Alcoholic extract

CONCLUSION

Holy basil (*Ocimum sanctum*) contains a number of potentially beneficial phytochemicals with strong anti-tumor effects, including cancer. The treatment of colds, coughs, fevers of all kinds including malaria and dengue, and respiratory conditions like bronchitis, asthma and influenza that spread widely during specific seasons can all be effectively treated with *Ocimum* extracts. Additionally, holy basil extracts have anti-inflammatory, anti-thyroid, anti-cancer, anti-diabetic, anti-oxidant, anti-microbial and anthelmintic properties.

Tulsi juice can treat vascular, heart problems, eye conditions, infections of the mouth and teeth. Additionally, it has radioprotective qualities and the ability to regulate the body's immunity levels. Therefore, research on this holy plant can be justified as having great medical value for the human community. Tulsi extract has antiviral properties that may help treat various viral diseases. Most likely, this review provides a detailed account of holy basil's therapeutic qualities.

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