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The Sacred Basil *Ocimum sanctum* L. An Ethnomedicinal Plant with Broad Therapeutic Potential

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Abstract

Ocimum sanctum L., also known as *Ocimum tenuiflorum* or Tulsi, is a well-known medicinal plant valued for its wide range of health benefits in both traditional and modern medicine. It has long been associated with helping the body cope with various physical and environmental stressors that can contribute to disease. As our understanding of stress and its effects on the body has grown, especially its role in causing imbalance and disease, the importance of Tulsi as a medicinal plant has become clearer.

The diverse pharmacological effects of *O. sanctum* are largely due to its rich phytochemical composition, which includes compounds such as eugenol, ursolic acid, rosmarinic acid, apigenin, and other flavonoids. These bioactive compounds act on multiple systems in the body, helping to reduce inflammation, enhance antioxidant defenses, regulate immune responses, and support neuroendocrine function.

Tulsi has been reported to exhibit a wide range of therapeutic activities, including antimicrobial, antidiabetic, cardioprotective, hepatoprotective, neuroprotective, anticancer, and radioprotective effects. Most of the research so far comes from experimental studies, but increasing clinical evidence also suggests that Tulsi has real therapeutic benefits. It supports overall balance in the body by improving metabolism, reducing oxidative stress, and helping the body better cope with stress.

This chapter presents a comprehensive overview of the ethnomedicinal importance, phytochemical composition, mechanisms of action, and therapeutic applications of *O. sanctum*. It also highlights existing research gaps and discusses future possibilities for integrating Tulsi into evidence-based healthcare. Overall, Tulsi emerges as a multi-targeted medicinal plant with significant potential for promoting holistic health and resilience.

Introduction

Ocimum sanctum (Tulsi) has long been valued in traditional medicine, especially Ayurveda, for its role in promoting overall health. It has been regarded as a plant that promotes longevity, vitality, and systemic balance. Its widespread use across different regions reflects its value in managing various health conditions. In recent years, scientific research has increasingly aimed to confirm these traditional uses through experimental and clinical studies.

Research now clearly shows stress plays a central role in the initiation and progression of many diseases. It can arise from physical strain, environmental exposure, infections, or psychological challenges. These stressors disturb physiological homeostasis and contribute to the development of oxidative stress, chronic inflammation, immune dysregulation, and metabolic imbalance (Selye, 1956; McEwen, 2004; Juster et al., 2010). Such effects are now linked to many diseases like cardiovascular diseases, diabetes, neurodegenerative conditions, and immune-related pathologies.

In this context, *O. sanctum* is significant due to its ability to influence multiple biological systems simultaneously. It is often described as an adaptogen, meaning it helps the body cope with stress and maintain internal equilibrium (Singh et al., 2002; Singh and Abbas 2006; Singh et al., 2002a; 2002b). The therapeutic potential of Tulsi is largely attributed to its rich and diverse phytochemical composition, which includes phenolic compounds, flavonoids, terpenoids, and essential oils. These constituents exhibit a range of biological activities, such as antioxidant, anti-inflammatory, antimicrobial, and immunomodulatory effects (Kelm et al., 2000; Pattanayak et al., 2010; Cohen, 2014).

Studies have shown that *O. sanctum* can support the body in several ways, such as reducing oxidative damage, controlling inflammation, strengthening immune responses, and maintaining neuroendocrine balance (Bhargava & Singh, 1981; Mondal et al., 2009; Jamshidi & Cohen, 2017). These multi-targeted actions provide a mechanistic basis for its broad therapeutic applications. However, despite extensive preclinical evidence, there remains a need for more well-designed clinical studies to establish its efficacy and safety in humans. Recent advances in molecular pharmacology have further strengthened the scientific basis of *Ocimum sanctum*. Emerging studies suggest that its bioactive constituents interact with key regulatory pathways involved in oxidative stress, inflammation, and immune modulation,

thereby supporting its role as a multi-targeted therapeutic agent. These findings have expanded its relevance in modern biomedical research, particularly in the context of chronic and stress-related disorders (Yadav et al., 2024; Kumar & Sarkar, 2023).

The present chapter aims to provide a comprehensive and integrated overview of *O. sanctum*, focusing on its ethnomedicinal significance, phytochemical profile, mechanistic pathways, and therapeutic applications. In addition, it critically examines the current limitations in research and highlights future directions for the scientific and clinical utilization of this important medicinal plant.

Botanical Description and Taxonomy

Ocimum sanctum L., also known as *Ocimum tenuiflorum* or Tulsi, belongs to the Lamiaceae family, which includes many aromatic plants with medicinal value. The genus *Ocimum* contains several species that are widely found in tropical and subtropical regions, many of which are known for their essential oils and therapeutic properties. Among them, *O. sanctum* is one of the most widely used species in traditional medicine because of its diverse biological activities.

From a taxonomic perspective, *O. sanctum* is classified under Kingdom Plantae, Division Angiosperms, Class Eudicots, Order Lamiales, Family Lamiaceae, Genus *Ocimum*, and Species *O. sanctum*. In the Indian subcontinent, it is commonly known as Tulsi and is generally grouped into two main types based on visible characteristics and chemical composition. These include Rama Tulsi, which has green leaves, and Krishna Tulsi, which is characterized by purplish leaves and stems. Both types are used medicinally, although slight differences in their chemical composition and therapeutic effects have been observed.

Morphologically, *O. sanctum* is a small, upright, and aromatic shrub that usually grows between 30 and 60 cm tall. Its stems are square-shaped and often slightly hairy, which is typical of plants in the Lamiaceae family. The leaves are simple, arranged opposite each other, oval in shape, and have serrated edges. They give off a strong characteristic aroma due to the presence of essential oils. The plant reproduces through white or purplish flowers arranged in clusters, and its tiny seeds are capable of surviving in different environmental conditions.

O. sanctum is widely distributed across India and other parts of Asia, as well as in Africa and other tropical regions. It grows well in different climatic conditions but prefers warm and moderately humid environments. Tulsi is commonly grown in home gardens, temples premises, and agricultural fields, reflecting both its medicinal value and cultural significance. Its adaptability to different environments contributes to its widespread availability and use.

Environmental factors such as soil type, climate, and cultivation practices can influence the chemical composition of *O. sanctum*. Differences in essential oil content and the levels of active compounds have been observed depending on the

region and harvesting conditions (Pattanayak et al., 2010; Mondal et al., 2009). These variations are important when considering the standardization and consistent use of the plant for therapeutic purposes.

Overall, the botanical features and adaptability of *O. sanctum* support its continued use as an accessible medicinal plant, while also emphasizing the importance of standardized cultivation and processing methods to ensure consistent quality and effectiveness.

Phytochemical Composition

The wide range of therapeutic effects of *Ocimum sanctum* is largely due to its rich and diverse phytochemical composition. The plant contains numerous bioactive compounds belonging to different chemical groups, such as phenolics, flavonoids, terpenoids, and essential oils. These compounds are responsible for its antioxidant, anti-inflammatory, antimicrobial, and immunomodulatory properties, which together contribute to its broad pharmacological profile.

One of the most important compounds found in *O. sanctum* is eugenol, a phenolic compound known for its anti-inflammatory and pain-relieving effects. Rosmarinic acid is an important compound known for its strong antioxidant activity and ability to neutralize reactive oxygen species. Ursolic acid, a triterpenoid, known for its anti-inflammatory, anticancer, and hepatoprotective effects. Flavonoids such as apigenin and luteolin help regulating cell signaling pathways and protecting cells from oxidative damage (Kelm et al., 2000; Pattanayak et al., 2010; Cohen, 2014).

The essential oil fraction of *O. sanctum* is particularly significant for its biological activity. It includes compounds such as eugenol, methyl eugenol, linalool, and β-caryophyllene, which have antimicrobial, antifungal, and anti-inflammatory properties. These volatile compounds also give the plant its characteristic aroma and have been widely studied for their ability to inhibit the growth of pathogenic microorganisms (Prakash & Gupta, 2005; Chanda & Baravalia, 2010).

In addition to these major constituents, *O. sanctum* contains other secondary metabolites such as tannins, saponins, and alkaloids, which further contribute to its therapeutic effects. These compounds are involved in various biological processes, including free radical scavenging, enzyme regulation, and stabilization of cellular structures. The combined action of these phytochemicals is believed to play a key role in the plant's multi-targeted therapeutic effects.

It is important to note that the phytochemical composition of *O. sanctum* can vary depending on factors such as geographical location, climate, soil conditions, harvesting time, and extraction methods. Differences in the levels of active compounds have been reported across studies, which may affect the consistency and reproducibility of its therapeutic effects (Mondal et al., 2009; Pattanayak et al., 2010). This highlights the importance of standardizing plant materials and extraction techniques to ensure consistent quality and efficacy.

Overall, the complex phytochemical profile of *O. sanctum* provides a strong scientific basis for its wide range of pharmacological activities. The presence of multiple bioactive compounds acting through different mechanisms supports its classification as a multi-targeted medicinal plant with significant potential in managing various health conditions.

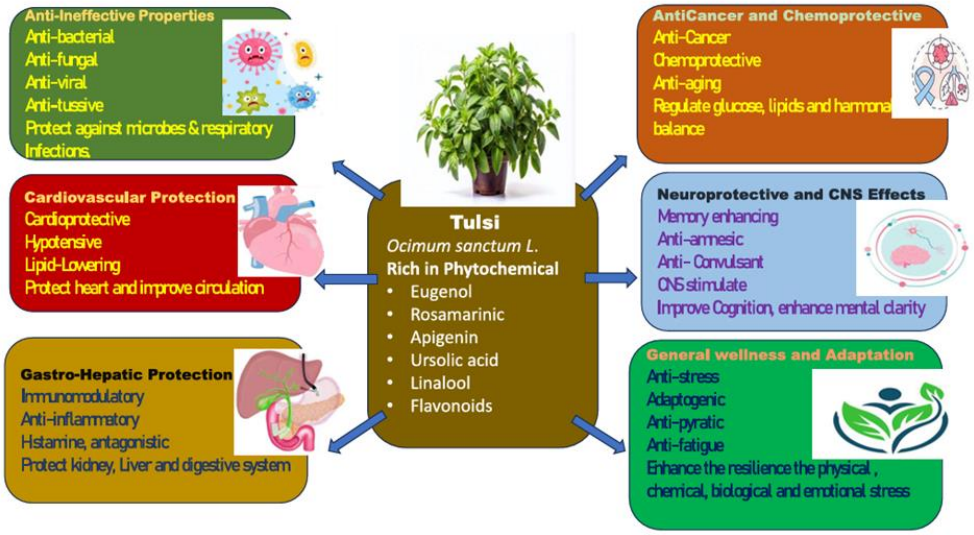


Figure 1

The Figure 1 illustrates the diverse therapeutic properties of *Ocimum sanctum* (Tulsi), highlighting its rich phytochemical composition such as eugenol, rosmarinic acid, and flavonoids. It demonstrates multiple biological activities, including antimicrobial, anti-cancer, cardioprotective, and neuroprotective effects. The diagram also emphasizes its role in gastrointestinal, hepatic, and immune system support. Overall, Tulsi is presented as a multifunctional medicinal plant that enhances stress resilience and promotes overall health and well-being.

Table 1 presents a comprehensive overview of the major phytochemical constituents of *Ocimum sanctum*, highlighting its chemical diversity across different groups such as phenolics, flavonoids, terpenoids, and essential oils. It shows that Tulsi contains a wide range of bioactive compounds, including eugenol, rosmarinic acid, and ursolic acid, which are associated with important therapeutic effects. The presence of both primary and secondary metabolites reflects its multifunctional role in antioxidant defense, regulation of inflammation, and cellular protection. Overall, the table shows that *O. sanctum* is a chemically complex, multi-targeted medicinal plant with broad pharmacological relevance.

Table 1. Major Phytochemical Classes Identified in Ocimum sanctum

Class	**Sub-class / Chemical Group**	**Representative Compounds**	**Key References**
Volatile Oils / Essential Oils	Phenylpropanoids, Monoterpenes, Sesquiterpenes	Eugenol, Methyl eugenol, Linalool, β-caryophyllene	Kelm et al., 2000; Prakash and Gupta, 2005
Phenolics	Hydroxycinnamic acids	Rosmarinic acid, Caffeic acid	Cohen, 2014; Bhattarai et al., 2024
Flavonoids	Flavones, Flavonols	Apigenin, Luteolin, Orientin, Vicenin	Pattanayak et al., 2010
Triterpenoids	Ursane-type compounds	Ursolic acid, Oleanolic acid	Hasan et al., 2023
Fatty Acids	Saturated and Unsaturated	Palmitic acid, Linoleic acid, Oleic acid	Mondal et al., 2009
Sterols	Phytosterols	β-sitosterol, Campesterol	Samanth, 2025; Yadav et al., 2024
Coumarins	Hydroxycoumarins	Esculetin, Esculin	Bhattarai et al., 2024
Other Secondary Metabolites	Alkaloids, Saponins, Tannins	Various compounds	Samanth, 2025

Conceptual Framework: Stress and Disease Link

The link between stress and disease has become a key focus in modern biomedical research. Stress is now understood not only as a psychological condition but also as a physiological response that affects multiple organ systems. It can arise from various sources, including physical strain, exposure to environmental toxins, infections, and emotional disturbances (Singh et al., 2002, Abbas and Singh 2006). When stress becomes persistent, it disrupts internal homeostasis and triggers a series of biochemical and cellular changes that contribute to disease development (Selye, 1956; McEwen, 2004).

One of the major outcomes of chronic stress is the increased production of reactive oxygen species, which leads to oxidative stress. This imbalance can damage important cellular components such as lipids, proteins, and DNA. Oxidative stress is closely linked to chronic inflammation, which further contributes to disease progression. Long-term inflammation involves the release of cytokines, prostaglandins, and other mediators that can harm tissues and interfere with normal body functions (Juster et al., 2010).

Stress also affects the immune system in several ways. Prolonged stress can weaken immune defenses, making the body more vulnerable to infections and disrupting normal immune signaling. Both innate and adaptive immunity can be affected, which may contribute to autoimmune diseases, metabolic conditions, and neurodegenerative disorders. Stress also impacts hormonal balance through the hypothalamic–pituitary–adrenal axis, leading to further disruptions in overall health. In this situation, *Ocimum sanctum* is particularly important because of its adaptogenic nature. Adaptogens are natural substances that help the body deal with stress and maintain balance. Studies show Tulsi's activity in lowering the oxidative damage, control inflammation, and support immune function. Its active constituents work through multiple pathways, helping the body by restore balance under stress (Bhargava & Singh, 1981; Mondal et al., 2009; Cohen, 2014).

The broad and multi-dimensional effects of *O. sanctum* make it especially useful in managing diseases that result from the combined effects of oxidative stress, inflammation, noise induced stress and immune dysfunction (Sembulingam et al., 1997). Overall, the stress–disease framework offers a useful perspective for understanding the therapeutic potential of *Ocimum sanctum*. By targeting the underlying mechanisms that connect stress with disease, Tulsi provides a more holistic approach to prevention and management, linking traditional knowledge with modern scientific insights.

Mechanisms of Action

The wide therapeutic potential of *Ocimum sanctum* is largely due to its ability to influence multiple biological pathways linked to stress, inflammation, and immune regulation. Unlike drugs that act on a single target, Tulsi works through a network

of interconnected mechanisms, which together contribute to its adaptogenic and protective effects.

1. Immunomodulatory Mechanisms

Ocimum sanctum affects both innate and adaptive immunity. Studies have shown that it enhances the activity of macrophages and neutrophils, improving phagocytosis and the clearance of pathogens. It also supports natural killer cell function and helps regulate cytokine production, leading to a more balanced immune response. In the adaptive immune system, Tulsi promotes lymphocyte proliferation, modulates T-cell activity, and enhances antibody production by B-cells (Mediratta et al., 2002; Mondal et al., 2009).

Importantly, its effects are not limited to immune stimulation. Tulsi also helps control excessive immune responses by regulating pro-inflammatory cytokines such as interleukin-6 and tumor necrosis factor. This dual action is essential for maintaining immune balance, especially under conditions of chronic stress or infection.

2. Anti-inflammatory Pathways

Inflammation is a key factor in many chronic diseases, and Tulsi helps control it through several mechanisms. It inhibits enzymes like cyclooxygenase and lipoxygenase, reducing the production of inflammatory mediators such as prostaglandins and leukotrienes (Singh et al., 1996; Karthikeyan et al., 1999).

It also influences transcription factors such as nuclear factor kappa B, which regulate inflammation-related genes. By limiting the activation of these pathways, Tulsi reduces the release of inflammatory mediators and protects tissues from damage.

3. Antioxidant Defense Mechanisms

Tulsi has strong antioxidant properties that help protect cells from damage. It boosts natural antioxidant enzymes such as superoxide dismutase, catalase, and glutathione peroxidase, which neutralize harmful reactive oxygen species (Geetha & Vasudevan, 2004; Mondal et al., 2009).

It also supports cellular defense systems by activating pathways that increase protective gene expression. This helps reduce oxidative damage and maintain normal cell function under stress.

Recent research shows that Tulsi's compounds interact with the Keap1–Nrf2 pathway, improving antioxidant responses and increasing cellular resistance to oxidative stress. This is particularly important in preventing degenerative conditions (Kumar & Sarkar, 2023).

4. Molecular Signaling Pathways

Tulsi also affects important signaling pathways that control cell survival, metabolism, and inflammation. It influences pathways like PI3K/Akt, which are

involved in maintaining cellular function and metabolic balance. It also regulates nitric oxide production, which is important for vascular health and immune responses (Kumar et al., 2001; Geetha & Vasudevan, 2004).

In addition, Tulsi interacts with neuroendocrine systems, particularly those involved in stress responses. By helping regulate hormones within the hypothalamic–pituitary–adrenal axis, it improves the body's ability to handle stress.

Recent studies further show that Tulsi can modulate signaling pathways involved in inflammation and cell survival, helping protect tissues in conditions such as ischemic injury (Yadav et al., 2024).

5. Neuroendocrine and Adaptogenic Effects

The adaptogenic properties of Ocimum sanctum are closely related to its effects on the neuroendocrine system. Studies have shown that it can lower stress-induced cortisol levels and improve cognitive performance under both psychological and physical stress (Bhargava & Singh, 1981; Samson et al., 2006).

These effects are associated with better mental clarity, emotional stability, and physical endurance. By acting on both central and peripheral systems, Tulsi helps the body adapt to environmental changes and maintain internal balance.

6. Integrated Mechanistic Perspective

These mechanisms do not function independently but are part of an interconnected biological network. By simultaneously influencing immune responses, inflammation, oxidative stress, and neuroendocrine regulation, *O. sanctum* produces a comprehensive therapeutic effect.

Overall, the mechanistic profile of *Ocimum sanctum* supports its classification as a systems-level therapeutic agent. Its ability to influence diverse yet interconnected pathways provide a scientific basis for its widespread use in traditional medicine and its growing relevance in modern integrative healthcare.

Table 2 illustrates the wide-ranging immunomodulatory effects of *Ocimum sanctum*, showing its impact on both innate and adaptive immunity as well as key molecular pathways. It indicates that Tulsi helps strengthen the body's primary defense mechanisms while also controlling inflammatory mediators like COX-2, NF-κB, and LOX. Its role in protecting cells is further supported by its ability to reduce oxidative stress through the activation of antioxidant pathways, especially Nrf2 and related enzymes. Additionally, Tulsi affects signaling pathways such as PI3K/Akt and nitric oxide production, helping maintain cellular balance and proper immune function. Overall, the table confirms the status of *O. sanctum* as a multi-targeted, mechanistically diverse therapeutic agent with considerable importance in the context of the treatment of inflammation and immune-mediated diseases.

Table 2. Integrated Immunomodulatory and Molecular Mechanisms of Ocimum sanctum

Immune Component / System	**Target / Mediator**	**Mechanism of Action of *O. sanctum***	**Key Pathways / Molecules**	**Verified References**
Physical barriers	Epithelial integrity	Enhances barrier protection and antioxidant defense	ROS scavenging	Cohen, 2014
Innate immunity	Macrophages, neutrophils	Enhances phagocytosis and immune signaling	Cytokines, NO	Mediratta et al., 2002; Mondal et al., 2009
Inflammatory response	Arachidonic acid pathway	Inhibits prostaglandin and leukotriene synthesis	COX, LOX	Singh et al., 1996; Kelm et al., 2000
Inflammation regulation	COX-2	Downregulates inflammatory enzyme activity	COX-2 inhibition	Kelm et al., 2000; Cohen, 2014
Lipid mediators	Lipoxygenase	Suppresses leukotriene formation	LOX inhibition	Singh et al., 1996
Nitric oxide system	iNOS, NO	Modulates NO production and prevents oxidative damage	NO signaling	Jagetia & Baliga, 2004
Transcription factors	NF-κB	Inhibits inflammatory gene expression	NF-κB pathway	Cohen, 2014; Arya et al., 2024
Cell survival pathways	PI3K/Akt	Regulates survival and metabolic signaling	PI3K/Akt pathway	Yadav et al., 2024
Antioxidant defense	Nrf2	Activates antioxidant response elements	Nrf2/ARE pathway	Kumar & Sarkar, 2023
Oxidative stress	Lipid peroxidation	Reduces membrane damage	ROS scavenging	Geetha & Vasudevan, 2004
Detoxification system	SOD, CAT, GST	Enhances enzymatic antioxidant activity	Antioxidant enzymes	Mondal et al., 2009
Stress response	Neuroendocrine system	Improves stress adaptation and hormonal balance	HPA axis	Bhargava & Singh, 1981; Jamshidi & Cohen, 2017
Adaptive immunity	T-cells	Enhances cell-mediated immunity	Cytokine regulation	Mediratta et al., 2002
Adaptive immunity	B-cells	Promotes antibody production	Immunoglobulins	Godhwani et al., 1987
Neuro-immune interaction	Melatonin, circadian rhythm	Supports immune–neuroendocrine balance	Hormonal regulation	McEwen, 2004

7. Pharmacological Activities

The wide therapeutic applicability of *Ocimum sanctum* is reflected in its diverse pharmacological activities, which arise from its multi-targeted mechanisms of action. These activities are supported predominantly by experimental studies, with a growing body of clinical evidence. For clarity, its pharmacological activities are grouped into major categories rather than described individually.

- **Anti-infective Activities**

Tulsi shows strong activity against many types of microorganisms, including bacteria, fungi, viruses, and parasites. Its natural compounds, especially essential oils and phenolics, damage microbial cells, disrupt their metabolism, and prevent their growth. It has been found effective against both Gram-positive and Gram-negative bacteria, as well as fungi such as *Candida* and *Aspergillus* (Singh & Majumdar, 2001; Chanda & Baravalia, 2010).

Antiviral effects have also been reported, particularly in relation to respiratory pathogens. Tulsi enhances host immune responses, promotes interferon production, and supports the early clearance of viral infections (Mediratta et al., 2002; Mondal et al., 2009). In addition, its anthelmintic properties have been associated with disruption of parasite neuromuscular activity, leading to paralysis and elimination of helminths (Asha et al., 2001).

- **Anti-inflammatory and Immunological Effects**

Inflammation plays a central role in many chronic diseases, and *O. sanctum* demonstrates potent anti-inflammatory activity through multiple pathways. It inhibits enzymes such as cyclooxygenase and lipoxygenase, thereby reducing the synthesis of pro-inflammatory mediators. Additionally, it modulates cytokine production and suppresses key signaling pathways involved in inflammatory responses (Singh et al., 1996; Kapoor et al., 2014).

The immunomodulatory effects of Tulsi complement its anti-inflammatory actions. It enhances both humoral and cell-mediated immunity by promoting lymphocyte activity, improving antibody production, and regulating cytokine balance. This dual role in immune enhancement and regulation is particularly beneficial in conditions characterized by immune dysfunction (Mediratta et al., 2002; Mondal et al., 2009).

- **Metabolic and Cardiovascular Effects**

Ocimum sanctum has been widely studied for its beneficial effects on metabolic and cardiovascular health. It has been reported to improve glucose metabolism by enhancing insulin secretion and sensitivity, as well as by reducing oxidative stress associated with diabetes (Rai et al., 1997; Gupta et al., 2006). In addition, Tulsi contributes to improved lipid profiles by lowering total cholesterol, low-density lipoprotein, and triglyceride levels while increasing high-density lipoprotein.

Cardioprotective effects are attributed to its antioxidant properties, regulation of lipid metabolism, and ability to improve vascular function. It also exhibits

hypotensive activity by vasodilation, anticoagulant and antiplatelet activities, which may reduce the risk of thrombotic events (Singh et al., 2001; Sood et al., 2005; Gupta et al., 2002).

- **Organ-Protective Effects**

The protective effects of *O. sanctum* extend to multiple organ systems. Hepatoprotective activity has been demonstrated in experimental models, where Tulsi reduces liver enzyme levels, prevents lipid peroxidation, and protects hepatocytes from toxin-induced damage (Chattopadhyay et al., 1992; Suanarunsawat et al., 2011).

Neuroprotective effects are associated with reduced oxidative stress, improved neurotransmitter balance, and enhanced cognitive function. Studies indicate its potential in protecting against neurodegenerative changes and stress-induced cognitive deficits (Geetha and Vasudevan, 2004; Samson et al., 2006). Renoprotective effects have also been reported, with improvements in kidney function and reduced oxidative damage (Devi et al., 2000).

- **Anti-stress and Adaptogenic Effects**

One of the most notable features of *Ocimum sanctum* is its adaptogenic activity. It enhances the body's ability to cope with physical, chemical, and psychological stress. Studies show that Tulsi can regulate cortisol levels, improve endurance, and enhance cognitive performance under stress (Bhargava & Singh, 1981; Sood et al., 2006).

These effects are closely linked to its influence on neuroendocrine pathways and antioxidant systems, helping maintain both mental and physical well-being.

- **Miscellaneous Therapeutic Effects**

In addition to the major categories described above, *O. sanctum* exhibits several other pharmacological activities. These include anticancer effects, which are associated with inhibition of tumor growth, induction of apoptosis, and enhancement of detoxification pathways (Karthikeyan et al., 1999). It also provides protection against radiation-induced damage by reducing DNA damage and improving survival (Bhartiya et al., 2006; Ganasoundari et al., 1997). Studies of Sharma and co-workers showed that *Ocimum sanctum* is quite effective in reducing mercury induced toxicity in animals (Sharma et al., 2002; 2005).

Recent comprehensive reviews have further validated the wide-ranging pharmacological properties of *Ocimum sanctum*, including its antibacterial, antidiabetic, and anticancer potential. These studies highlight the role of its bioactive compounds in modulating multiple cellular targets, thereby reinforcing its classification as a multi-functional therapeutic agent (Arya et al., 2024). In addition, updated analyses of its anticancer potential emphasize its ability to regulate

apoptosis, inhibit tumor progression, and enhance detoxification pathways through molecular-level interactions (Hasan et al., 2023).

These diverse activities further support the classification of Tulsi as a multi-functional medicinal plant with broad therapeutic relevance.

- **Integrative Perspective**

The pharmacological activities of *Ocimum sanctum* are not isolated phenomena but are interconnected through common underlying mechanisms such as antioxidant defense, anti-inflammatory action, immune modulation, and metabolic regulation. This integrative mode of action explains its effectiveness across a wide range of disease conditions.

While the majority of evidence is derived from preclinical studies, the consistency of findings across different models provides a strong basis for its therapeutic potential. However, more well-designed clinical studies are needed to confirm its efficacy and safety in humans.

Clinical Evidence and Human Studies

Although a large body of research supports the pharmacological potential of *Ocimum sanctum*, most of this evidence comes from laboratory and animal studies. In comparison, clinical research in humans is still relatively limited, though interest in its therapeutic applications is steadily increasing. This section provides an overview of the available clinical evidence, along with its key strengths and limitations.

Several clinical and observational studies have examined the adaptogenic and anti-stress effects of *O. sanctum*. Findings suggest that Tulsi supplementation may help reduce stress-related symptoms, improve cognitive performance, and enhance overall well-being. Improvements in anxiety, fatigue, and mental clarity have been reported, indicating its potential role in managing psychological stress and improving quality of life (Cohen, 2014; Jamshidi & Cohen, 2017). These outcomes are consistent with earlier experimental findings on its effects on neuroendocrine regulation.

Clinical investigations have also explored the metabolic effects of Tulsi, particularly in relation to glucose and lipid regulation. Some studies have reported reductions in fasting blood glucose levels, improved lipid profiles, and better glycemic control in individuals with metabolic disorders. These effects are believed to be mediated through improved insulin sensitivity, antioxidant activity, and modulation of metabolic pathways (Rai et al., 1997; Gupta et al., 2006). However, the sample sizes in many of these studies are relatively small, and variations in study design make it difficult to draw definitive conclusions.

In the context of immune function and infectious diseases, limited clinical evidence suggests that *O. sanctum* may enhance immune responses and support recovery from infections. Observations include improved resistance to recurrent infections

and modulation of immune markers. However, most of these findings are based on preliminary or indirect evidence, and well-controlled clinical trials are still lacking.

Despite these promising findings, several limitations must be acknowledged. Many clinical studies on *O. sanctum* involve small sample sizes, short durations, and variations in dosage forms and preparation methods. The lack of standardized extracts and uniform protocols poses challenges for reproducibility and comparison across studies. In addition, there is a need for more rigorous randomized controlled trials to establish clear cause-and-effect relationships and to determine optimal dosing strategies.

Another important consideration is the variability in phytochemical composition of Tulsi preparations used in different studies. Differences in plant varieties, cultivation conditions, and extraction techniques can influence the concentration of active compounds, thereby affecting therapeutic outcomes. This variability emphasizes the importance of standardization in future clinical research.

Overall, existing clinical evidence suggests that *Ocimum sanctum* has potential benefits in areas such as stress management, metabolic health, and general well-being. However, the current evidence is not strong enough to support definitive clinical recommendations. Future research should focus on larger, well-controlled studies using standardized preparations.

Recent clinical investigations, although limited, provide encouraging evidence regarding the therapeutic efficacy of *Ocimum sanctum* in human populations. Randomized clinical trials have demonstrated its effectiveness in improving oral health conditions such as gingivitis, indicating its anti-inflammatory and antimicrobial potential in clinical settings (Nadar et al., 2020).

Additional studies have reported benefits in conditions such as oral submucous fibrosis, suggesting a role in managing chronic inflammatory and precancerous disorders (Biswas et al., 2022). These findings highlight its translational potential for clinical use, while also emphasizing the need for larger and more standardized trials.

Safety, Toxicity, and Dosage Considerations

Ocimum sanctum has been used for centuries in traditional medicine and as part of the diet, which suggests that it is generally safe. Most experimental studies and limited clinical evidence indicate that Tulsi is well tolerated when taken in moderate amounts. However, a careful evaluation of its safety, potential toxicity, and appropriate dosage is essential for its rational and evidence-based use.

1. Toxicological Profile

Toxicological studies in animal models show that *O. sanctum* has low acute and sub-chronic toxicity. At moderate doses, Tulsi extracts do not appear to cause significant adverse effects on major organs such as the liver, kidneys, or heart (Mondal et al., 2009; Pattanayak et al., 2010). Biochemical markers, including liver

enzymes and renal function indicators, generally remain within normal ranges, suggesting a good margin of safety.

However, the effects of long-term use or high doses are not well established. As with many herbal preparations, safety may vary depending on dosage, duration, and the specific formulation used.

2. Reproductive and Fertility Considerations

Some animal studies have reported reversible antifertility effects associated with *O. sanctum*, particularly in males. These include reduced sperm count and motility, as well as changes in reproductive hormone levels (Batta & Santhakumari, 1971; Raghunandan Reghunandan, 1995; Ahmed et al., 2002). Similar findings have been observed in female models, including possible interference with implantation.

Although these findings are primarily based on animal studies and may not directly translate to humans, they highlight the need for caution in individuals who are planning conception. Until more definitive clinical evidence is available, prolonged or high-dose use of Tulsi for reproductive-age individuals should be approached carefully.

3. Effects on Metabolic and Hormonal Systems

Ocimum sanctum has been shown to influence metabolic and hormonal pathways, including glucose regulation and thyroid function. Some studies suggest that it may lower blood glucose levels and modulate thyroid hormones, particularly triiodothyronine and thyroxine (Panda and Kar, 1998; Gupta et al., 2006). While these effects may be beneficial in certain conditions, they could potentially lead to unintended alterations if not monitored appropriately.

These effects may be beneficial in certain conditions but could also cause unwanted changes if not properly monitored. Therefore, People with diabetes or thyroid disorders use Tulsi under medical supervision, especially when combined with conventional medications.

4. Herb–Drug Interactions

The potential for herb–drug interactions is an important consideration in the use of *O. sanctum*. Due to its effects on metabolic pathways, antioxidant systems, and enzyme activity, Tulsi may influence the pharmacokinetics or pharmacodynamics of certain medications. For example, its hypoglycemic activity may enhance the effects of antidiabetic drugs, increasing the risk of hypoglycemia. Similarly, its anticoagulant and antiplatelet properties may interact with blood-thinning medications.

Although detailed research on these interactions is still limited, it is important to consider these possibilities, particularly for individuals on long-term medication.

5. Dosage Considerations

There is currently no universally accepted dosage for *Ocimum sanctum*, as it is used in various forms such as fresh leaves, powders, extracts, and essential oils. Traditionally, people consume a few fresh leaves daily or use it in herbal preparations.

In experimental and clinical settings, dosages vary widely depending on the preparation and intended therapeutic use.

The lack of standardization makes it difficult to determine the most effective dose. Differences in plant quality and preparation methods also affect the concentration of active compounds. Variations in phytochemical composition due to differences in cultivation and processing further complicate this issue. Therefore, more research is needed to establish a consistent and validated dosage guideline.

6. Overall Safety Perspective

Overall, *Ocimum sanctum* can be considered a relatively safe medicinal plant when used appropriately and in moderate amounts. Its long-history of traditional use and supportive experimental evidence provide a basis for its safety in general populations. However, specific considerations related to reproductive health, metabolic effects, and potential drug interactions should not be overlooked.

A balanced approach that integrates traditional knowledge with modern scientific evaluation is essential to ensure the safe and effective use of Tulsi. Combining traditional knowledge with scientific research will help ensure its safe use. Future studies focusing on long-term safety, standardized formulations, and clinical validation will further strengthen its position as a reliable therapeutic agent.

Limitations, Future Perspectives, and Conclusion

Limitations of Current Research

Despite extensive documentation of the therapeutic potential of *Ocimum sanctum*, several limitations restrict its full integration into evidence-based medical practice. One of the main challenges is that most studies are based on in vitro experiments and animal models, with relatively few well-designed clinical trials in humans. While preclinical findings provide valuable mechanistic insights, their direct translation to human physiology remains uncertain.

Another important limitation is the lack of standardization in plant material and extract preparation. Variations in geographical origin, cultivation practices, harvesting time, and extraction methods can significantly influence the phytochemical composition of *O. sanctum*. This variability affects reproducibility and consistency of results across studies, making it difficult to establish uniform therapeutic guidelines.

In addition, many studies rely on small sample sizes, short experimental durations, and limited control measures. The absence of large-scale, randomized controlled

trials reduces the strength of evidence supporting its clinical efficacy. There is also a tendency in some reports to generalize findings without clearly distinguishing between experimental and clinical outcomes, which may lead to over interpretation of results.

Furthermore, there is limited information on pharmacokinetics, bioavailability, and long-term safety. Potential herb–drug interactions and dose-dependent effects have not been comprehensively evaluated. These gaps highlight the need for more rigorous and systematic research approaches.

Future Perspectives

Future research should focus on connecting traditional knowledge with modern scientific methods. One important step is the development of standardized extracts with well- defined phytochemical profile, which will improve the reliability of research findings. This will enhance reproducibility and allow for more accurate assessment of therapeutic efficacy.

Large-scale well designed clinical trials with standardized protocols are needed to confirm the safety and effectiveness of Tulsi in humans. Such studies should also explore optimal dosage regimens, duration of treatment, and potential interactions with conventional medications.

New developments in molecular biology and systems pharmacology can help provide a deeper understanding of how Tulsi works at the cellular and molecular levels. Studying its effects on multiple pathways at once may reveal new therapeutic possibilities. In addition, modern technologies such as nanotechnology and improved drug delivery systems may enhance the effectiveness of its bioactive compounds.

Recent global health challenges have renewed interest in plant-based therapeutics, and *Ocimum sanctum* has been investigated for its potential role in emerging infectious diseases. Contemporary studies suggest that its immunomodulatory and antiviral properties may contribute to host defense mechanisms, highlighting its relevance in integrative approaches to disease prevention and management (Cohen, 2014; Pattanayak et al., 2010; Arya et al., 2024).

There is also scope for exploring the role of *O. sanctum* in preventive healthcare and lifestyle management, particularly in stress-related and chronic diseases. Its adaptogenic and immunomodulatory properties make it a promising candidate for integrative and complementary medicine.

Conclusion

Ocimum sanctum is a unique medicinal plant with a long history of use and a wide range of pharmacological activities. Its therapeutic potential is supported by a diverse range of bioactive compounds that act through multiple mechanisms, including antioxidant defense, anti-inflammatory regulation, immune modulation,

and neuroendocrine balance. These properties enable Tulsi to address the complex interplay of factors involved in the development of many diseases.

Clinical effectiveness and ensure safe and standardized use. Combining traditional knowledge with modern research approaches offers great potential for advancing its use in healthcare The concept of stress as a central contributor to disease provides a unifying framework for understanding the wide-ranging benefits of *O. sanctum*. By reducing oxidative stress, controlling inflammation, and improving the body's ability to adapt, it helps maintain overall balance and health.

Tulsi contributes to the maintenance of physiological homeostasis and overall health.

Although current evidence is promising, further research is required to fully validate its clinical applications and ensure standardized, safe, and effective use. The integration of traditional knowledge with modern scientific approaches holds significant potential for advancing the role of *Ocimum sanctum* in contemporary healthcare.

In summary, Tulsi can be considered a multi-targeted medicinal plant with significant potential in the prevention and management of stress-related and chronic diseases. Continued scientific research will further establish its role as an important natural resource for promoting health and resilience.

References

1. Abbas, S.S., Singh, N., 2006 Anti-stress Agents (Herbs) of Indian Origin, in: Sharma, R.K., Arora, R. (Eds.), Herbal Drugs-A Twenty First Century Perspective. Jaypee Brothers Medical Publications (P) Ltd, New Delhi. pp. 578-591.
2. Ahmed, M., Ahamed, R. N., Aladakatti, R. H., & Ghosesawar, M. G. (2002). Reversible anti-fertility effect of benzene extract of Ocimum sanctum leaves on sperm parameters and fructose content in rats. Journal of Basic and Clinical Physiology and Pharmacology, 13(1), 51–59. https://doi.org/10.1515/jbcpp.2002.13.1.51
3. Arya, R., Faruquee, H. M., Shakya, H., Rahman, S. A., Begum, M. M., Biswas, S. K., et al. (2024). Harnessing the antibacterial, antidiabetic and anticancer properties of Ocimum sanctum Linn. Plants, 13(24), 3516. https://doi.org/10.3390/plants13243516
4. Asha, M. K., Prashanth, D., Murali, B., Padmaja, R., & Amit, A. (2001). Anthelmintic activity of Ocimum sanctum and other medicinal plants. Indian Journal of Pharmacology, 33, 172–173.
5. Batta, A. K., & Santhakumari, G. (1971). The antifertility effect of Ocimum sanctum leaves. Indian Journal of Medical Research, 59, 777–784.
6. Bhargava, K. P., & Singh, N. (1981). Anti-stress activity of Ocimum sanctum Linn. Journal of Ethnopharmacology, 3, 385–392.

7. Bhartiya, U. S., Raut, A. A., & Joseph, L. J. (2006). Radioprotective effect of Ocimum sanctum on chromosomal aberrations in mice. Journal of Radiation Research, 47, 1–9.
8. Bhattarai, S., Kafle, A., & Subedi, L. (2024). Phytochemical profiling and pharmacological potential of Ocimum tenuiflorum: A comprehensive review. Plants, 13(5), 742. https://doi.org/10.3390/plants13050742
9. Biswas, D., Naik, Z., Kumar, S. L., Patil, N., & Bagewadi, A. (2022). Efficacy of topical Tulsi paste in oral submucous fibrosis. Indian Journal of Dental Research, 33(2), 146–151.
10. Chanda, S., & Baravalia, Y. (2010). Novel antifungal and wound healing activity of Ocimum sanctum Linn. Journal of Natural Medicines, 64, 117–123.
11. Chattopadhyay, R. R., Sarkar, S. K., Ganguly, S., Banerjee, R. N., & Basu, T. K. (1992). Hepatoprotective effect of Ocimum sanctum leaf extract on experimental liver damage. Indian Journal of Pharmacology, 24, 163–165.
12. Cohen, M. M. (2014). Tulsi—Ocimum sanctum: A herb for all reasons. Journal of Ayurveda and Integrative Medicine, 5(4), 251–259.
13. Devi, P. U., Ganasoundari, A., Rao, B. S., & Srinivasan, K. K. (2000). In vivo radioprotective effect of Ocimum sanctum. Indian Journal of Experimental Biology, 38, 204–210.
14. Geetha, Kedlaya, R., & Vasudevan, D. M. (2004). Inhibition of lipid peroxidation by botanical extracts of Ocimum sanctum: in vivo and in vitro studies. Life Sciences, 76(1), 21-28. https://doi.org/10.1016/j.lfs.2004.05.036
15. Godhwani, S., Godhwani, J. L., & Vyas, D. S. (1987). Ocimum sanctum: an experimental study evaluating its anti-inflammatory, analgesic and antipyretic activity in animals. Journal of Ethnopharmacology, 21(2), 153-163.
16. Gupta, S. K., Prakash, J., & Srivastava, S. (2002). Validation of traditional claim of Tulsi, Ocimum sanctum Linn. as a medicinal plant. Indian Journal of Experimental Biology, 40(7), 765-773.
17. Halder, N., Joshi, S., & Gupta, S. K. (2003). Lens aldose reductase inhibiting potential of some indigenous plants. Journal of Ethnopharmacology, 86(1), 113-116. https://doi.org/10.1016/S0378-8741(03)00052-7
18. Hasan, M. R., Alotaibi, B. S., Althafar, Z. M., Mujamammi, A. H., & Jameela, J. (2023).
19. An update on the therapeutic anticancer potential of Ocimum sanctum L.: “Elixir of life.”
20. Molecules, 28(3), 1193. https://doi.org/10.3390/molecules28031193
21. Jamshidi, Negar, Cohen, Marc M., (2017). The Clinical Efficacy and Safety of Tulsi in Humans: A Systematic Review of the Literature, Evidence-Based Complementary and Alternative Medicine, Article ID 9217567, 1-13. https://doi.org/10.1155/2017/9217567

22. Jagetia, G. C. & Baliga, M. S. (2004). The Evaluation of Nitric Oxide Scavenging Activity of Certain Indian Medicinal Plants In Vitro: A Preliminary Study. J Med Food 7(3),343–348. https://doi.org/10.1089/jmf.2004.7.343
23. Juster, R. P., McEwen, B. S., & Lupien, S. J. (2010). Allostatic load biomarkers of chronic stress and impact on health and cognition. Neuroscience & Biobehavioral Reviews, 35(1), 2-16. https://doi.org/10.1016/j.neubiorev.2009.10.002
24. Karthikeyan, K., Ravichandran, P., & Govindasamy, S. (1999). Chemopreventive effect of Ocimum sanctum on DMBA-induced hamster buccal pouch carcinogenesis. Oral oncology, 35(1), 112-119. https://doi.org/10.1016/S1368-8375(98)00035-9
25. Kelm, M. A., Nair, M. G., Strasburg, G. M., & DeWitt, D. L. (2000). Antioxidant and cyclooxygenase inhibitory phenolic compounds from Ocimum sanctum. Phytomedicine, 7(1), 7–13. https://doi.org/10.1016/S0944-7113(00)80015-X
26. Kumar, S., & Sarkar, B. (2023, March). In silico approach to assessing the polyphenols from krishna tulsi (Ocimum tenuiflorum L.) as a Keap1/Nrf2 receptor for the treatment of inflammatory bowel disease. In Medical Sciences Forum (Vol. 21, No. 1, p. 13). MDPI. https://doi.org/10.3390/ECB2023-14207
27. McEwen, B. S. (2004). Protection and damage from acute and chronic stress: Allostasis and allostatic overload and relevance to the pathophysiology of psychiatric disorders. Annals of the newYork Academy of Sciences, 1032(1), 1-7. https://doi.org/10.1196/annals.1314.001
28. Mediratta, P. K., Sharma, K. K., & Singh, S. (2002). Evaluation of immunomodulatory potential of Ocimum sanctum seed oil and its possible mechanism of action. Journal of Ethnopharmacology, 80(1), 15-20. https://doi.org/10.1016/S0378-8741(01)00373-7
29. Mondal, S., Mirdha, B. R., & Mahapatra, S. C. (2009). The science behind sacredness of Tulsi (Ocimum sanctum Linn.). Indian J Physiol Pharmacol, 53(4), 291-306.
30. Nadar, B. G., Usha, G. V., & Lakshminarayan, N. (2020). Comparative evaluation of efficacy of 4% Tulsi extract (Ocimum sanctum), fluoridated and placebo dentifrices against gingivitis and plaque among 14–15 years school children in Davangere City, India–A triple blinded randomized clinical trial. Contemporary Clinical Dentistry, 11(1), 67-75. https://doi.org/10.4103/ccd.ccd_109_19
31. Panda, S., & Kar, A. (1998). Ocimum sanctum leaf extract in the regulation of thyroid function in the male mouse. Pharmacological Research, 38(2), 107-110. https://doi.org/10.1006/phrs.1998.0338

32. Pattanayak, P., Behera, P., Das, D., & Panda, S. K. (2010). Ocimum sanctum Linn. A reservoir plant for therapeutic applications: An overview. Pharmacognosy reviews, 4(7), 95. https://doi.org/10.4103/0973-7847.65323
33. Prakash, P. & Gupta, N. (2005). Therapeutic uses of Ocimum sanctum Linn (Tulsi) with a note on eugenol and its pharmacological actions: a short review. Indian journal of physiology and pharmacology, 49(2), 125-131.
34. Rai, V. A., Iyer, U., & Mani, U. V. (1997). Effect of Tulasi (Ocimum sanctum) leaf powder supplementation on blood sugar levels, serum lipids and tissues lipids in diabetic rats. Plant foods for human nutrition, 50(1), 9-16. https://doi.org/10.1007/BF02436038
35. Reghunandanan, P., Sood, S., Reghunandanan, V., Mehta, R. M., & Singh, G. P. (1995). Effect of Ocinium Sanctum Linn (Tulsi) extract on testicular function. Indian Journal of Medical Sciences, 49(4), 83-87.
36. Samanth, Mahima, The Chemical Constituents of and Its Pharmacological Applications: A Review (February 17, 2025). Available atSSRN: https://ssrn.com/abstract=5141330 or http://dx.doi.org/10.2139/ssrn.5141330
37. Samson J, Sheela Devi R, Ravindran R, Senthilvelan M (2006) Biogenic amine changes in brain regions and attenuating action of Ocimum sanctum in noise exposure. Pharmacol Biochem Behav 83:67-75. https://doi.org/10.1016/j.pbb.2005.12.008
38. Selye, H. (1956). The stress of life. McGraw-Hill.
39. Sembulingam, K., Sembulingam, P., & Namasivayam, A. (1997). Effect of Ocimum sanctum Linn on noise induced changes in plasma corticosterone level. Indian Journal of Physiology and Pharmacology, 41, 139-143.
40. Sharma, M. K., Kumar, M., & Kumar, A. (2002). Ocimum sanctum aqueous leaf extract provides protection against mercury induced toxicity in Swiss albino mice. Indian journal of experimental biology, 40(9), 1079-1082.
41. Sharma, M. K., Kumar, M., & Kumar, A. (2005). Protection against mercury-induced renal damage in Swiss albino mice by Ocimum sanctum. Environmental toxicology and pharmacology, 19(1), 161-167. https://doi.org/10.1016/j.etap.2004.06.002 PMID: 21783472
42. Singh, N., Abbas, S.S., Singh, V. and Singh, A., 2002a. Adaptogens/Anti-Stress Agents – A study focusing Indian plants. The Antiseptic J. Med. Surg, 99(6), 198-201.
43. Singh, N., Abbas, S.S., Singh, V. and Singh, A., 2002b. Adaptogens/Anti-Stress Agents – A study focusing Indian plants. The Antiseptic J. Med. Surg, 99(7), 243-249.
44. Singh, S., Rehan, H. M. S., & Majumdar, D. K. (2001). Effect of Ocimum sanctum fixed oil on blood pressure, blood clotting time and pentobarbitone-induced sleeping time. Journal of ethnopharmacology, 78(2-3), 139-143. https://doi.org/10.1016/S0378-8741(01)00336-1

45. Singh, A., Malhotra, S., & Subban, R. (2008). Anti-inflammatory and analgesic agents from Indian medicinal plants. International journal of integrative biology, 3(1), 57-72.
46. Singh, S., Majumdar, D. K., & Rehan, H. M. S. (1996). Evaluation of anti-inflammatory potential of fixed oil of Ocimum sanctum (Holybasil) and its possible mechanism of action. Journal of Ethnopharmacology, 54(1), 19-26. https://doi.org/10.1016/0378-8741(96)83992-4
47. Singh N, Hoette Y, Miller R. (2002). Tulsi 'The Mother Medicine of Nature' Eds. Dr. V. Singh & Dr. S.S. Abbas.1st Edition. International Institute of Herbal Medicine, Lucknow.
48. Sood, S., Narang, D., Dinda, A. K., & Maulik, S. K. (2005). Chronic oral administration of Ocimum sanctum Linn. augments cardiac endogenous antioxidants and prevents isoproterenol-induced myocardial necrosis in rats. Journal of pharmacy and pharmacology, 57(1), 127-133.
49. Sood, S., Narang, D., Thomas, M. K., Gupta, Y. K., & Maulik, S. K. (2006). Effect of Ocimum sanctum Linn. on cardiac changes in rats subjected to chronic restraint stress. Journal of ethnopharmacology, 108(3), 423-427.
50. Suanarunsawat, T., Devakul Na Ayutthaya, W., Songsak, T., Thirawarapan, S., & Poungshompoo, S. (2011). Lipid-lowering and antioxidative activities of aqueous extracts of Ocimum sanctum L. leaves in rats fed with a high-cholesterol diet. Oxidative Medicine and Cellular Longevity, 2011(1), 962025.
51. Ganasoundari, A., Devi, P. U., & Rao, M. N. A. (1997). Protection against radiation-induced chromosome damage in mouse bone marrow by Ocimum sanctum. Mutation Research/Fundamental and Molecular Mechanisms of Mutagenesis, 373(2), 271-276. https://doi.org/10.1016/S0027-5107(96)00208-4
52. Yadav, I., Kumar, R., Fatima, Z., & Rema, V. (2024). Ocimum sanctum as a potential immunomodulator for ischemic brain injury. Current Molecular Medicine, 24(1), 60–73. https://doi.org/10.2174/1566524023666221212155340