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TULSI (OCIMUM SANCTUM), A JOURNEY FROM HOLY PLANT TO A MYRIAD MEDICINAL PLANT: A CONTEMPORARY REVIEW ON SECRETS BEHIND ITS INNUMERABLE BENEFITS

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Abstract

Tulsi, or Ocimum sanctum, is a common, useful plant that is also considered sacred in Hinduism and hence is always displayed in front of a Hindu home. In India, the spiritual, religious & therapeutic benefits of this Lamiaceae-family plant is extensively acknowledged. Throughout the second half of the 20th century, scientific enquiry into the traditional belief that Tulsi has medicinal properties accelerated. The plant's characteristic pungent, bitter, hot, light, and dry effects indicate that it has therapeutic properties. It is widely renowned and has been utilized for centuries in Ayurveda and Greek medicine due to its numerous therapeutic characteristics. Phytochemicals found in leaves, such as flavonoid, phenol, terpenoid, alkaloid, eugenol & others, provide the ability for target cells to overcome infection and produce these effects. Antimicrobial, pharmacological, medicinal, or nutritional properties of a plant, or even the exploitation of certain phytochemical levels, may contribute to a plant's ability to give cellular protection. This review aimed to offer an overview of the available information on Tulsi's religious significance, physiological characteristics, antibacterial qualities, pharmacological use, therapeutic applications, phytochemical analysis, neuropsychological influence, and biotechnology investigations.

Keyword: *Tulsi, Ocimum sanctum, therapeutic, study*

INTRODUCTION

Tulsi is recognized in ancient literature as a sacred and therapeutic herb [1]. The word Tulsi is derived from Sanskrit, where it signifies "unrivaled one." This plant be a member of Labiatae family due to its square stem & unique fragrance. Ocimum sanctum is the Latin name for the sacred Tulsi plant (Linn). Tulsi (Ocimum basilicum) plays a significant role in Indian Hindu culture & tradition. For the vast majority of religious holidays, it is garlanded and offered to the gods [2]. Tulsi, an aromatic herb in the Lamiaceae family, has been used for thousands of years. Nearly every family on the Indian subcontinent has some kind of basil plant in their home because of the many health, spiritual, and culinary benefits basil provides. It has been called "the unrivaled one, mother of natural medicine, & queen of herbs" [3,] among other titles. Because several types of basil—but especially "tulsi"—are revered in Hinduism, you may find basil in nearly every Indian Hindu home. The leaves are utilized in a variety of events, including births, weddings, religious rituals, and funerals [4-6].

The plant is cultivated throughout India, from the Andaman & Nicobar Islands to the Himalayas at altitudes as high as 1,800 metres above sea level. Moreover, it can be found in large numbers in a number of Arab nations, Malaysia, and Australia. The most prominent

species in the genus is Ocimum sanctum (Linn). The plant's leaves are regarded as extremely holy and are a common component of Hindu spiritual rites (Tirtha or Prasada) [7]. Black (Krishna Tulsi) & green (Rama Tulsi) varieties of Ocimum sanctum have similar chemical compositions [8]. There are similar therapeutic effects between the both.

Numerous traditional medical systems, including Ayurveda, Siddha, the Greek, Roman, and Unani, credit the herb with curative capabilities [9]. The Tulsi plant's leaves were traditionally used to make a juice that was used as a demulcent, stimulant, and expectorant. As well as treating earaches, bronchitis, skin infections [10], and other upper respiratory tract infections, tulsi was also utilized to treat these conditions.

Tulsi is helpful for the heart, the digestive system, and the lungs; it eases breathing problems and alleviates coughing. Charaka and Sushruta, two ancient authors, both mention its usage in treating snake and scorpion bites. As a result, every portion of the plant is functional. It is still common practice to employ this plant, or parts of it, for the treatment of a wide spectrum of disorders, with most of this practice being based on ancient knowledge.

Physiological analyses of Tulsi

The variations in photosynthetic efficiency discovered [11] show Sri Tulsi's ecological superiority over Krishna Tulsi. The study compared the general adaptability of Sri Tulsi & Krishna Tulsi, two morphotypes of Ocimum sanctum (holy basil). Synecological studies evaluate ecophysiological similarities and differences by analyzing parameters such as chlorophyll a fluorescence, pigment composition & proline content in photosystem II (PSII). The results show that when comparing Sri and Krishna Tulsi, the effective quantum yield of PSII in Sri Tulsi is 30% higher (F/Fm'stat) & the maximal apparent electron transport rate (ETRmax) is 35% higher. Sri Tulsi contains twice as much chlorophyll and carotenoids as Krishna Tulsi, according to the study authors. Another study was done between May and October of 2017 to discover the best time to harvest Ocimum sanctum (Tulsi) for extracting its photosynthetic pigments (Total Chlorophyll & total Carotenoids concentration) to use in pharmaceuticals [12]. The analysis of several seasons reveals that the autumn (October) season would have the highest amounts of photosynthetic pigments, while the rainy season would have the lowest levels (July). So, providing the necessary information for the extraction of these pigments from the fresh leaves of this incredibly helpful medicinal plant in the pharmaceutical & food industries to create herbal goods. The antioxidant properties of these two photosynthetic pigments make them effective against various cancers; they are also recommended for skin and eye problems [12].

Therapeutic Applications of Ocimum sanctum

There are numerous case studies describing the usage of natural resources, including plants, bacteria, fungi, yeast & honey. The ocimum sanctum plant is also a major component in many alternative medicine and herbal supplements. Therapeutic applications of Tulsi have been the subject of numerous investigations (in-vivo and in-vitro). Listed below are the studies that were reported:

1. Analgesic

The Ocimum sanctum plant's oil supposedly has pain-relieving effects. Mice were used in this study, and acetic acid was used to cause them to wriggle in various ways (tail flicking, tail clipping, and tail immersion). Evidently, the oil's inhibitory efficacy is due to the synergistic inhibition of acetylcholine, histamine & prostaglandin [13].

2. Anti-oxidant

O. sanctum demonstrated antioxidant activity in a trial with diabetic rats produced by streptozocin. It is believed that the plant's antioxidant capabilities come from a hydroalcoholic extract found in its leaves. The plasma level of thiobarbituric acid in the kidneys and liver was shown to be decreased [14] when diabetic rats produced by streptozocin were administered O. sanctum leaves for 30 days & the activity of the antioxidant enzyme catalase was shown to be increased.

3. Anti-ulcer

The O. sanctum plant showed antiulcer efficacy against histamine, aspirin, reserpine, serotonin, aspirin & indomethacin in rats [15]. According to the research, an aqueous extract of o. sanctum protected Wistar rats from developing stomach ulcers after being fed ethanol [16].

4. Anti-arthritic

Oil extracted from o. sanctum seeds has antiarthritic properties that alleviate the pain of arthritis caused by turpentine oil [17]. The experiment was conducted on a mouse model in order to determine the anti-arthritic activity.

5. Antitussive:

According to studies conducted on guinea pigs, both aqueous & methanolic extracts of the OS plant exhibited antitussive properties [18].

6. Hepatoprotective:

The paracetamol-induced liver damaged in albino rats was significantly mitigated by the hepatoprotective action that was demonstrated by the leaf extract of the O. sanctum plant [19].

Tulsi protected the liver from several experimentally caused damages. In rats with carbon tetrachloride-induced liver injury, the group treated with Tulsi extracts exhibited no mortality while the control group exhibited 60% mortality [20]. Tulsi ethanol extract protects experimental rats' livers from the toxicity of antitubercular drugs [21]. Tulsi ethanol extract has been shown to prevent paracetamol-induced liver injury. Experimental rats had significantly elevated serum enzyme levels (aspartate aminotransferase, alkaline phosphatase & acid phosphatase) & liver glutathione [22]. By assessing the activity of splenic leukocyte natural killer (NK) cells against the K-562 cell line, the cytotoxic potential of the polyherbal formulation "Imu-21," which consists of four herbs including Ocimum

sanctum, was determined. According to the findings, Imu-21 pretreatment for 7 days can stimulate NK cell activity in mice. Mature NK cells or NK cell precursors are likely activated, which leads to the proposed procedure.

7. Anti-stress:

In today's competitive environment, stress is a common problem. Stress-induced increases in the generation of free radicals have negative impacts on numerous essential organs and tissues. Adaptogen refers to the plant compound that increases the condition of non-specific resistance to multiple stimuli. Given to mice and rats, the ethanolic extract (dry entire plant) of Tulsi boosted athletic endurance and enhanced the healing of experimentally created ulcers. In addition to preventing hepatotoxicity & leukocytosis, ethanolic extract at a dose of 100 mg/kg body weight avoided hepatotoxicity & leukocytosis. Animals have been subjected to a wide variety of stimuli, including the swimming endurance test, milk-induced leukocytosis, aspirin-induced ulcers, and carbon tetrachloride-induced hepatotoxicity [23]. When mice were subjected to swimming and gravity stress, Tulsi ethanolic extract administered at a dose of 20 mg/kg, bw for 7 days boosted the synthesis of adrenaline, noradrenaline & monoamine oxidase while lowering the levels of dopamine & 5-hydroxytryptamine (serotonin) [24]. According to rabbit studies [25], the leaves of O. sanctum show antistress properties.

8. Anti-plasmodial:

Ocimum sanctum root & leaf extract was found to have antiplasmodial activity [26] because to the existence of ethanolic extract including mostly flavonoid, phenol, saponin, alkaloid, glycoside, proteins, resins, steroids, and triterpenenoids.

9. Memory Enhancer:

Extracts of O. sanctum leaves, both aqueous and alcoholic, were tested for their antidementia and anticholinesterase effects on rats. Dementia was induced with electroshock, atropine, and cyclosporine. It has been claimed that the inactive constraint [27] was employed to evaluate long-term memory.

10. Immunomodulatory:

The immune system is said to be strengthened by consuming a fresh O. sanctum leaf. This topic has been investigated through animal research. When attacked with typhoid H-antigen & sheep red blood cells (SRBCs), both groups of rats cured with a methanolic extract of O. sanctum had higher antibody titres compared to rats treated with saline. In the experiment for Erythrocyte (E)-rosette generation, O. sanctum-treated groups produced considerably more E-rosette than untreated groups [28].

Experiment mice showed enhanced humoral immune responses after being given O. sanctum leaf extract. Passive cutaneous anaphylaxis in rats was used to detect anti-sheep red blood cell (anti-SRBC) haemagglutination titre & IgE antibody titre, proving the point. O. sanctum leaf extract inhibited histamine release from sensitised rat peritoneal mast cells in response to

in vitro antigen (egg albumin) [29]. Blood cell production, as well as that of white blood cells, haemoglobin, and antibodies, was increased in mice fed O. sanctum leaves [30].

Twenty-three buffaloes with confirmed cases of bovine mastitis were also studied to determine the therapeutic efficacy of O. sanctum seed oil. Four groups of rats were given distinct intra-mammary treatments for a period of three to five days each. Liquid paraffin was administered daily to 3 ml/teat in Group I (n=5). A daily dose of 3 milliliters per tetrapod (n=6) of oil extracted from O. sanctum seeds was given to Group II. Cloxacillin (200 mg) was given to Group III (n=6) together with O. sanctum seed oil, while Group IV (n=6) received cloxacillin (200 mg) alone. Complete healing occurred in 5 days for the fixed oil group, 4 days for the antibiotics group & 3 days for the combo group. Evidence like this suggests that fixed oil may also be effective in treating bovine mastitis [31].

11. Anti-fertility:

It has been observed that the tulsi leaves has antifertility properties. In the experiment with albino rats, the model was given a tulsi leaf extract in benzene for 48 days. Sperm count and motility decreased, according to the findings [32,33].

12. Antifungal:

The antifungal activity of linalool & methyl chavicol, produced from the essential oil of tulsi leaves, was studied & detected to be effective against experimentally isolated dermatophytes [34].

Antimicrobial studies in Tulsi

Holy Basil, also known as Ocimum sanctum, possesses numerous pharmacological actions, such as anti-toxic, anti-oxidant, anticancer, antibacterial, antihypertensive, anti-inflammatory, anticoagulant, analgesic, & antithyroid properties [35,36]. Components including such as isothymusin, apigenin, rosmarinic acid, cirsineol & eugenol are phenolic in O. sanctum leaf extract [37]. O. sanctum leaf aqueous extracts are significantly more efficient against infections than methanolic extracts [38-42]. O. sanctum leaf extract has strong anti-oxidant properties and can halt the development of Escherichia coli, Klebsiella, Staphylococcus aureus, and Proteus [41].

The antibacterial activity of methanolic tulsi & neem leaf extracts was examined in another work [43]. Tulsi (Ocimum sanctum) leaf extract was found to be more effective against Gram-positive (S. aureus) bacteria than neem (Azadirachta indica) leaf extract against Gram-negative (E. coli) bacteria. By using methanol as a solvent and powdered dried leaves in a cold maceration extraction procedure, phytochemical extracts have been created. After 24 hours of incubation at 37ºc Celsius, zones of inhibition were observed in the medium where phytochemical extracts of neem & tulsi had been dispersed. An examination of statistical data revealed that while neem was efficient against E. coli, tulsi was more effective against S. aureus. MIC values for tulsi and neem were 0.4 g/ml & 0.2 g/ml, respectively, against the two bacteria. When tulsi and neem extracts were combined in equal volumes at each concentration, they exhibited greater antibacterial activity than either extract alone, and their

MIC was decreased to 0.2 g/ml against both bacteria. Both A. indica & O. sanctum leaf extracts have been demonstrated to be efficient against E. coli & S. aureus. It has been demonstrated that O. sanctum is more efficient against E. coli than A. indica is against S. aureus (represented by the zone of inhibition).

Clinical isolates of multidrug-resistant gram-negative bacteria & the antibacterial properties of methanol extracts of medicinal herbs [44]. Utilizing a modified Kirby-Bauer disc diffusion technique for antibiotic susceptibility testing, MDR potential was determined for Gram-negative bacteria isolated from a variety of clinical samples. 6 herbal remedies, such as *Acorus calamus (bojho), Ocimum sanctum (tulsi), Azadirachta indica (neem), Cinnamomum tamala (tejpatta), Aloe vera* & *Zanthoxylum alatum (timur)*, had their methanol extracts examined for their antibacterial activity against multidrug-resistant bacteria. A wide variety of bacteria, including E.coli, K. pneumoniae, Citrobacter species, Proteus mirabilis, Proteus vulgaris, Acinetobacter species, and Pseudomonas species, were found in clinical samples, with E. coli predominating. The zones of inhibition for Z. alatum, C. tamala, and Ocimum sanctum were 9, 11, and 13 mm, respectively, out of a total of 6. The antibacterial properties of medicinal plants can serve as an alternate source of treatment for MDR Gram-negative bacteria. Antimicrobial-resistant (MDR) Gram-negative bacteria can be killed by a variety of botanical plant extracts. Plant extracts' antibacterial activity may differ depending on the plant used and the method of extraction used. Consequently, it demonstrates that a proper extraction procedure and the usage of a purified product are vital for maximizing the benefits of plant extract.

Phytochemical analysis of Tulsi

Borah et al. (2018) [45] analyzed tulsi leaf phytochemical constituents. 50 grammes of Tulsi powder was introduced to the thimble of a Soxhlet apparatus containing methanol, ethanol & distilled water for each experiment. The relative percentage yields were 8%w/w, 7%w/w & 5%w/w. In the study, secondary metabolites including carbohydrate, tannin, flavonoid, saponin, glycoside, terpenoid, fatty acids & phenol were found in tulsi leaf extract. Quantitative studies have explored that the Tulsi leaf contains phenols at a concentration of between 1.6% and 7.6%. As a result, alkaloid and flavonoid concentrations ranged from 0.91 and 1.28 percent, respectively, whereas flavonoid concentrations went from 1.5 and 2.24 percent. GC-MS analysis of the methanolic extract revealed numerous significant constituents, including eugenol, benzene, 1, 2-dimethoxy- 4- (2- propenyl), - farnesene & 1, 2, 4-triethyl cyclohexane. It has been proven that these phytochemicals provide a wide range of health benefits, including those that are antibacterial, antifungal, antiviral, antifungal, antifungal, antistress, immunomodulatory, hypoglycemic, hypotensive, & antioxidant.

A phytochemical screening experiment using methanol fractions revealed that crude extracts of Ocimum tenuiflorum L. leaves contained no steroid or terpenoid [46]. Even ethanol & butanol fractions failed the screening test for steroid presence. HPLC analysis of crude extracts and fractions isolated from those extracts showed the presence of bioactive compounds that may control blood sugar levels. These extracts helped diabetic rats keep their blood glucose levels regular since they contained polyphenolic active components like 3,4-

dimethoxycinnamic acid, caffeic acid, diosmetin, luteolin, kaempferol, rosmarinic acid, apigenin, and genistein. Further research into extracting the active components may hasten the development of novel drugs for treating diabetes and its complications, as shown in this study.

There is evidence that phytochemical analysis of methanol & aqueous extracts of O. sanctum, A. indica, and P. emblica can be used to produce antibacterial compounds for use in phytomedicines [47]. Tannin, saponin, flavonoid, glycoside, reducing sugar, steroid, & alkaloids were among the phytoconstituents examined. The purpose of this investigation was to discover new antibacterials derived from plants that could replace synthetic drugs while maintaining their therapeutic potential.

Pharmacological application of Tulsi

Anticancer activity

Several studies [48-51] have demonstrated the anticancer activity of OS. Enzymes such cytochrome P 450, cytochrome b5, aryl hydrocarbon hydroxylase, and glutathione S-transferase (GST) remove carcinogens and mutagens from the body [52]. OS leaf alcoholic extract (AlE) has a modulatory effect on several enzymes. OS exhibited anticancer efficacy against human fibrosarcoma cells in vitro, with cytotoxicity produced by AlE at doses of 50 g/ml and higher. The cytoplasm and nucleus of the cells were shrunken. When the DNA was examined in agarose gel electrophoresis, it was discovered to be fragmented [53]. Both benzo(a)pyrine- & 3'-methyl-4-dimethylaminoazo-benzene-induced forestomach neoplasias in mice and hepatomas in rats were significantly decreased by OS [54]. Scientific studies have shown that the AlE in OS leaves can prevent the development of cutaneous papillomas in mice that have been induced artificially [55]. The frequency of tumours, the avg. number of papillomas per animal & the overall number of papillomas were all significantly reduced when Tulsi leaf extract was applied topically to DMBA-treated mice. When applied topically, the extract significantly elevated low levels of both GSH & GST activity [56]. Eugenol, a flavonoid found in various plants, including Tulsi [57], was discovered to have a comparable effect. Oral treatment of tulsi leaf paste may inhibit the initial stages of DMBA-induced buccal pouch carcinogenesis [58]. Chemical carcinogenesis can be prevented or stifled by using OS leaf extract [59]. This is accomplished by inhibiting the carcinogen's metabolic activity. OS suppressed both Ehrlich ascites carcinoma (EAC) & S 180 tumours in Swiss albino mice [60].

Central Nervous System (CNS) depressant activity

Pentobarbital (40 mg/kg ip) treatment in mice resulted in a prolonged period of lost reflex, a longer time until electroshock recovery & a reduction in the recovery time & intensity of

electroshock & pentylenetetrazole-induced convulsions. It also reduced fighting time & ambulation induced by apomorphine in "open field" experiments. OS extract increased swimming time at high doses, indicating CNS stimulant and/or antistress activity. Comparable to the antidepressant desipramine [61], the impact was remarkably similar. It has been demonstrated that OS fixed oil (2-3 ml/kg, i.p.) prolongs the sleep induced by pentobarbitone in rats. Fixed oil may increase the duration of pentobarbitone-induced sleep by decreasing its hepatic metabolism & renal clearance [62].

Contraceptive studies

In search of a secure herbal contraceptive, the characteristics of the Tulsi plant have been thoroughly examined in experimental animals. Despite the fact that some alterations have been reported, this plant cannot be considered a real contraceptive. Fresh Tulsi leaves (465 mg/kg, bw, daily) were discovered to increase total body weight while reducing the size of the testes, prostate & adrenal glands in rats fed the herb for a prolonged period. Fresh leaves caused changes in spermatogenic cells, including a reduction in pH, a hypotonic environment, & chemical compounds including mucoproteins, alkaline phosphatase,& acid phosphatase, which all contributed to the generation of non-viable spermatozoa when ingested. Male mice were capable of mating, but no offspring were produced [63]. Treatment with 100, 150, or 200 mg/kg, bw of benzene extract of Ocimum sanctum leaves for 15 days significantly affected testicular weight, while having no effect on the epididymis, seminal vesicle, prostate, or vas deferens. Sperm production & activity were successfully inhibited [64]. Tulsi leaves (20, 200 & 400 mg/100 g, bw) administered to male rats for three months lowered sperm count, motility, & organ weight, but had no impact on the organ weight of female rats. After two months of therapy, the mating behavior of experimental rats decreased, but few of the female rats that did mate carried normal pregnancies to term and gave birth to babies of normal weight and without birth abnormalities. Tulsi powder may lower testosterone levels in two ways: by inhibiting the production of LHRH (leutinizing hormone releasing hormone) and so blocking the release of LH (leutinizing hormone), which is necessary for a mating response [65]. Both 200 & 400 mg/kg bw significantly suppressed reproductive behavior in male rats for 15 days. After administering escalating doses, the sexual behavior of experimental rats was tracked by noting various behaviors, including such as grooming, pursuit, mounting, intromission & ejaculation.

Neurocognitive Impact

There were statistically significant changes in mood and/or cognitive function across all age groups, sexes, formulations, doses, and research quality in the four trials that found neurocognitive effects [67-70]. Forty healthy young adults (aged 17 to 30) participated in a randomized, placebo-controlled clinical trial, where their cognitive performance was assessed. After 4 weeks of therapy with 300 mg of tulsi daily, subjects showed enhanced cognitive flexibility, short-term memory & attention [68]. The tulsi group and the placebo group did not differ significantly in their stress levels. On the other hand, three clinical research [69,70] discovered that greater tulsi dosages spread out over a longer period of time greatly reduced anxiety and tension. There have been three studies indicating the positive

effects of tulsi on mood, with two of them showing significant decreases in overall stress-related symptoms in persons with psychosomatic diseases compared to a control group, at the 31.6% and 39.0% levels respectively.

Genome sequencing studies in Tulsi

Ocimum is commonly utilised in Ayurvedic, Siddha, Unani, and traditional Chinese medicine. The phenylpropanoids, terpenoids & their derivatives found in abundance in Tulsi provide it a long list of medicinal uses. The whole genome sequence data is useful for more than just pinpointing the genes needed to produce therapeutic molecules; it also helps locate genes not previously linked with the synthesis of significant secondary metabolites in this plant, which opens the door to their production via synthetic biology methods. The researchers analyzed genomic data and concluded that O. sanctum is most closely linked to Salvia miltiorrhiza, a common Chinese medicinal herb [71].

The preliminary genomic sequence of Ocimum tenuiflurum L. can be found at [72]. (subtype Krishna Tulsi). The whole genome sequencing data was 374 Mb in size, representing 61% of the genome, and was obtained utilising paired-end & mate-pair sequence libraries using the Illumina Hiseq 1000. (612 Mb projected genome size). As previously described, comparing the transcriptomes (RNA-Seq) of the Krishna & Rama Tulsi (subtypes of O. tenuiflorum) revealed differences in gene expression. The expression of six candidate genes was verified in many tissues from five distinct species using quantitative real-time polymerase chain reaction (q-RT-PCR). Urosolic acid-producing genes were found to be highly represented in Rama subtype immature leaves. Due to the existence of eugenol & ursolic acid, these results demonstrate that these substances have the potential to treat a variety of illnesses, such as cancer, utilizing mass spectrometry.

Nanotechnological studies in Tulsi

In today's materials science, nanotechnology is the most actively studied topic. Although many chemical and physical methods exist, green production of nanomaterials is the fastest growing approach. Nanoparticles carrying extracts from the leaves of 'tulsi,' an Indian basil plant, have been used to coat the fabric, resulting in a novel type of antibiotic cotton discovered by the researchers (Ocimum sanctum).

Ocimum sanctum (Tulsi) leaf broth has been used in an attempt to synthesize silver nanoparticles (AgNPs) with antibacterial properties [73]. UV-Vis spectroscopy, transmission electron microscopy (TEM) & X-ray diffractometry are all used to characterise AgNPs and learn about their properties. TEM analysis revealed that the produced NPs had a mean particle size of 18 nm. An abundance of reducing entities were found through qualitative analysis of leaf extract's reducing potential. Analyses of the FTIR spectra of the extract demonstrated that the eugenols, terpenes & other aromatic chemicals kept the AgNPs stable. Staphylococcus aureus and Escherichia coli were two of the bacteria that benefited from the enhanced antibacterial effectiveness of these AgNPs stabilized by Tulsi leaf extract.

Ocimum sanctum L. leaf extracts were investigated for their potential use in the production of silver nanoparticles (SNPs) or green nanoparticles (Green-Silver) in an aqueous solution [74]. Several instruments, including a UV-vis Spectrophotometer, XRD, FTIR & TEM, were used to examine the generated silver nanoparticles and determine their properties (SNPs). X-ray diffraction & Fourier transform infrared spectroscopy showed the presence of methoxy & allyl groups in SNPs, while UV-vis spectroscopy revealed that the particles were round and had a diameter of 15-45 nm based on the SPR optical absorption band peak at 440 nm. Ocimum sanctum L. leaves contain several anti-oxidants of diverse structures and functions, which contribute to the lowering of Ag metal ions. This current research opens the door to a novel approach for advancing our awareness of how SNPs might be tuned to enhance human antibacterial activity.

CONCLUSION

Tulsi (Ocimum sanctum) is the most sacred & valuable medicinal plant in the world, having been employed for ages to cure bacterial, viral, fungal, & insecticidal disorders. Many therapeutic qualities of O. sanctum are advantageous to human health without causing adverse effects. So, this plant's favourable characteristics distinguish it from others. The leaf extract of Tulsi contains antimicrobial properties. The O. sanctum plant is readily available & non-toxic; therefore, it has piqued the curiosity of scientists. Many studies have found that the extract & essential oil of Tulsi (O. sanctum) leaves are effective antimicrobials. The available facts & evidences from the aforementioned research and results strongly imply that Tulsi is a truly beneficial & medicinal plant for a broad range of disorders, including common ailments & cancer-like diseases that are a threat to humanity. The data presented here may reaffirm Tulsi's therapeutic potential, but more study of this sacred plant using the latest techniques and technology is needed to fully understand the mechanisms at work in its healing abilities.

REFERENCES

1. Kirtikar KR, Basu BD. Indian Medicinal Plant 1975; 2nd Ed. Vol. 3. Bishen Singh Mahendra Pal Singh, New Connaught Place, Dehradun, (Uttarakhand) (India). p. 1965–1968.
2. Desi Wisdom, 2018 Holy Basil leaves of Tulsi. Online article https://www.thehealthsite.com/topics/desi-wisdom/
3. Ashok Kumar Sah, M Vijaysimha and Md. Mahamood. 2018. The Tulsi, Queen of Green Medicines: Biochemistry and Pathophysiology – A Review. International Journal of Pharmaceutical Sciences Review and Research 50(2): 106-114. ISSN 0976 – 044X.

4. Majupuria TC and Joshi DP. 1997 Religious & Useful Plants of Nepal and India Bangkok: Craftsman, pp: 44-45.
5. Pandey BP. 1989 Sacred Plants of India: Plants for Human Kind. New Delhi: Shree publications edition, pp: 34-35.
6. Simoons J F. 1998 Plants of Life, Plants of Death Madison: University of Wisconsin Press; pp: 38- 39.
7. Ghosh GR. Tulasi (N.O. Labiatae, GenusOcimum). New Approaches to Medicine and Health (NAMAH) 1995; 3: 23–29.
8. Phillip MP, Damodaran NP. Chemo-types of Ocimum sanctum Linn. Indian Perfumer 1985; 29: 49–56.
9. Gupta SK, Jai Prakash, Srivastava S. Validation of traditional claim of Tulsi, Ocimum sanctum Linn. as a medicinal plant. Indian J Exp Biol 2002; 40: 765–773.
10. Harsa BH, Hebbar SS, Shripathi V, Hedge GR. Ethnobotany of Uttara Kannada district in Karnataka, India – plants in treatment in skin diseases. J Ethnopharmacol 2003; 84: 37–40.
11. Batra N. G, N. Kumari and V. Sharma. 2016 Photosynthetic Performance of Ocimum sanctum Morphotypes in a Semiarid Region. Journal of Herbs, Spices and Medicinal Plants. 22 (3): 211-224. https://doi.org/10.1080/10496475.2016.1163309.
12. Subham Banik, Ranjita Mukherjee, Pranabesh Ghosh, Srabani Karmakar and Sirshendu Chatterjee. 2018 Estimation of plant pigments concentration from tulsi (Ocimum sanctum Linn.): a six months study. Journal of Pharmacognosy and Phytochemistry; 7(4): 2681-2684.
13. Singh S, Majumdar DK. Analgesic activity of Ocimum sanctum and its possible mechanism of action. International journal of Pharmacognosy. 1995.
14. Muralikrishnan G, Pillai SK, Shakeel F. Protective effects of Ocimum sanctum on lipid peroxidation and antioxidant status in streptozocin-induced diabetic rats. Natural product research. 2012.
15. Pandey G, Madhuri S. Pharmacological activities of Ocimum sanctum (tulsi): a review. Int J Pharm Sci Rev Res. 2010.
16. Ghangale GR, Tushar M, Jadhav ND. Evaluation of antiulcer activity of Ocimum sanctum in rats. Veterinary world. 2009.
17. Singh S, Majumdar DK. Effect of fixed oil of Ocimum sanctum against experimentally induced arthritis and joint edema in laboratory animals. International Journal of Pharmacognosy. 1996.
18. Nadig P, Laxmi S. Study of anti-tussive activity of Ocimum sanctum Linn in guinea pigs. Indian journal of physiology and pharmacology. 2005.
19. Lahon K, Das S. Hepatoprotective activity of Ocimum sanctum alcoholic leaf extract against paracetamol-induced liver damage in Albino rats. Pharmacognosy research. 2011.
20. Bhargava KP, Singh N. Anti-stress activity of Ocimum sanctum Lin. Indian J Med Res 1981; 73: 443–451.

21. Ubaid RS, Anantrao KM, Jaju JB, Mateenuddin MD. Effect of Ocimum sanctum leaf extract on hepatotoxicity induced by antitubercular drugs in rats. Indian J Physiol Pharmacol 2003; 47: 465–470
22. Chattopadhyay RR, Sarkar SK, Ganguly S, Medda C, Basu TK. Hepato-protective activity of Ocimum sanctum leaf extract against paracetamol induced hepatic damage in rats. Indian J Pharmacol 1992; 24: 163–165.
23. Bhargava KP, Singh N. Anti-stress activity of Ocimum sanctum Lin. Indian J Med Res 1981; 73: 443–451.
24. Singh N, Mishra N, Srivastava AK, Dixit KS, Gupta GP. Effect of anti stress plants on biochemical changes during stress reaction. Indian J Pharmac 1991; 23: 137–142.
25. Jyoti S, Satendra S, Sushma S, Anjana T, Shashi S. Antistressor activity of Ocimum sanctum (Tulsi) against experimentally induced oxidative stress in rabbits. Methods and findings in experimental and clinical pharmacology. 2007.
26. Inbaneson SJ, Sundaram R, Suganthi P. In vitro antiplasmodial effect of ethanolic extracts of traditional medicinal plant Ocimum species against Plasmodium falciparum. Asian Pacific Journal of tropical medicine. 2012.
27. Giridharan VV, Thandavarayan RA, Mani V, Ashok Dundapa T, Watanabe K, Konishi T. Ocimum sanctum Linn. leaf extracts inhibit acetylcholinesterase and improve cognition in rats with experimentally induced dementia. Journal of medicinal food. 2011
28. Godhwani S, Godhwani JL, Vyas DS. Ocimum sanctum – a preliminary study evaluating its immunoregulatory profile in albino rats. J Ethanopharmacol 1988; 24: 193–198.
29. Mediratta PK, Devan V, Bhattacharya SK, Gupta PC, Maiti PC, Sen P. Effect of Ocimum sanctum Linn. on humoral immune response. Indian J Med Res 1988; 87: 384–386.
30. Joshi H, Parle M. Cholinergic basis of memory improving effect of Ocimum tenuiflorum Linn. Indian journal of pharmaceutical sciences. 2006.
31. Singh S, Majumdar DK, Singh JP. Studies of therapeutic efficacy of fixed oil of Ocimum sanctum in bovine mastitis. Indian Vet J 1995; 72: 867–869.
32. Ahmed M, Ahamed RN, Aladakatti RH, Ghodesawar MA. Effect of benzene extract of Ocimum sanctum leaves on cauda epididymal spermatozoa of rats. Iranian journal of reproductive medicine. 2011.
33. Sethi J, Yadav M, Sood S, Dahiya K, Singh V. Effect of tulsi (Ocimum Sanctum Linn.) on sperm count and reproductive hormones in male albino rabbits. International journal of Ayurveda research. 2010.
34. Pandey G, Madhuri S. Pharmacological activities of Ocimum sanctum (tulsi): a review. Int J Pharm Sci Rev Res. 2010.
35. H. Skaltsa, S. Philians and M. Singh, Phytochemical study of the leaves of Ocimum sanctum, Fitoterapia, 1987, 8: 286.
36. N. Dev, A. K. Das, M. A. Hossain and S. M. M. Rahman, Chemical Compositions of Different Extracts of Ocimum basilicum Leaves, J Sci Res., 2011, 3: 197- 206.

37. N. Singh, P. Verma, B. R. Pandey and M. Bhalla, Therapeutic Potential of Ocimum sanctum in Prevention and Treatment of Cancer and Exposure to Radiation: An Overview, Int J Pharm Sci Drug Res., 2012, 4: 97-104.
38. P. Bhattacharyya and Bishayee, An Ocimum sanctum Linn. (Tulsi): an ethno medicinal plant for the prevention and treatment of cancer, Anticancer Drugs, 2013, 24: 659-666.
39. C. Pasha, S. Sayeed, S. Al Md, and Md. Z. Khan, Anti-salmonella Activity of Selected Medicinal Plants, Turk. J. Biol., 2009, 33: 59-64.
40. B. Joshi, G. P. Sah, B. B. Basnet, M. R. Bhatt, D. Sharma, K. Subedi, J. Pandey and R. Malla, Phytochemical extraction and antimicrobial properties of different medicinal plants: Ocimum sanctum (Tulsi), Eugenia caryophyllata (Clove), Achyranthes bidentata (Datiwan) and Azadirachta indica (Neem), J. Microbiol. Antimicrob., 2011, 3(1): 1-7.
41. E. M. Williamson, Major herbs of Ayurveda, Londen: Churchill Livingstone, 2002.
42. V. D. M. Geeta, R. Kedlaya, S. Deepa and M. Ballal, Activity of Ocimum sanctum (the traditional meditional plant) against the enteric pathogens, Ind. J. Med. Sci., 2001, 55: 434- 438.
43. Vipul Kumar, Anurag Chakraborty, Manpreet Kaur, Sony Pandey and Manoj Kumar Jena. 2018 Comparative Study on Antimicrobial Activity of Tulsi (Ocimum sanctum) and Neem (Azadirachta indica) Methanol Extract. Asian Journal of Pharmacology Clinical Research 11(12): 514-517.
44. Bishnu Thapa, Anjana Singh and Reshma Tuladhar. 2018 In vitro Antibacterial Effect of Medicinal Plants against Multidrug Resistant Gram Negative Bacteria. Tribhuvan University Journal of Microbiology 5(1): 25-31. DOI: https://doi.org/10.3126/tujm.v5i0.22298.
45. Borah, R., & Biswas, S. P. (2018). Tulsi (Ocimum sanctum), excellent source of phytochemicals. *International Journal of Environment, Agriculture and Biotechnology*, *3*(5), 265258.
46. Leila Mousavi, Rabeta Mohd Salleh and Vikneswaran Murugaiyah. 2018 Phytochemical and bioactive compounds identification of Ocimum tenuiflorum leaves of methanol extract and its fraction with an anti-diabetic potential, International Journal of Food Properties, 21(1): 2390- 2399. DOI: 10.1080/10942912.2018.1508161.
47. Anjali, T., Ankit, P., & Verma, O. P. (2016). Phytochemical screening of Ocimum sanctum (Tulsi), Azadirachta indica (Neem) and Phyllanthus emblica (Amla). *Asian journal of bio science*, *11*(1), 28-31.
48. Madhuri S. Studies on oestrogen induced uterine and ovarian carcinogenesis and effect of ProImmu in rats. PhD thesis, Rani Durgavati Vishwa Vidyalaya, Jabalpur, MP, India: 2008.
49. Madhuri S., Pandey Govind. Effect of ProImmu, a herbal drug on estrogen caused uterine and ovarian cytotoxicity. biomed 5(1):2010,57-62.
50. Pandey Govind. An overview on certain anticancer natural products. J Pharm Res 2(12):2009,1799-1803.

51. Pandey Govind, Madhuri S. Autochthonous herbal products in the treatment of cancer. Phytomedica 7:2006,99-104.
52. Pandey Govind, Madhuri S. Medicinal plants: Better remedy for neoplasm. Indian Drug 43(11):2006,869-874.
53. Kathiresan K, Guanasekan P, Rammurthy N, Govidswami S. Anticancer activity of Ocimum sanctum. Pharmaceutical Biology 37(4):1999,285-290.
54. Aruna K, Sivaramakrishnan VM. Anticarcinogenic effects of some Indian plants products. Food Chem Toxicol 30:1992,953.
55. Uma Devi P. Radioprotective, anticarcinogenic and antioxidant properties of the Indian holy basil, Ocimum sanctum (Tulasi). Indian J Exp Biol 39:2001,185-190.
56. Prashar R, Kumar A, Banerjee S, Rao AR. Chemopreventive action by an extract from Ocimum sanctum on mouse skin papillomagenesis and its enhancement of skin glutathione-S-transferase activity and acid soluble sulfhydryl level. Anticancer Drugs 5:1994,567-572.
57. Sukumaran K, Unnikrishnan MC, Kuttan R. Inhibition of tumour promotion in mice by eugenol. Indian J Physiol Pharmacol 38:1994,306.
58. Karthikeyan K, Ravichadran P, Govindasamy S. Chemopreventive effect of Ocimum sanctum on DMBA-induced hamster buccal pouch carcinogenesis. Oral Oncol 35(1):1999, 112-119.
59. Prashar R, Kumar A, Hewer A, Cole KJ, Davis W, Phillips DH. Inhibition by an extract of Ocimum sanctum of 7, 12-dimethylbenz(a)anthracene in rat hepatocytes in vitro. Cancer Lett 128(2):1998,155-160.
60. Somkuwar AP. Studies on anticancer effects of Ocimum sanctum and Withania somnifera on experimentally induced cancer in mice. PhD thesis, JNKVV, Jabalpur, MP, India: 2003
61. Sakina MR, Dandiya PC, Hamdard HE, Hameed A. Preliminary psychopharmacological evaluation of Ocimum sanctum leaf extract. J Ethnopharmacol 28:1990,143.
62. Singh S, Rehan HMS, Majumdar DK. Effect of Ocimum sanctum fixed oil on blood pressure, blood clotting time and pentobarbitone-induced sleeping time. J Ethnopharmacol 78:2001,139
63. Kasinathan S, Ramakrishnan S, Basu SL. Antifertility effect of Ocimum sanctum L. Indian J Exp Biol 1972; 10: 23–25.
64. 91. Seth SD, Johri N, Sundaram KR. Anti-spermic effect of Ocimum sanctum. Indian J Exp Biol 1981; 19: 975–976.
65. Khanna S, Gupta SK, Grover JK. Effect of long term feeding of Tulsi (Ocimum sanctum L) on reproductive performance of adult albino rats. Indian J Exp Biol 1986; 24: 302–304.
66. Kantak SM, Gogate MG. Effect of short-term administration of Tulsi (Ocimum sanctum) on reproductive behavior of adult male rats. Indian J Physiol Pharmacol 1992; 36: 109–111.

67. Verma A. K., Dubey G. P., Agrawal A. Biochemical studies on serum Hb, Sugar, Urea and lipid profile under influence of ocimum sanctum L in aged patients. *Research Journal of Pharmacy and Technology.* 2012;5(6):791–794.
68. Sampath S., Mahapatra S. C., Padhi M. M., Sharma R., Talwar A. Holy basil (Ocimum sanctum Linn.) leaf extract enhances specific cognitive parameters in healthy adult volunteers: a placebo controlled study. Indian Journal of Physiology and Pharmacology. 2015;59(1):69–77.
69. Saxena R. C., Singh R., Kumar P., et al. Efficacy of an extract of ocimum tenuiflorum (OciBest) in the management of general stress: A Double-blind, Placebo-controlled Study. Evidence-based Complementary and Alternative Medicine. 2012;2012:7. doi: 10.1155/2012/894509.894509
70. Bhattacharyya D., Sur T. K., Jana U., Debnath P. K. Controlled programmed trial of Ocimum sanctum leaf on generalized anxiety disorders. Nepal Medical College Journal. 2008;10(3):176–179.
71. Subhra Priyadarshini, 11 September 2015 Indian holy basil hot favourite of genomic scientists. Published online DOI:10.1038/nindia.2015.126
72. Upadhyay Atul K., Anita R. Chacko, A. Gandhimathi, Pritha Ghosh, K. Harini, Agnel P. Joseph, Adwait G. Joshi, Snehal D. Karpe, Swati Kaushik, Nagesh Kuravadi, Chandana S Lingu, J. Mahita, Ramya Malarini, Sony Malhotra, Manoharan Malini, Oommen K. Mathew, Eshita Mutt, Mahantesha Naika, Sathyanarayanan Nitish, Shaik Naseer Pasha, Upadhyayula S. Raghavender, Anantharamanan Rajamani, S Shilpa, Prashant N. Shingate, Heikham Russiachand Singh, Anshul Sukhwal, Margaret S. Sunitha, Manojkumar Sumathi, S. Ramaswamy, Malali Gowda and Ramanathan Sowdhamini. 2015 Genome sequencing of herb Tulsi (Ocimum tenuiflorum) unravels key genes behind its strong medicinal properties. BMC Plant Biology 15:212. DOI 10.1186/s12870-015-0562-x.
73. Charusheela Ramteke, Tapan Chakrabarti, Bijaya Ketan Sarangi, and Ram-Avatar Pandey. 2013 Synthesis of Silver Nanoparticles from the Aqueous Extract of Leaves of Ocimum sanctum for Enhanced Antibacterial Activity. Hindawi Publishing Corporation Journal of Chemistry (278925): 7. http://dx.doi.org/10.1155/2013/278925.
74. Bindhani BK and Panigrahi AK. 2015 Biosynthesis and Characterization of Silver Nanoparticles (SNPs) by using Leaf Extracts of Ocimum sanctum L (Tulsi) and Study of its Antibacterial Activities. Journal of Nanomedicine and Nanotechnology S6: 008. doi:10.4172/2157- 7439.S6-008.