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Bioactive Phytocompounds of Ocimum sanctum and their Multifaceted Pharmacological Properties: A Mini-Review

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Abstract

In traditional healthcare system, medicinal plants are widely used for curing various diseases by utilizing different parts of plants (leaves, steam, flower, roots and seeds). Ocimum sanctum (Holy basil) is recognized as queen of herbs that is bestowed with many therapeutical properties and used for treating several ailments such as cancer, diabetes, anemia, diarrhea and bacterial infections. The present study reviewed the chemical composition of essential oil and solvent-soluble extracts and pharmacological activities of O. sanctum. The bioactive components identified from oil includes camphene, sabinene, thymol, carvacrol, eugenol ocimene, with eugenol being the most active constituents responsible for biological actions. The different extracts of Holy basil contain fatty acids (oleanolic acid, stearic acid, sinapic acid), flavonoids (luteolin, orientin, quercetin), tannins, saponins that are embarked with several therapeutic potential as anti-cancer, antibacterial, antioxidant, anti-diabetic agents. The pharmacological properties reported in the present review confirm the curative measures of O. sanctum and the studies supported the use of this plant for human and animal pharmacotherapy. However, despite the widespread pharmacological activities of O. sanctum, experimental human clinical trials are needed for establishing the effective and safe doses for treating various diseases.

Keywords: Ocimum sanctum, Phytochemical constituents, Holy basil, bioactive compounds, Pharmacological activities.

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1. Introduction

Plants have been an instant solution to the humans' significant problems from providing raw materials to ensuring a sustainable environment and medicinal plants have been integral parts to traditional health system since ages (Ezeorba et al., 2024). Among these, *Ocimum sanctum*, commonly known by the name of Holy Basil, stands out due to its profound cultural and medicinal significance and is a cornerstone of Hindu traditions and beliefs(Yadav et al., 2024). The *Ocimum* is a vast genus belonging to family Lamiaceae and consisting of more than 160 species that are cultivated all over the temperate regions of the world. The species *Ocimum sanctum* is commercially cultivated in several countries of East Asia, America and Australia for food and essential oils (Vasudevan et al., 2001).

Botanically, it is an aromatic herb and has extensive utilization in traditional medicines, as its leaves are rich in methyl eugenol, phenolics, neolignans and terpenoids (Rithichai et al., 2024). Like other aromatic and medical plants, most of the aromatic compounds of Holy basil are concentrated in the essential oil fraction of the plants, and this can be isolated majorly by hydro-distillation from the whole plant, their leaves, flower, root, stems, and seeds (N et al., 2017). This medicinal herb is known to have potential of bactericidal, fungicidal activity due to the presence of secondary metabolites that includes alkaloids, saponins, tannins and eugenol (Anil Kadam et al., 2026). Among these, the most diverse bioactive compounds are terpenoids, flavonoids and phenolic acids with varied bioactivities such as gastroprotective, cytotoxic, antidiabetic, anticancer (Zahran et al., 2020).

The diversity and traits of this species have gained a plenty of attention of the scientific community owing to the biological properties of essential oil and botanical extracts that led to the development of novel drugs (Ferreira et al., 2025). Also known for its adaptogenic and immunomodulatory characteristics, this aromatic herb is used in respiratory ailments and infections (Bargah et al., 2025) and the extracts prepared from this species is known to lower blood glucose level notably and thus used as antidiabetic agents (Rithichai et al., 2024).

The present review focuses on phytochemistry and bioactivities of *Ocimum* essential oil and extracts prepared from its aerial parts and roots. This review also highlighted understanding and perspective gained from the phytochemical analysis of compounds so that *Ocimum* oil and extracts can be further analysed in future for clinical trial as well as development of natural, novel therapeutic agents based on local medicinal flora.

2. Phytochemical Constituents

The Holy Basil contains various important compounds in different plant parts that also vary in concentrations in different plant parts. The chemical composition of basil essential oil has been investigated and more than 200 compounds have been identified and is said to be highly complex and the quantity of many components is significantly affected by various factors such as different growing conditions, harvesting and storage periods (Shanmugam et al., 2016). It contains volatile compounds of approximately 40-50%, with eugenol comprising 5-15 % of oil (Revashankar et al., 2026). The stem and leaves of *O. sanctum* contain tannins, flavonoids, triterpenoids that possess various biological activities (Table 1). Amongst the phenolic compounds found in *O. sanctum,* gallic acid, catechins, syringic acid, vanillic acid and vanillin and eugenol exhibits antibacterial and flavonoids such as quercitin, luteolin, hymenoxin, apigenin has been reported to have anticancer activities (Ugbogu et al., 2021). Compounds present in volatile oil isolated from leaf include eugenol, euginal (eugenic acid), carvacrol, linalool, methyl carvicol and urosolic acid (Pattanayak et al., 2010), camphene, limonene, p-cymene, p-menthane, oxygenated monoterpenes, thymol methyl ester, trans-sabinene, while the seed volatile oil contains sitosterol and fatty acids like Oleic acid, Stearic acid and Palmitic acid, as seeds of this plant are considered to be the chief source of fixed oils (Bano et al., 2017).

Phytochemical screening of different extracts such as hexane, methanol, ethyl acetate and chloroform has shown the presence of tannins, flavonoid and glycosides. Terpenoid was found to be present in all crude extracts except for aqueous steroid, while saponin was detected in all crude extracts except hexane (Mousavi et al., 2018). The analysis of LC-MS (liquid chromatography mass spectrometry) identification has shown that methanolic crude extract and its fraction of *O. sanctum* leaves contains phenolics, flavon, flavones and isoflavone with high medicinal value. The phenolic compounds detected in crude extract and leaf fractions including caffeic acid, rosmarinic acid, permethrin and other compounds such as luteolin (flavonoid), isosakuranetin (flavanone) were reported. Other reports highlighted the hyperglycaemic and hypolipidemic effects of ethanolic extracts *of O. sanctum* that shows its

ability as glucose and insulin tolerant (Narendhirakannan et al., 2006). This herb is also a good source of vitamins as Vitamin C and Vitamin A are found in this plant which helps in antibody stimulation to protect against diseases (Devendran et al., 2011).

Table 1: Chemical constituents isolated from *O. sanctum* and their related biological activities

S. no.	Compound	Biological activity	Source	References
1.	Quercetin	Antioxidant at conc. of 200 mg kg^{-1}	*O. sanctum* leaves	(Zahran et al., 2020), (Ugbogu et al., 2021)
2,	Isoquercetrin	Antiprotozoal against *E. histolytica*	*O. sanctum* leaves	(Almatroodi et al., 2020)
3.	Luteolin	Leishmanicidal against L. Major	*O. sanctum* leaves	(Zahran et al., 2020)
4.	Orientin	Cytotoxic against colon cancer cell line	*O. sanctum* aerial parts	(Zahran et al., 2020)
5.	Syringic acid	Antibacterial against *E. coli* and *P. mirabilis*	*O. sanctum* aerial parts	(Mousavi et al., 2018)
6.	Gallic acid	Antibacterial against *E. coli* and *P. mirabilis*	*O. sanctum* aerial parts	(Zahran et al., 2020)
7.	Vanillin	Anticancer against A549 lung cancer	*O. sanctum* aerial parts	(Ugbogu et al., 2021)
8.	Citrusin C	Superoxide scavenging activity	*O. sanctum* leaves	(Pattanayak et al., 2010)
9.	Ursolic acid	Cytotoxic against HL-60 and Hela, cell lines	*O. sanctum* leaves	(Zahran et al., 2020)
10.	Oleanolic acid	Leishmanicidal against L. major, IC_{50}	*O. sanctum* leaves	(Zahran et al., 2020)

3. Pharmacological Activities

Ocimum sanctum has been bestowed with several bioactive components that have potential pharmacological traits as shown in figure 1.

a. Antibacterial activity

O. sanctum oil contains several fatty acids, among which linoleic acid is in higher percentage and is said to be effective against many bacterial strains such as *Staphylococcus aureus*, *Bacillus pumius* and *Pseudomonas aeruginosa* (Pattanayak et al., 2010). Another study showed that a wider zone of inhibition was observed with aqueous extract of *O. sanctum* as compared to that of alcoholic extract against *Kleibsiella*, *Escherichia coli* and *Proteus* (Vasudevan et al., 2001). A broader range of antibacterial activities was showed by aqueous extract and aqueous ethanolic extract of Tulsi leaf that strongly inhibited *Pseudomonas aeruginosa*, *Bacillus cereus* and has a moderate inhibition against *Staphylococcus aureus* (Talabi & Makanjuola, 2017). Ugbogu et al. (2021) in his studies highlighted the antibacterial potential of *Ocimum* essential oil that showed a concentration of 0.75 µg/mL of oil suppressed the growth of *Staphylococcus aureus* and 3 to 12 µg/mL for *E. coli*, *Klebsiella* species and *Proteus mirabilis*. Also, the essential oil exhibited bactericidal properties in rice-based foods against *Bacillus cereus* and as a component of mouth washes, the volatile oils inhibited the microbial growth at a concentration of 0.5%(Marwat et al., 2011).

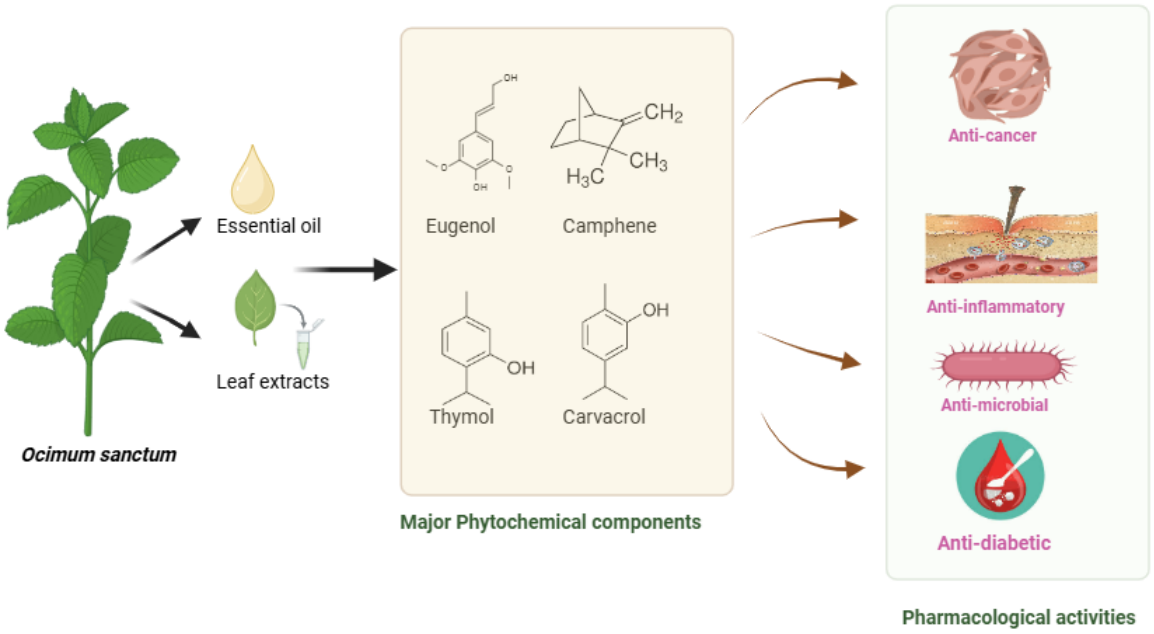

Figure 1: Phytochemical components of *O. sanctum* and their related bioactivities.

b. Anticancer agent

Many studies suggested the efficacy of *Ocimum* extract as anticancer therapeutics as it alleviated the basement membrane disintegration, angiogenesis and matrix metalloproteinases (MMP-2 and MMP-9) that resulted in tumor growth and breast cancer cells inhibition (Nangia-Makker et al., 2013). The alcoholic extract of leaves plays an important role in detoxifying carcinogens as it modulates carcinogen metabolizing enzymes such as cytochrome b_5, glutathione S-transferase (Pandey et al., 2010). The anticancer efficacy of *Ocimum* seed oil was evaluated against fibrosarcoma tumors and the increased survival rate and delay in tumor incidence was observed (Gupta et al., 2000). Also, a study was conducted on the antiproliferative activity of essential oil that showed the highest potential against murine leukemia (P388) cell line (Marwat et al., 2011) and several other reports highlighted the significant role of *O. sanctum* against various tumorigenesis states, as it has a protective action on DNA from harmful radiations and aqueous and alcoholic extracts are said to effective in tumor size reduction (N et al., 2017).

c. Antidiabetic properties

Chronic and sustained hyperglycemic conditions and distortion of primary metabolic pathways (carbohydrate, fat, protein) characterizes the Diabetes mellitus disorder (Ezeorba et al., 2024). Holy basil essential oil has been reported to possess antidiabetic properties such as lowering of blood sugar levels, alteration of glycation activities and many more (P. Singh et al., 2016). This essential oil contains many bioactive components that includes camphor, eucalyptol, eugenol, ocimene and terpinolene responsible for inhibition of glycation end products. However, several researchers have identified anti-hyperglycemic compounds in solvent extracts such as hydroalcoholic, methanol and other solvents that exhibited potent antidiabetic agents (Parasuraman et al., 2015). The bioactive fraction from hydroalcoholic extract revealed the presence of tetracyclic triterpenoids that acts as an antidiabetic agent (Almatroodi et al., 2020). Another study highlighted the antiperoxidative action of *O. sanctum* that regulates the serum concentration of both glucose and cortisol and thus represents a potential candidate for regulating the corticosteroid-induced diabetes mellitus (Rahman et al., 2011).

4. Conclusion

Medicinal plants and their products are the chief source of bioactive compounds and thus acts as alternative therapeutics for human health care system. *Ocimum sanctum* holds significant pharmacotherapy roles in disease management and traditional practices, as it contains various phytochemicals such as flavonoids, phenolics, tannins, saponins etc. Also, the natural products obtained from Holy basil are suggested to serve as a promising candidate in dietary supplements to combat diseases. Further, this medicinal shrub gains much attention of researchers owing to its role in cancer prevention and treatment. The *Ocimum* EO contains volatile compounds that serve as responsible candidate for its characteristic aroma and potential therapeutic properties. The oil has many applications as it is used in aromatherapy, as a flavouring agent in the food and beverage industry. *Ocimum* extracts also have potential medicinal properties; they may exhibit antioxidant, antimicrobial, anti-inflammatory, and anticancer activities. However, for the development of natural drugs, further studies are needed on the safety and quality of their use. These features have fostered extensive research on developing new products and natural drugs.

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