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HEALTH AND THERAPEUTIC USES OF TULSI (HOLY BASIL)

Shashi Prabha Yadav^a, *Puneet Pathak^a, Anil Kanaujia^b, Aparajita Das^b, Mohan Ji Saxena^b, Anup Kalra^b

a. R&D, Agriliv Research Foundation, Panipat-Gohana NH Road, Chidana, Sonipat, Haryana- 131306, INDIA

b. Head Office, Agriliv Research Foundation, 4th Floor, Sagar Plaza, Laxmi Nagar, New Delhi- 110092, INDIA

*Corresponding author's E-mail: pathakpuneet26aug@gmail.com

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Abstract: The most significant herb in Ayurveda, tulsi (*Ocimum sanctum*), is a member of the Lamiaceae family, and the current review is confirming its therapeutic properties. The chemical composition of tulsi is quite complex, containing a wide range of nutrients and physiologically active compounds like eugenol, urcolic acid, apigenin, caryophyllene, carvacrol, cirsimaritin, estragole, oleanolic acid and rosmarinic acid. *Ocimum sanctum* is also known as the Queen of Herbs because of its numerous health benefits, which include anti-oxidative, antibacterial, antistress, anti-diabetic, anti-cancer, antiepileptic, anti-alzheimer, and insecticidal activity. Tulsi is one of the most significant aromatic herbs frequently employed in the pharmaceutical industry. Medicinal crop cultivation is less hazardous regarding pests, diseases, attacks by wild animals, and price fluctuations, and it can potentially provide profits. Human progress in the pharmaceutical industry is fueling a rapid increase in the value of medicinal plants and their derivatives. Encouraging the cultivation of tulsi can benefit farmers by helping them switch from low-value to high-value, market-oriented crops, raising their standard of life and income, and creating opportunities for entrepreneurship.

Keywords: Adatogenic herb, Alternative crop, Anti-microbial, Anti-oxidant, Tulsi (*Ocimum sanctum*)

Postal Address: R&D, Agriliv Research Foundation, Panipat-Gohana NH Road, Chidana, Sonipat, Haryana- 131306, INDIA

INTRODUCTION

Chronic diseases connected to lifestyle are the leading cause of morbidity and death worldwide. With its emphasis on good lifestyle practises and frequent use of adaptogenic herbs, Ayurveda can effectively treat many of these disorders. Tulsi (*Ocimum sanctum*) belongs to Lamiaceae family is the most important herb in Ayurveda, and modern studies are now verifying its health benefits (Cohen, 2014). Tulsi is considered the queen of herbs, also known as holy basil in english or Tulasi in sanskrit, and comprises various medicinal benefits in herbal drug. In the Indian subcontinent, it has been used from more than 3000 years (Jamshidi and Cohen, 2017). Using tulsi in the right dose singly or combined with other herbs shows a significant health benefit without any harmful reaction. It enhances immunity and improves health conditions and it is extensively grown in warm climates in Asia,

the Middle East, Malaysia, Australia, and Africa. It is used in many traditional medical systems as herbal medicine, cuisine, cosmetics, foods, and religious ceremonies. According to Ayurvedic literature, tulsi is one of the primary foundations of herbal therapy; it was first referenced in the Rig Veda approximately 1500 BC. It represents the Hindu goddess Virinda Tulsi, also known as Vishnupriya, which signifies a worshipper of Vishnu (Bhamra *et al.*, 2022). It is an antipyretic, analgesic, antistress and anti-inflammatory agent that shows anticarcinogenic, anti-asthmatic, and hypolipidemic (lowers cholesterol) with antiemetic properties that reduce the blood sugar and blood pressure levels (Rao *et al.*, 2023; Baliga *et al.*, 2023). Tulsi was utilized as the primary immune booster during COVID-19 to improve the immune system and aid in treating, preventing, and managing COVID-19 infection (Upadhyay

et al., 2022). Patients with diabetes had more significant morbidity and mortality rates during the Novel coronavirus (COVID-19) pandemic. Instead of high doses of drugs to reduce blood sugar, tulsi combined with other herbs is an excellent option to improve immunity and health (Savita et al., 2021).

This genus has over 160 species, widely distributed throughout the world's warm regions. Examples of significant *Ocimum* species that are known to exist and are known to have therapeutic qualities are *Ocimum sanctum* (Rama tulsi or Sri tulsi), *Ocimum gratissimum* (Vana tulsi), *Ocimum canum* (dulal tulsi), *Ocimum tenuiflorum* (Krishna tulsi or Shyam tulsi), *Ocimum basilicum*, *Ocimum killimandscharicum*, *Ocimum Americanum*, *Ocimum camphora*, and *Ocimum miranthum*. Mostly, four varieties of tulsi are used in India. Rama tulsi green leaves have a strong aroma and flavour in tea. Krishna tulsi purple color leaves used in tea and dishes. Vana tulsi's bright green leaves contain a strong spicy flavour that serves as an immunity booster, providing mental and physical stamina with anti-aging properties. Kapoor tulsi has a lemony, sweet flavour and aroma that may be used as insecticides to cure serious illness.

Non-timber forest products (NTFPs) and medicinal and aromatic plants (MAPs) provide an alternate source of income for almost 50 million people in India. According to data, the harvesting and processing of aromatic and medicinal herbs generates at least 35 million working days of employment annually in India. Similarly, there has been a significant rise in the demand for MAPs worldwide. The global demand for aromatic and medicinal herbs is rising at five to fifteen percent yearly. By 2050, the global market for MAPs is expected to grow to USD 5 trillion (Shah et al., 2019).

TULSI AS AN ALTERNATIVE CROP FOR FARMERS

Indian farmers are exploring farming alternatives to secure their livelihoods and increase their income. Medicinal crop cultivation offers potential returns and is less hazardous regarding pests, diseases, wild animal attacks,

and price fluctuations. These crops can be produced as intercrops in orchards or on degraded and marginal soils. One of the most potent herbs, tulsi is used to cure a wide range of illnesses, including those affecting the skin, central nervous system, endocrine, respiratory, and cardiovascular systems.

Tulsi has historically been used to treat a wide range of skin conditions, fever, insect bites, snake bites, malaria, asthma, bronchitis, diabetes, diarrhoea, and eye issues (chronic conjunctivitis, cataracts, and glaucoma) (Bhamra et al., 2022). Tamil Nadu, Gujrat, Rajasthan, M.P., Uttar Pradesh, Haryana, Bihar, and Bengal are tulsi-growing state. Tulsi intercropping with other fruit crops provides more opportunities to use the land and other resources. Both farmers, Nishant Kumar M. Patel of Porda, Petladh, and Shri Neil Saha of Pandori, were encouraged to cultivate medicinal crops under the Central Sector Scheme, funded by the DASD, Calicut, Kerala. Following a year of cultivation, they made a respectable profit. The maximum net return (Rs. 59,201/ha/year) was achieved when lime was intercropped. Conversely, the solo crop yielded the lowest net return (Rs. 32,095) (ICAR). Tulsi is an aromatic medicinal plant, and the demand for tulsi is much higher because of its different medicinal benefits. It can be an easy and cost-effective cultivable plant without extensive hard work and pesticide requirements. Cultivation of tulsi with different crops like cereals, rice, wheat, etc. may play a significant role in the value chain development of intercropping and also overcome the fear of crop production failure.

CULTIVATION CLIMATE AND SOIL CONDITION

This annual plant is 30–60 cm tall (Verma et al. 2016), heavily branched, with a typically purplish or brown stem and sub-quadrangular branches. Its leaves are 2.5–5 cm by 1.6–3.2 cm, elliptic, oblong, and obtuse, hairy on both sides, and minutely gland-dotted. Tulsi belongs to Order Lamiales and Family Laminaceae. Tulsi plant grows well in soils that range from rich loam to poor laterite, saline and alkaline to somewhat acidic. pH 5.5-6.5 and a temperature minimum

of 17°C and a maximum of 39.2°C are suitable conditions for growth (Monga et al. 2017).



Figure 1 (a) Tulsi Plant

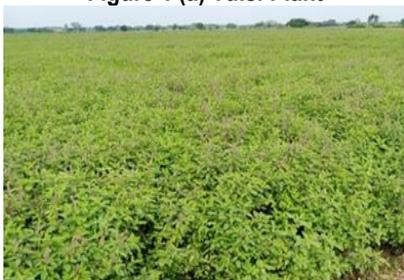


Figure 1 (b) Cultivation of Tulsi as Medicinal crop

Soil that drains well promotes healthier vegetative growth. The waterlogged field might lead to root rot and stunted growth. Low oil-content plants can be grown in partially shaded environments. It grows best in humid climates with a considerable amount of rainfall. Long days and high temperatures have been found to benefit plant development and oil production. It can be grown in a tropical and subtropical climate up to 900 meters above sea level. The moisture content of the soil determines whether to irrigate. During the summer, three monthly irrigations are needed and irrigation is not needed during the rainy season. Throughout the year, 12 to 15 irrigations are sufficient. Generally, the cost of dry tulsi leaves is between INR 50 and 80 per kg. An acre farming cost of tulsi is between INR 28,000 and 30,000 covering labor, irrigation, fertilizers, insecticides, seeds, and seedlings. After planting, the first harvest is completed about 90 days later, and then cuttings are taken every 75 days after that. Farmers offer

essential oils that are extracted from tulsi leaves in addition to dry leaves. An acre of tulsi farming yields 20–25 quintals of dry leaves per acre. The total income might be somewhere between INR 1.5 and 2 lakhs and INR 3 lakhs from tulsi farming in three months when you combine the sales of dried tulsi leaves and essential oils (Times of Agriculture).

Cultivating medicinal plants without adding chemical fertilizers and pesticides is also essential to keep plants chemical-free. Tulsi can be grown without chemical fertilizers or pesticides because it is not susceptible to any significant diseases or pests. In case of disease, organic manures such as farm yard manure (FYM), vermi-compost, green manure, etc., may be utilized. Bio-pesticides (single or combination) from neem (kernel, seeds, and leaves), chitrakmool, dhatura, cow urine, etc., could be made to stop infections. When the crop matures, it is harvested. After 90 to 95 days of planting, the first crop is received. After that, it can be harvested every 65 to 75 days. Harvesting is often done on bright, sunny days for optimal oil yield and quality. If there was rain the day before, harvesting the crop is not ideal (Tnau Agritech). Products made of tulsi or raw material in dry forms have good market value and may be obtained by farmers for agricultural purposes, which are more sustainable and reliable than other crops.

PHYTOCHEMICAL CONSTITUENTS OF TULSI

Tulsi has a very complex chemical makeup that includes numerous nutrients and substances that are biologically active. The standardization of Tulsi's active ingredient is a highly intricate process because of its botanical origins and intrinsic biochemical complexity. Phytochemical present in tulsi is shown in Table 1.

Table 1: Phytochemical Constituents of Tulsi

S.No.	Compound Name	Chemical Formula	PubChem CID	Reference
1	Eugenol	C ₁₀ H ₁₂ O ₂	3314	Hasan <i>et al.</i> , 2023 & Bhattacharjya <i>et al.</i> , 2019
2	Ursolic acid	C ₃₀ H ₄₈ O ₃	64945	
3	Apigenin	C ₁₅ H ₁₀ O ₅	5280443	
4	Caryophyllene	C ₁₅ H ₂₄	5281515	
5	Carvacrol	C ₁₀ H ₁₄ O	10364	

6	Cirsimaritin	C ₁₇ H ₁₄ O ₆	188323
7	Estragole	C ₁₀ H ₁₂ O	8815
8	Linalool	C ₁₀ H ₁₈ O	6549
9	Oleanolic acid	C ₃₀ H ₄₈ O ₃	10494
10	Rosemarinic acid	C ₁₈ H ₁₆ O ₈	5315615

NUTRITIONAL CONSTITUENTS OF TULSI

Tulsi's nutritional contents vary slightly throughout its several varieties. Based on *Ocimum gratissimum* species tulsi contains energy 94 kilocalories, 2.65 g of carbohydrates, 11.4 mg choline, 1.6 gram of dietary fibre, 18 mg vitamin C, 3.15 g protein, 414.8 µg vitamin K, 0.8 mg vitamin E, 0.64g fat, 92.06 g of water,

177 mg of calcium, 264 µg of vitamin A, 3.17 mg of iron and 3142 µg of β-carotene 64 mg of magnesium, 0.034 mg of thiamine, 1.148 mg of manganese, 0.076 mg of riboflavin, 56 mg of phosphorus, 0.902 mg of niacin, 295 mg of potassium, 0.209 mg of pantothenic acid, and 4 mg of sodium 0.81 mg Zinc, 0.155 mg vitamin B6, and folate 68 µg. (Monga et al., 2017). Nutritional constituents in tulsi extract is shown in Table 2.

Table 2: Nutritional constituents of tulsi extract (Raghav et al., 2018)

Nutritional Composition	Nutrient Value	%age of RDA
Energy	23 Kcal	1%
Carbohydrates	2.65 g	2%
Protein	3.15 g	6%
Total Fat	0.64 g	2%
Cholesterol	0 mg	0%
Dietary Fibre	1.60 g	4%
Vitamins		
Folates	68 µg	17%
Niacin	0.902 mg	6%
Pantothenic acid	0.209 mg	4%
Pyridoxine	0.155 mg	12%
Riboflavin	0.076 mg	6%
Thiamin	0.034 mg	2.5%
Vitamin A	5275 IU	175%
Vitamin C	18 mg	30%
Vitamin E	0.80 mg	5%
Vitamin K	414.8 µg	345%
Electrolytes		
Sodium	4 mg	0%
Potassium	295 mg	6%
Minerals		
Calcium	177 mg	18%
Copper	385 mg	43%
Iron	3.17 mg	40%
Magnesium	64 mg	16%
Manganese	1.15 mg	57 %
Zinc	0.81 mg	7 %
Phyto-nutrients		
Carotene-β	3142 µg	--
Crypto-xanthin- β	46 µg	--
Lutein-zeaxanthin	5650 µg	--

USES OF TULSI

As a Seasoning: Because of its sweet and minty flavor, Tulsi is an excellent herb for garnishing dishes, sauces, and soups. It is

frequently cooked for flavor and scent and is a mainstay in Thai and Indian cuisines.

As a Tea: In India, people often drink tulsi tea instead of coffee. It has several health benefits and is simple to produce. It's an excellent

method to strengthen your immune system and start the day. Tulsi's anti-oxidant properties aid in the body's detoxification by eliminating pollutants and free radicals. Tulsi regulates the body's metabolism and aids in absorbing vital nutrients. It strengthens the digestive system because it is a digestant. It provides no calories and increases endurance. Compared to green tea, tulsi has a stronger growth inhibitory effect. According to electrochemical studies, tulsi inhibited development in acidic circumstances more effectively than green tea (Chowdhury et al., 2023).

As a Supplement: Dried Tulsi is available as capsules, making it a practical alternative in disliking of flavour or basil aroma. Fermented choices, according to some authorities, facilitate easier digestion. The tulsi leaf and stem are excellent sources of macro and micronutrients for the body's metabolic processes (Mannan et al., 2019).

As an Essential Oil: The Tulsi plant contains essential oil used in lotions, soaps, perfumes, shampoos, and conditioners. It can be diffused in house or inhaled, and it has relaxing and immune-boosting qualities. Eugenol, eucalyptol, and camphor were probably present in tulsi oil. Smaller levels of β -caryophyllene may have also contributed to the oil's antibacterial properties. Tulsi essential oil may prove to be an effective topical antibacterial agent in treating skin infections resulting from *S. aureus*, *P. aeruginosa*, and *E. coli*. It may also be useful as a wound dressing to prevent infection. (Yamani et al., 2016)

To Combat Illnesses: Tulsi is widely known for its capacity to boost immunity and fend off various illnesses. Its anti-microbial properties alleviate cold symptoms and lower acidity by maintaining the stomach's pH equilibrium. Several phytochemicals found in tulsi have also been connected to a lower cancer risk.

Sipping Water Infused with Tulsi Leaves: One of the best ways to benefit from this plant is to sip water infused with Tulsi leaves in morning.

As an Eye Care Product: Because of pollution, eyes are more susceptible to dust, which can lead to many problems associated with the eyes. Tulsi relieves tension and has a calming impact on the eyes. It shields the eyes from a

variety of conditions related to the eyes, such as conjunctivitis and boils (Bhamra et al., 2022).

Mouth and teeth infection: Oral infections and ulcers respond well to the leaves' therapeutic properties. Chewing a few leaves can help with several health issues. The plant is helpful for dental problems. After being ground and drying in the sun, the leaves can be used to clean teeth. It can also be used to make a paste that can be used as dental paste, together with collected oil. This is a great way to preserve dental health, avoid bad breath, and massage the gums. It also relieves pyorrhea and other dental problems (Rao et al., 2023). The greatest amounts of secondary metabolites present in these plants have the potential to generate anti-microbial agents against oral germs, which can be used in toothpaste, mouthwash, and other products to prevent and treat oral infections, as demonstrated by tulsi's effects on oral flora (Lolayekar et al., 2019).

Skin disorder and care: Using local tulsi leaf extract helps treat ringworm and other skin disorders. Tulsi has also been effectively used to treat leucoderma, a skin condition, and has proven highly beneficial (Chandra et al., 2016).

PHARMACOLOGICAL ACTIVITY

Tulsi also known as the 'Elixir of life' composing different pharmacological benefits such as anti-microbial, anti-cancer, antistress anti-alzheimer's, anti-oxidant, anti-epileptic, antidiabetic and insecticidal activity shown in Figure 2.

Anti-microbial Activity: Medicinal plant extracts are a natural source of anti-microbials that are safer than synthetic drugs, more readily available in local communities, and capable of providing significant therapeutic advantages at a lower cost. In addition, medicinal plant extracts could be a helpful substitute therapy to allopathic medicine, reducing the severity of adverse side effects, adulteration and medication resistance (Vaou et al., 2021). Leaf extracts or oil of *Ocimum sanctum* show significant anti-microbial activity against different pathogenic bacteria due to different chemical constituents like eugenol, terpenoids,

urosolic acid, linoleic acid, etc. It is reported that *Ocimum sanctum* methanolic extract showed effective anti-microbial activity (0.4 g/ml) against *E. coli* and, when mixed with tulsi extract, becomes more efficient (0.2 g/ml) against *E. coli* as well as *Staphylococcus aureus* (Kumar et al., 2018). Similarly, *Ocimum sanctum* L. extract has the highest antibacterial activity at 2.5 percent (25 mg/ml) and 10 percent (100 mg/ml) against *Lactobacillus acidophilus* and *Streptococcus mutans*, respectively (Gadiyar et al., 2017). *Ocimum americanum*, *Ocimum basilicum*, and *Ocimum sanctum* exhibited the highest inhibition zone against *S. aureus* among Gram-positive bacteria. In contrast, *Ocimum gratissimum* demonstrated the highest inhibition zone against *E. faecalis* and *Ocimum campechianum* demonstrated the most potent inhibition against *L. ivanovii*. Also, *Ocimum americanum* shown the largest inhibition zone against *P. gingivalis* and *P. intermedia* among Gram-negative bacteria, followed by *Ocimum*

basilicum against *P. aeruginosa*, *Ocimum gratissimum* against *P. mirabilis*, *Ocimum campechianum* against *E. coli*, and *Ocimum sanctum* against *Yersinia enterocolitica* (Dharsono et al., 2022). An analysis was conducted on the immunotherapeutic potential of an aqueous holy basil leaf extract in bovine sub-clinical mastitis. The outcomes showed that the aqueous extract treatment raised the numbers of neutrophils and lymphocytes with improved phagocytic activity while lowering the total bacterial count (Almatroodi et al., 2020). *Ocimum tenuiflorum* extract with 70% ethanol also found to be effective against *Staphylococcus aureus* and *Staphylococcus agalactiae* in case of mastitis disease in cows (Srichok et al., 2022). Consumption of tulsi in different forms like in tea, leaf extract and powder, may boost our immune system, gut health and provide a healthy lifestyle, increase the fighting efficiency against the different harmful pathogenic microorganisms.

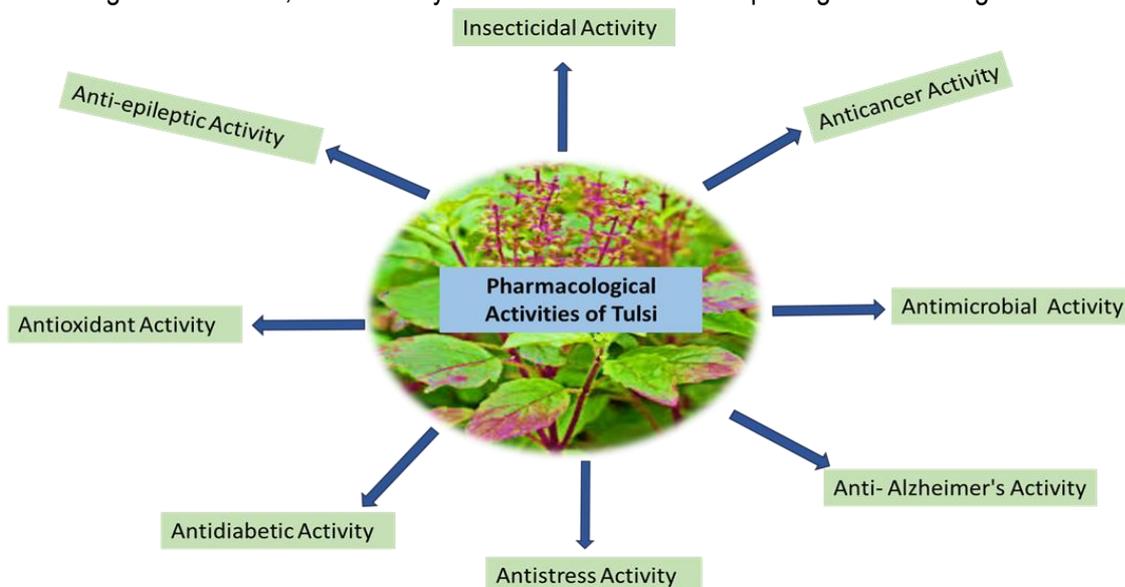


Figure 2: Different Pharmacological activities of tulsi (*Ocimum sanctum*)

Anti-Cancer Activity: Cancer is an irregular proliferation of cells that initiates with a gene mutation that alters cellular function, disrupts cellular interactions and relations, and then leads to oncogene generation. It can be inherited or acquired. Chemotherapy is the most frequently used therapeutic option to treat cancer. However, it also destroys many healthy cells and causes undesirable drug-resistance effects (Perna et al., 2022). Ayurveda uses a

variety of plants that may include antitumor and anti-cancer effects. *Ocimum sanctum* ethanolic extract has been shown to significantly reduce tumor cell growth and lengthen the survival of mice with solid Sarcoma-180 tumors (Verma, 2016). Tulsi contains phenolics and flavonoids, such as neo-lignans, as well as tannins, triterpenoids, sterols, alkaloids, and saponin most of which are well-known for their biological effects both in vivo and in vitro. These effects

include cytotoxic, antiviral, hepatoprotective, anti-inflammatory, anti-cancer. *Ocimum sanctum* contains eugenol which is an anti-cancer agent by several pathways it reduces the tendency to cancer are described below in points.

- Skin cancer- downregulate the BCL-2 and upregulate p53 and caspase 3.
- Breast cancer: Downregulate the NF-kB and cyclin D1 and upregulate cyclic-dependent kinase inhibitor p21.
- Lung cancer: Downregulate COX-2, P13K/Akt pathway and upregulate p65.
- Gastric Ulcer: Downregulate cyclin D1 cyclin-B & BCL-2 and upregulate IκBα, p21 p53, caspase 3 & 9.
- Osteocarcinoma: Downregulate DFF-45 and upregulate p53 and caspase 3.
- Colorectal cancer: Downregulate KRAS pathway and upregulate p53 & APC.

It has been demonstrated that tulsi leaves contain high eugenol concentrations and have anti-cancer qualities. Eugenol exerts its antitumor effects in various cancers by several mechanisms (Hasan et al., 2023). Oleanolic acid from the ethanolic leaf extract of *O. gratissimum* repressed human breast carcinoma, prostate adenocarcinoma, lung carcinoma, colon adenocarcinoma, pancreatic carcinoma, and renal carcinoma, while 3, 4-dihydroxycinnamic acid from *O. gratissimum* suppressed HeLa cervical cell line also reported (Ohiagu et al., 2021). Tulsi may be a potential medicinal plant that can suppress the carcinogenic activity in the human body if incorporated into our daily lifestyle.

Antistress Activity: Stress is a natural response to life's challenges; it can turn harmful when it interferes with daily activities. Stress causes modifications to almost every physiological system, which affects how people feel and act. Stress directly leads to psychological and physiological disorders and diseases, altering both physical and mental health and lowering quality of life through mind-body alterations (American Psychological Association). Lack of neurotransmitters like dopamine, norepinephrine, and serotonin causes stress reactions. To control stress

nowadays public comes around different drugs, alcohol addiction, smoking and medication but all of has different side effects and a short-term effect lead to overdose of drugs. In Ayurveda, several medicinal plants used to reduce stress naturally one of them is tulsi, which activates the serotonin level in the brain and gives calming effect to the mind. There are different types of stress and through several activities, tulsi may reduce its tendency and act as a booster.

a. Toxicant Stress

Experimental research has demonstrated that Tulsi can avert the harmful effects that lead to immunological, cellular, and genetic damage due to radiation, heavy metals, and chemicals. It reduces oxidative cellular and chromosomal damage amplified by radiation and eliminates free radicals (Bhooshitha et al., 2020).

b. Physical & Metabolic Stress

Extended physical effort, physical limitation, exposure to low temperatures, and loud noises disrupt the balance of the body by causing stress on the metabolism and physiology. Modern lifestyles are marked by metabolic stress caused by poor food, inactivity, and psychological stress. This condition is known as metabolic syndrome, and it is thought to impact up to one-third of the population. The deadly quartet of centripetal obesity, hypertension, high cholesterol, and impaired glucose regulation comprise metabolic syndrome, sometimes referred to as prediabetes or Syndrome X. It is linked to chronic inflammation and an increased risk of diabetes, heart disease, and stroke. Adaptogenic herbs, like tulsi, strengthen physiological and cellular adaptive mechanisms to guard against this harm. Research has demonstrated that tulsi can enhance lipid profiles, avert weight gain, hyperglycemia, hyperinsulinemia, hypertriglyceridemia, and insulin resistance, as well as shield the blood vessels and organs against atherosclerosis in experimental animals given high-fat diets (Cohen et al., 2014 & Jamshidi et al., 2017).

Anti-Alzheimer's Activity: Three components of mental talents are mentioned in Ayurveda: Dhi (acquisition/learning process), Dhuti (retention process), and Smriti (process of recall). Dementia is defined as a malfunction in

the acquisition/learning, retention, or recall processes. Approximately 40 million senior people worldwide have dementia. There are an estimated 3.7 million older persons in India who have dementia; by 2030, the frequency is forecast to double, and by 2050, it is predicted to triple. Alzheimer's disease and other neurodegenerative diseases are linked to dementia. Progressive memory loss, linguistic impairments, agitation, depression, mood swings, and psychosis are its defining characteristics (Mehla et al., 2020). Tulsi's efficacy in treating Alzheimer's disease was assessed in models of neurotoxins such as colchicine and isobotenic acid. A structural equivalent of glutamate, isopentenic acid excitotoxically stimulates glutamate receptors, leading to neuronal necrosis. Injections of isophthalic acid reduce the body's capacity to learn and remember spatial information. Therefore, holy basil stimulates acetylcholine (ACh) neurotransmission, which is in charge of memory function, by inhibiting the acetylcholinesterase enzyme, which degrades acetylcholine in the brain. As a result, tulsi improves memory and cognitive function by making more acetylcholine available in the brain. The main active ingredient in *O. basilicum* that gives tulsi its medicinal properties is eugenol. Furthermore, ischemia reperfusion-enhanced oxidative stress and chronic hypoperfusion-enhanced cognitive impairment in rodents have both been statistically reduced by the standardised extract of *Ocimum sanctum* (Bhooshitha et al., 2020).

Anti-oxidant Activity: Free radicals are unstable molecules that the body produces in response to external and internal stresses. Anti-oxidants are compounds that can stop or lessen the damage that free radicals do to cells. Free-radical scavengers is another term for them. Anti-oxidants can originate from synthetic or natural sources (Saravanan and Ramamurthy, 2021). Anti-oxidant are present in both the extract and oil of tulsi. In male albino rabbits, the aqueous tulsi extract inhibits the erythrocyte lipid peroxidation activity produced by hypercholesterolemia in a dose-dependent manner. Oral eating significantly protects the liver and aorta against peroxidative damage

brought on by hypercholesterolemia (Raghav and Saini, 2018). Similarly, it is found that *Ocimum sanctum* leaves extract has great anti-oxidant capacity and high phenolic and flavonoid content could be extracted using n-butanol and ethyl acetate solvents. Using *Ocimum sanctum* extracted anti-oxidant in spite of synthetic anti-oxidant in the food industry can reduce human health risk (Chaudhary et al., 2020).

Anti-diabetic Activity: Diabetes mellitus (DM) is a complicated metabolic illness that seriously harms people. *O. sanctum* possesses anti-microbial, anti-oxidant, and anti-inflammatory characteristics that protect human health and could be useful in treating metabolic diseases and diabetes (Islam, 2022). In streptozotocin STZ-induced DM rats, treatment with the fixed oil derived from tulsi leaves for three weeks markedly increased serum insulin levels while lowering the diabetically raised blood glucose levels and serum lipid profile. Through the suppression of elevated thiobarbituric acid reactive substances (TBARS) levels and the enhancement of the activity of many antioxidative enzymes in the rat kidney tissue, the *O. sanctum* fixed oil demonstrated a free radical scavenging action that protected the kidneys against diabetic kidney disease. Studies on histology revealed that the tulsi fixed oil shielded the renal tissues of rats from diabetic mellitus (Suanarunsawat et al., 2016). It is also reported that with 69 percent inhibition in acetone extracts, green tulsi exhibited the highest level of anti-diabetic action, followed by jungli tulsi (67 percent inhibition) and black tulsi (61 percent inhibition). All three *Ocimum* species exhibited nearly identical levels of anti-diabetic efficacy in acetone and methanol extracts. Likewise, 40–50% anti-diabetic activity was observed in the hexane extract of *O. sanctum* and 50 percent anti-diabetic activities in the hydroalcoholic extract of *O. tenuiflorum*. These findings corroborate earlier studies that show how medicinal plant extracts suppress α -amylase activity. Tulsi extracts may have hypoglycemic potential because they include phenolics and flavonoids (Sharma et al., 2022).

Anti-epileptic Activity: About 50 million people worldwide have epilepsy, a chronic, noncommunicable brain condition. Recurrent

seizures are brief periods of uncontrollable movement that can affect the whole body (generalised) or only a portion of it. It can also occasionally be followed by loss of consciousness and control over bladder or bowel movements. Excessive electrical discharges in a cluster of brain cells cause seizure episodes. Such discharges can occur in several brain regions. From the smallest attention-deficit or muscular twitches to severe and protracted convulsions, seizures can take many different forms. The frequency of seizures can also differ, ranging from fewer than one per year to multiple per day (WHO). Using the maximum electroshock (MES) model, several extractives of the *Ocimum sanctum* stem, leaf, and stem callus were evaluated for their anticonvulsant potential versus the conventional medication phenytoin. Transcorneal electroshock-induced tonic convulsions were effectively prevented by ethanol and chloroform extractives of the stem, leaf, and stem calli (Triveni et al., 2013).

Insecticidal Activity: Essential oils are highly volatile, complex secondary metabolites with diverse biological functions. Its safe and successful application has led to a renewed focus on its use as a biopesticide in recent years. The essential oil obtained from holy basil (*Ocimum sanctum* Linn.) also shows remarkable activity as botanical pesticides (Zabka et al., 2021). Eugenol and caryophyllene, two of the main ingredients in *O. tenuiflorum* oil, shown insecticidal efficacy by blocking acetylcholinesterase activity, and potential to be used as a botanical pesticide (Bhavya et al., 2018). *O. sanctum* var. *cubensis*'s essential oil has the chemical components to affect *Musca domestica* at every stage of its life cycle without negatively affecting the environment, an efficient insecticide against this species (Chil et al., 2020). Similarly, essential oil from *Ocimum sanctum* is reported as an effective insecticide against mosquitoes (Anzaku et al., 2021). Additionally, the ability of Tulsi essential oil to repel *Rhyzopertha dominica* and *Tribolium castaneum*, two pests of stored grain, was studied (Rashmi and Neeta, 2018).

CHALLENGES, FUTURE PROSPECTIVE AND CONCLUSION

Tulsi plants are highly vulnerable to frost. Soil logged with water can lead to root rot and inhibit growth of plants. The tulsi plant thrives in humid, quite heavy rainfall environments are some challenges in tulsi plantations. Regular care and observation by farmers easily overcome these challenges. Understanding climate and the correct timings of tulsi cultivation also help the farmer grow a healthy crop. With human progress in the pharmaceutical sectors, the value of medicinal plants and their derivatives is increasing rapidly. These plants may contain biomolecules essential to modern medicine's efforts to treat conditions including cancer, diabetes, and hypertension. A reputation for having fewer side effects contributes to the growing demand for therapeutic herbs. They are also considered an affordable way to create novel, ground-breaking medications. In comparison to traditional crops, medicinal plants have the potential to provide a substantial profit for farmers due to the expanding global demand for them. The program encourages Small farmers to switch from low-value crops and grains to high-value aromatic and medicinal plants in the planted area. Because these high-value plants demand less inputs, farmers can take a higher revenue and their production can be in harmony with the environment. Tulsi (*Ocimum sanctum*) with other herbs like Ashwagandha, Mentha, Lemon grass, Kalmegh, Akarkara, black cumin and turmeric among the MAP (medicinal and aromatic plants) crops have been given priority. Promoting tulsi farming may help farmers economically sustainable by transitioning from low-value crops to high-value, market-oriented ones, improving living standards and income, and opening up markets for entrepreneurship.

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