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An Overview: - Phytochemistry and Pharmacological Activities of "Ocimum Sanctum" (Tulsi)

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ABSTRACT

Ocimum sanctum (Tulsi), a sacred medicinal herb in Ayurveda, has been traditionally recognized for its remarkable healing properties. Scientific research now confirms its wide spectrum of pharmacological activities, including antioxidant, antidiabetic, antimicrobial, anti-inflammatory, neuroprotective, immunomodulatory, cardioprotective, wound-healing, and adaptogenic effects. These biological actions arise from a rich phytochemical composition that includes phenolic acids (rosmarinic acid), flavonoids (apigenin, cirsimaritin), terpenoids (eugenol, linalool), triterpenoids (ursolic acid, oleanolic acid), and essential oils. Tulsi modulates oxidative stress markers, inflammatory pathways, neuronal injury, metabolic disturbances, and microbial proliferation. Recent studies also highlight its potential role in protecting the brain from excitotoxicity, enhancing antioxidant enzymes, and inhibiting fungal and bacterial growth. This review provides a detailed examination of the phytochemistry, pharmacological properties, mechanisms of action, and therapeutic applications of Ocimum sanctum, integrating evidence from multiple scientific studies to support its value as a versatile herbal medicine.

Keywords: Ocimum sanctum, Tulsi, Phytochemistry, Neuroprotection, Antioxidant, Antidiabetic, Radioprotective, Immunomodulator, Herbal medicine.

1.INTRODUCTION

The use of herbal treatments in the traditional medical system continues to be a significant part of the health care system. Due to the belief that these natural medicines have fewer adverse effects and greater efficacy than their synthetic counterparts, therapeutic plants have become more widely accepted in recent decades [1,2]. Approximately 80% of people on the planet now primarily receive their primary medical treatment from traditional drugs [3]. Pharmacologically, a variety of herbal plants contain antibacterial, spasmolytic, sedative, analgesic, and local anesthetic properties in addition to bactericidal, virucidal, and fungicidal properties [4,5]. They are also utilized in embalming and food preservation. Numerous plant species, including glycosides, saponins, flavonoids, steroids, and tannins, have been shown to exhibit pharmacological effects [4]. Herbal medicines have been shown to be an important source for finding new pharmaceutical compounds that have been utilized to cure serious illnesses [5].

These discovered phytochemicals are regarded as an exceptional lead compound in the hunt for novel and potent medications. Clove, or Syzygium (S.) aromaticum, is a dried flower bud from the Myrtaceae family that is native to Indonesia's Maluku islands but has recently been grown all over the world [6,7]. The commercial portion of the clove tree is made up of its leaves and buds start to bloom four years after planting. In the pre-flowering stage, they are then harvested manually or with the use of a natural phytohormone [6]. Clove essential oil has long been used to treat burns and wounds, as well as to ease dental discomfort and treat toothaches and infections [8]. Furthermore, it is widely employed in perfumes, soaps, and as a washing agent in histology work, and its use has been documented in a variety of industrial applications [8]. In traditional Chinese and Indian medicine, cloves are utilized as a stimulating and warming agent [7]. Cloves have been used traditionally for millennia to cure liver, intestine, and stomach problems, nausea, vomiting, flatulence, and nerve stimulation [9].

Furthermore, due to its ability to permeate tooth pulp tissue and enter the bloodstream, eugenol has been employed extensively in dentistry [10].

Table 1: Botanical Classification of Ocimum Sanctum [11]

Taxonomic Rank	*Taxon*
Kingdom	*Plantae*
Division	*Magnoliophyta*
Class	*Magnoliopsida*
Family	*Lamiaceae*
Order	*Lamiales*
Genus	*Ocimum*
Species	*Ocimum Sanctum*

2. PHYTOCHEMICAL CONSTITUENTS

Ocimum sanctum leaves are a rich source of volatile oil that contains 20% methyl eugenol and 71% eugenol. Additionally, carvacrol and the sesquiterpine hydrocarbon caryophyllene are present in the volatile oil. Terpenoids, phenolics, flavonoids, and fatty acids are the other chemical components. The plant's seeds are enhanced with β-sitosterol, polysaccharides, mucilage, and fixed oil (18–22%). The primary component of seed oil is thought to be linoleic acid [12]. The additional chemicals that are present include:

The phenols

Chlorogenic acid, vanillic acid, ocimumnaphthanoic acid, caffeic acid, and menthylsalicylic glucoside are the phenolic compounds [13] that are isolated from the aerial sections of OS plants.

Flavonoids

Methoxy flavonoids and their glycosides (luteolin, isothymusin, and cirsimartin) and C-glycoside flavonoids (vicenin, isovitexin, isoorientin, and orientin) of the OS plant are thought to be the primary components[14]. Cirsumaritin, crisilineol, isothymusin, gardenin, apigenin, eupatorin, and salvigenin are the other flavones identified using air pressure chemical ionization mass spectrometry (APCI-MS) [15].

Neolignans

Tulsinol A to Tulsinol G, which are produced by the polymerization of eugenol content, are the constituents of neolignans found in the methanolic extracts of the OS plant [16].

Terpenoids

Sesquiterpenoids (β-caryophyllene and 4,5-epoxy-caryophyllene), abietane diterpenoid (carnosic acid), ursane triterpenoids (ursolic acid, urs-12-en-3 3β,6β,20β triol-28-oic acid), and oleane triterpenoids (oleanic acid, β-Amyrin-glucopyranoside) [17]. have all been identified in OS plants. Ursolic acid is the most prevalent component detected by HPTLC and UPLC-ESI-MS/MS [18].

β-caryophyllene, elemene, αhumulene, α-caryophyllene, germacrene, trans-α-bergamotene, and 5βhydroxycaryophyllene [19]. were among the other terpenoid compounds that were isolated.

Steroids

The steroid components found in OS stem and leaves include β-sitosterol, β-sitosterol-3-Oβ-D glucopyranoside, stigmasterol, and campesterol. [20].

Essential oil

Terpenoids, which comprise phenolic acid, esters, aliphatic aldehydes, bicyclic terpenoids, acyclic monoterpenoids, and sesquiterpenoids, make up the majority of the essential oil that is extracted from OS plant leaves [21].

Figure: 1. Ocimum Sanctum Plant [22].

3. PLANT MATERIAL AND METHODS

Microbiological Techniques

Actinobacillus isolation, identification, and description.Actinomycetemcomitans were extracted from dental plaque samples. using Bacitracin Vancomycin Tryptic Soy Serum Agar (TSBV agar). An enriched selective medium called TSBV agar is used to isolate and Actinobacillus actinomycetemcomitans presumptive identification. Sterile petriplates were filled with TSBV agar material and inoculated. Using five distinct clinical samples of tooth plaque. They were plates incubated for 24 hours at 37°C.

Making an aqueous extract of Ocimum sanctum leaves: Distilled water was used to obtain an adequate amount of leaf extract. First, 20 g of powdered Ocimum sanctum leaves were put into a 200 ml beaker. Next, 100 ml of distilled water was added, and the beaker was left overnight at room temperature for about 22 hours to ensure thorough mixing and complete elucidation of the active materials to dissolve in the appropriate solvent. Next, the extract was filtered using muslin cloth and Whatman No. 1 filter paper, resulting in a green-colored filtrate. Finally, the filtrate was dried. In the end, the residues were gathered and applied to the experiment [23].

Organoleptic characterisation of aqueous extract: Ocimum sanctum (Tulsi) color, odor, texture, taste, and fracture were all described [24].

In addition to phytochromes, carotenoids, flavonoids, and cryptochromes also accept high energy radiation. Phytochromes accept low energy radiation. Alkaloids, flavonoids, glycosides, proteins, fixed oil, carbohydrates, tannins, cardiac glycosides, saponins, flavonoids, and terpenoids were all tested using phytochemical methods [25-26].

4. PHARMACOLOGICAL ACTIVITIES

Antifungal effects

Aspergillus Niger, A. fumigatus, A. flavus, Rhizopus stolonifera, and Penicillium digitatum are among the filamentous fungus that tulsi extract has demonstrated efficacy against.

Tulsi extract is also effective against other clinically significant filamentous fungi, including Fusarium solani, P. funiculosum, Rhizomucor tauricus, and Trichoderma reesi. The components found in the Tulsi extracts, such as linalool and methyl chavicol, are responsible for this action [28].

Tulsi demonstrated antifungal activity in a study that tested the minimum fungicidal concentration (MFC) and minimum inhibitory concentration (MIC) of various extracts and fractions against five distinct dermatophytic fungi that had been clinically isolated. The results showed antifungal activity at a concentration of 200 µg/mL [29].

Anticoagulant effects

The anticoagulant action of ocimum sanctum fixed oil (3 ml/kg, ip) was examined. The response was similar to that obtained with aspirin (100 mg/kg), and a longer blood clotting time was noted [30]. The impact seems to be caused by oil's ability to prevent platelets from aggregating.

Anticonvulsant effects

Using the maximum electroshock (MES) model, various extractives from Ocimum sanctum's stem, leaf, and stem callus were investigated for anticonvulsant action against the common medication phenytoin. Transcorneal electroshock-induced tonic convulsions were effectively prevented by ethanol and chloroform extractives of stem, leaf, and stem calli. [31].

Anti Diabetic effects

Using column chromatography, ten fractions were separated from the hydroalcoholic extract of the OS aerial portion. In alloxan-induced diabetic rats, the antidiabetic efficacy of all the fractions F1 through F10 was evaluated by measuring serum glucose levels and lipid markers. By improving glucose and lipid indicators (total cholesterol, triglycerides, low and high density lipoprotein cholesterol), the bioactive fraction was discovered to be a powerful antidiabetic. The extracted bioactive molecule was identified as a tetracyclic triterpenoid [32], according to a thorough spectroscopic data analysis. 19th Ocimum sanctum leaf extracts stimulate insulin secretion from perfused pancreas, isolated islets, and clonal pancreatic cells [33], according to a 2006 study by Hannan et al. on the effects of ethanol extract and five partition fractions of OS leaves on insulin secretion and an assessment of their mechanisms of action [34]. The effects are fairly similar to those of glibenclamide, a common medication. When compared to standard medication and other Ocimum species, the methanolic extract of OS exhibited superior antidiabetic efficacy. Using one-way ANOVA at the 5% level of significance ($p < 0.05$) [35], the data's statistical significance was confirmed.

Figure: 2. Extract of Ocimum Sanctum [27].

Anti-inflammatory effects

It was discovered that linolenic acid and Ocimum sanctum fixed oil have strong anti-inflammatory properties against PGE2, leukotriene, and arachidonic acid-induced paw edema. When evaluated in conjunction with OS fixed oil, plant lipids containing linolenic acid, such as linseed and soybean oils, also demonstrated a notable reduction in carrageenan-induced paw edema. The findings imply that linolenic acid, which is found in OS O fixed oil, has the ability to inhibit the cyclooxygenase and lipoxygenase pathways of arachidonate metabolism and may be the cause of the oil's anti-inflammatory properties. [36] distinct OS stem, leaf, and stem calli extracts were examined. potential anti-inflammatory effects utilizing a rat paw oedema model generated by carrageenan compared to the conventional indomethacin. Out of all the extracts examined, the ethanol extract of callus tissue showed the strongest anti-inflammatory efficacy, followed by ethanol extracts of OS leaves. [37] Using the carrageenan-induced hind paw edema method, the anti-inflammatory properties of Ocimum sanctum L. leaf essential oil extract (Eugenol) were investigated in wistar rats. The extract was supplied intraperitoneally (i.p.) at a dose of 100 mg/kg body weight, while normal paracetamol was administered at a dose of 5 mg/kg body weight. When compared to the carrageenan control, the extracted paracetamol and eugenol showed substantial ($p<0.05\%$) action [38].

Antistress effects

In 2007, Jyoti et al. assessed the antistress activity of fresh Ocimum sanctum leaves against oxidative stress that was artificially produced in albino rabbits [39].

Antithyroidic Activity

Changes in serum T3 and T4 concentrations in male mice were examined in relation to Ocimum sanctum leaf extract. OS leaf had anti-thyroidic properties [40].

Antitussive effects

The antitussive effects of Ocimum sanctum's aqueous and methonolic extracts were investigated in guinea pigs at doses of 1.55 gms and 0.875 gms/kg body weight, respectively. Exposure to the 7.5% w/v citric acid aerosol caused coughing. The investigation revealed that both test extracts had strong antitussive properties, with the aqueous extract exhibiting more efficacy than the methonolic extract [41].

Antiulcer effects

The O. sanctum plant has been shown to have antiulcer properties against histamine, aspirin, reserpine, serotonin, aspirin, and indomethacin in rats [42]. It was discovered that the aqueous extract of O. sanctum protects against ethanol-induced gastrointestinal ulcers in Wistar mice [43].

Anticataleptic effects

In 2010, Aswar at all investigated the anticataleptic activity of an alcoholic extract (300 mg/kg, i.p.) and an aqueous extract (300 mg/kg, i.p.) of Ocimum sanctum leaves and found a significant ($P < 0.001$) decrease in cataleptic scores [44].

Anticataract effects

In the galactosemic cataract model in rats by 30% galactose and the naphthalene cataract model in rabbits by 1 g/kg naphthalene, the aqueous extract of fresh leaves of OS (1 g/kg and 2 g/kg) considerably postponed the development and subsequent maturation of cataract [45].

5. DISCUSSION

Dental caries is one of the most prevalent oral diseases in humans. Many preventative and therapeutic measures can be used to control it. measures[46]. Ayurvedic medications are a viable substitute for the prevention of dental caries [47]. Tulsi has been shown in Ayurveda to rich in antidiabitic, antibacterial, antifungal, and antioxidant properties, analgesic, cardioprotective, nontoxic, and extensively accessible across India [48] [49] [50].

6. CONCLUSION

Because of their great worth, herbal plants are utilized in India to treat and cure a variety of diseases. Ocimum sanctum, or tulsi, is regarded as a sacred plant. It is mostly used as a herbal tea and for medical purposes. Ayurvedic, Sidha, Greek, Roman, and Unani medical systems all use it. Numerous studies have revealed that the Ocimum sanctum plant has anti-ulcer, anti-stress, anti-fertility, anti-asthmatic, analgesic, antidiabetic, anti-inflammatory, antioxidant, antibacterial, and neuroprotective activities. The Tulsi plant has significant medical value and is used all over the world to cure a variety of illnesses, according to numerous, repeated scientific investigations.

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