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## *Ocimum Sanctum*- A Traditional Remedy and Ethno Medicinal Uses, A Concise Review

Vijay P. Sonar, Buddhabhushan V. Bansod, pavankumar N. Desale, Shailesh S. Chalikwar\*

Department of Pharmaceutical Quality Assurance, R. C. Patel Institute of Pharmaceutical  
Education & Research, Shirpur - 425 405, Maharashtra, India.

### ABSTRACT

Medicinal plants are major source of bioactive compounds and chemical structures that gives potential beneficial effects. *Ocimum sanctum* (Tulsi) belongs to the Lamiaceae family, cultivated around tropical and semitropical zone of India and other surrounding Asian countries. In the present review on *O. sanctum*, the traditional uses, chemical constituents and pharmacological activities are explored. Various medicinal and therapeutic characteristics of Tulsi are found in the aerial parts, roots, leaves and seeds which have a broad range of activity on human being. *O. sanctum* has multiple medicinal and therapeutic properties such as antibacterial, anticholinesterase, antioxidant, antifungal, antimicrobial, antiaflatoxigenic, anti-inflammatory and antinoceptive, anticandidal, toxicological, anti-stress and anticonvulsant, anticancer, wound healing activities. Recent research has proven the anticancer and anti-HIV activity of *O. sanctum*. The chemical compounds of *O. sanctum* like alkaloids, phenolics, phenyl, coumarins, flavonoids, fatty acids, essential oils, steroidal, and tannin contents play an important role in herbal medicine. This paper examines the various traditional uses, phytochemical constituents and therapeutic potentials of Tulsi plant will be helpful in the treatment of oral diseases and many medicinal disorders and also will be useful in the expansion of new active principles.

**Keywords:** *Ocimum sanctum*, Medicinal plants, Chemical constituents, Pharmacological profile, Tulsi.

\*Corresponding Author Email: [pharmashailesh@rediffmail.com](mailto:pharmashailesh@rediffmail.com)

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## INTRODUCTION

Plants have fulfilled all needs of mankind throughout the ages. Humans have relied on nature for food, shelter, cloths, flavors and fragrance etc. and not the least, medicines. Plants have been utilized as medicines for thousands of years. The use of natural products with therapeutic potential is as old as human civilization. These natural medicines have given the foundation to traditional medicine system which is still exists and continues to serve mankind and by providing new remedies. In the recent era of herbal revitalization, the demand of herbal medicines is increasing steadily. Medicinal plants have been used therapeutically all around the world, being an important aspect of various traditional medicine systems. Traditional medicine may contribute to the treatment of several diseases. In high-income countries, the extensive use of phytotherapy declined due to the development and production of synthetic medicines. During the past few decades, however, phytotherapy has started to be increasingly used even in industrialized countries. In low and middle income countries, phytotherapy never stopped being important, often signifying the only therapeutic system to which certain people could refer. The World Medicines Situation report of WHO estimates that 70 to 95% of the population in developing countries consumes traditional medicines and that every country in the world uses them in some capacity <sup>1</sup>.

*Ocimum sanctum* L. (family Lamiaceae), also termed as “Tulsi” in Hindi and “holy basil” in English, is a domestic Indian plant religious to Hindus <sup>2</sup>. *O. sanctum* has huge number of therapeutic application such as asthma, homeopathy, vomiting, ophthalmia, cardiopathy, ringworm and skin diseases etc.<sup>3</sup> It plays multipurpose role in traditional medicine. It is an aboriginal of Afghanistan, Iran and India. *O. sanctum* generally used for headache, worm, constipation and kidney disease treatment. It is also used as an antidote for snake bite and scorpion sting <sup>4</sup>. *O. sanctum* is great botanical collections which are used with the other plants for various stress-related disorders treatment in India and other Asian countries.

*O. sanctum* L. (Lamiaceae), a well-known herbal medicine, is extensive everywhere the globe. This plant has been venerate since *Vedic* times and is considered inaccessible for its medicinal properties in the Indians landmass and is well value in Ayurvedic medicine in India. Its leaves have been used to treat a diversity of ailments, including ozena, skin diseases, and gastric and hepatic disorders and are used as a diaphoretic, an antiperiodic, and an expectorant <sup>5</sup>.



**Figure 1: Ocimum**

The medicinal use of plants is very aged. The writings specify that therapeutic use of plants is as old as 4000-5000 B. C. The crucial oil of *Ocimum* withdraws via steam distillation from the frond and season. *Ocimum* are used to scent foods, pedodontist and oral products, in perfume and in traditional habitude and medicines. Withdrawal crucial oils have also been shown to carry biologically active voter that are lindane, nematicidal and fungi static. These properties can be constantly attributed to cardinal essential oil constituents such as methyl chavicol, eugenol, linalol, camphor and methyl cinemetic <sup>6</sup>.

*O. sanctum* have been recorded for antibacterial, anticholinesterase, antioxidant, antifungal, antimicrobial, antiaflatoxic, anti-inflammatory, antinociceptive, anticandidal, toxicological, anti-stress and anticonvulsant, anticancer, wound healing activities <sup>4, 5, 7-21</sup>. The toxicity studies indicate that *O. sanctum* is a nonpoisonous or nontoxic herb and it is secure and careful to human use <sup>22</sup>. In many industries such as pharmaceutical, food and cosmetics the essential oil of *O. sanctum* has commercial important as an anti-allergic and antimicrobial agent <sup>15</sup>.

### **Plant Description**

*O. sanctum* belongs to a family Lamiaceae. It is found around the tropical and semitropical zone of India and other countries in Asia region <sup>2</sup>. It is a perpendicular, branched, aromatic herb and about 30 to 60 cm height. Its leaves are simple, oval, oblong and acute and up to 5 cm long with dentate margin, i.e. entire or toothed. Flowers are small; stamen exerted having purple colour, which is present in small packed array or cylindrical spike <sup>23</sup>. The fruits are small, nutlets, non-mucilaginous and smooth and these are yellow to reddish in colour. The whole plant of *O. sanctum*

is bitter and sore <sup>3</sup>. *O. sanctum* plants has various medicinal value, out of them are diuretics, aromatic, expectorant, vermifuge etc. <sup>3,24</sup>

**Common names:**

**English:** Holy basil

**Hindi:** Kala-Tulsi, Vishnu priya

**Sanskrit:** Tulsi

Detailed classifications are listed in table 1.

**Table. 1: Classification of *O. sanctum***

Scientific classification <sup>4</sup>					
Kingdom	Order	Family	Genus	Species	Synonym
Plantae	Lamiales	Lamiaceae	<i>Ocimum</i>	<i>O. tenuiflorum</i>	<i>Ocimum sanctum</i> L.

**Traditional Uses of *O. sanctum***

There are numerous medicinal properties have been characterized to *O. sanctum* L. Different portions of Tulsi plant i.e. leaves, flowers, stem, root, seeds etc. are shows the remedial and medicinal potentials and are used as expectorant, painkiller, anticancer, antiemetic, antidiabetic, ant-fertility etc.<sup>25</sup> Detailed ethno medicinal uses are listed in table no.2.

**Table 2: Traditional uses with its parts used of *O. sanctum***

Sr.	Parts of Plants and its Preparation used	Traditional uses	References
1.	Leaves Aqueous decoction	Gastro-hepatic diseases	Gupta et al., 2002 <sup>3</sup>
2.	Leaf Juice with Triphala	Ayurvedic eye drop preparation (glaucoma, falls, chronic conjunctivitis and other hurting eye diseases)	Gupta et al., 2002 <sup>3</sup>
3.	Leaves Paste	Antidote for scorpion bite	Reddy et al., 1988 <sup>26</sup>
4.	Leaves Juice	Acute and chronic inflammatory action in animals	Cohen 2014 <sup>27</sup>
5.	Leaf extraction with <i>Piper nigrum</i> and palmgur in water	Fever	Nazar et al., 2008 <sup>28</sup>
6.	Whole plant	Headache, nausea, cold, cough, fever and exterior (skin) diseases	Rahman et al., 2013 <sup>29</sup>
7.	Leaves and tops (Essential oil extract)	Flavor food, oral products as well as dental product	Wakchaure et al., 2016 <sup>30</sup>
8.	Leaves strike with <i>Tricosanthes diocia</i> fruits, <i>Leucasindica</i> flowers and <i>Aristolochia bracteata</i> leaves	Typhoid fever	Reddy et al., 1989 <sup>31</sup>
9.	Whole plant paste	Skin diseases	Sen et al., 2011 <sup>32</sup>
10.	Root (Decoction)	Malarial fever	Kumar et al., 2011 <sup>33</sup>
11.	Leaves (Eugenol extract)	Vasodilator action on rabbit arterial tissue	Nishijima et al., 1999 <sup>34, 35</sup>
12.	Seed oil	Chemo-preventive activity	Prakash and Gupta 2005 <sup>25</sup>
13.	Whole plant (Aqueous decoction)	Lowers the high level of blood sugar	Kumar et al., 2011 <sup>33</sup>
14.	Leaves (paste with black pepper)	Fever and Diarrhea	Kandari et al., 2012 <sup>36</sup>
15.	Dried leaves	Brushing teeth, to treat gingival	Sumit and Geetika 2012 <sup>37</sup>

## CHEMICAL CONSTITUENTS OF *O. sanctum*

The *O. sanctum* leaf contains volatile oil (0.7%), eugenol (71%) and methyl eugenol (20%). It also contains phenolic, flavonoids, terpenoids and fatty acids derivatives. Ursolic acid has been separated from the part of *O. sanctum* i.e. leaf. It also contains fixed oil, mucilage and polysaccharides in the non-saponifiable matter. The triglycerides contain 43.8% of linolenic acid is the major and important constituents of *O. sanctum* seed oil<sup>38</sup>.

### Phenolic content:

About  $4.07 \pm 0.11$  g of gallic acid has been found as a total phenolic content<sup>39</sup>. There are various phenolic contents were isolated/separated from the *O. sanctum* parts such as caffeic acid, chlorogenic acid, vanillic acid and menthyl salicylic glucoside<sup>7</sup>. The HPLC technology is used with precise and certified samples for the confirmation of phenolic compounds like gallic acid, gallic acid methyl and ethyl ester, vanillin<sup>40</sup>. The APCI mass spectrometry method were also used to figure out the ester derivatives of caffeic acid i.e. Rosmarinic acid in *O. sanctum* leaf<sup>41</sup>.

### Flavonoids content:

In the class of chemical constituents, the flavonoids are the major and important class containing methoxy flavonoids and its glycoside derivatives such as luteolin, isothymusin, cirsimartin, also C-glycosides flavonoids (orientin, isoorientin, isovitexin and vicenin) isolated from *O. sanctum*<sup>13</sup>. Norr *et al.*, (1992) have studied the distribution of 8-oxygenated flavones on the surface of *O. sanctum* leaf and find out apigenin, cirsimartin, salvigenin, crisilineol, eupatorin, isothymusin and gardenin<sup>13, 42, 43</sup>.

### Phenyl content:

In the biologically active constituents, Eugenol plays a crucial role as a phenyl propanoid in the essential oil which is obtained from the *O. sanctum* leaves. Ociglycoside, citrusin C, ferulaldehyde, bieugenol and dehydro-dieugenol are the phenyl propane derivatives were separated from the tulsi leaves<sup>13,42</sup>. 4-allyl-1-O- $\beta$ -D-glucopyranosyl-2-hydroxybenzene and 4-allyl-1-O- $\beta$ -D-glucopyranosyl-2-methoxybenzene (eugenyl- $\beta$ -D-glucoside) are two phenyl propane glucosides were obtained by ethanolic extract and separated by semi-preparative HPLC technique<sup>40</sup>.

### Coumarins content:

Ocimarin, aeculetin and aesculin are the three coumarins derivatives of *O. sanctum* were reported<sup>5</sup>.

### Steroidal content:

$\beta$ -sitosterol,  $\beta$ -sitosterol-3-*O*-  $\beta$ -D-glucopyranoside, stigmasterol and campesterol are the four phytosterols were isolated from *O. sanctum* leaf as well as stem <sup>42, 43</sup>.

#### Neolignans:

Tulsinol A to Tulsinol G are the seven neolignans discovered from the methanolicleaves extract of tulsi which are produced by the method of polymerization of eugenol <sup>42</sup>.

#### Fatty acid contents:

Four cerebrosides fatty acid secondary metabolites were separated from the leaves as well as roots of *O. sanctum* <sup>5, 44</sup>. Palmityl glucoside and sanctumoic acid are the fatty acid secondary metabolites were showed mosquitocidal property, while cerebrosides exhibited antistress activity <sup>45</sup>.

Detailed various active compounds are listed in table no. 3.

**Table 3: Various naturally active compounds found in *O. sanctum* plants**

Parts of <i>O. sanctum</i> plant	Chemical constituents
Leaf	Flavonoids, tannins, alkaloids, saponins, phenols, sterols, anthocynins, terpenoids Jaggi et al., 2003 and Pattanayak et al., 2010 <sup>46, 47</sup> .
Seeds	Fatty acids, sito-sterol.
Stem	Phenols, saponins, tannins, flavonoids, triterpenoids.
Whole plant	Flavonoids, alkaloids, saponins, tannins, phenols, anthocynins, flavonoids, triterpenoids, tannins Kelm et al., 2000 and Pattanayak et al., 2010 <sup>13, 47</sup> .

### PHARMACOLOGICAL PROFILE OF *O. sanctum*

Numerous scientific and technological investigation have demonstrated the pharmacological consequences of steam filtered, petroleum ether, extracts of benzene of various portions of *O. sanctum* plant and its active component i.e. eugenol on blood chemistry, gastric system, reproductive system, immune system, urinary system, central nervous system and cardiovascular system. Tulsi is generally called as a vitalizer and energizer and enhances physical abidance <sup>4</sup>. Eugenol is the major phenolic content of essential oil. Therefore with eugenol the medicinal grades of essential oils are extracted from the leaves of *O. sanctum* (fresh leaves). When the experiment is conducted on the animal's eugenol possess the antidiabetic action, reduction in the triglyceride cholesterol and blood serum <sup>48</sup>. Eugenol also shows vaso-relaxation activity on arterial tissue of rabbit <sup>35</sup>.

The chemical component of *O. sanctum* are generally studied for its medicinal and therapeutic applications like antiemetic, hepatoprotective, anti-inflammatory, anticancer, larvicidal, antibacterial, antimicrobial, antiaflatoxicogenic and antistress activity. Detailed pharmacological activities are listed in table no. 4.

**Table 4: Pharmacological activities of *O. sanctum***

Sr. no.	Tissue	Compound/ Extract	Activity	References
1.	Leaves	Methanol extract and aqueous suspension	Immuno regulatory activity	Godhwani et al., 1988 <sup>2</sup>
2.	Leaves	Chloroform extract	Antibacterial activity	Mishra and Mishra 2011 <sup>4</sup>
3.	Aerial parts	Essential oil extract (Eugenol)	Antagonistic effect (Antioxidant and Antifungal)	Kalagatur et al., 2015 <sup>49</sup>
4.	Leaves	Chloroform and oil extract (Eugenol and Phenolic compound)	Antibacterial activity	Rehman et al., 2013 <sup>29</sup>
5.	Whole plant	Crude ethanol extract	Antibacterial activity	Joshi et al., 2009 <sup>10</sup>
6.	Leaf	Ethanol leaf extract	Acetylcholinesterase activity	Kandhan et al., 2018 <sup>12</sup>
7.	Leaves and stems	Methanol and Ethyl acetate extract (Eugenol, Cirsilineol, Cirsimaritin, Isothymusin, Apigenin, Isothymunin and rosmarinic acid)	Antioxidant and cyclooxygenase inhibitory activity	Kelm et al., 2000 <sup>13</sup>
8.	Leaves	Fixed oil extract ( $\alpha$ -linolenic acid)	Anti-diabetic and antioxidative activity	Suanarunsawat et al., 2016 <sup>21</sup>
9.	Leaves	Aqueous and alcohol leaf extract	Antifungal activity	Balakumar et al., 2011 <sup>8</sup>
10.	Leaves	Eugenol and essential oil extract	Antifungal and antiaflatoxinigenin activity	Kumar et al., 2010 <sup>15</sup>
11.	-	Essential oil (methyl eugenol)	Antifungal activity	Khan et al., 2010 <sup>14</sup>
12.	Leaves	Aqueous extract (Orientin and Vicenin)	Antimicrobial activity	Ali and Dixit 2012 <sup>7</sup>
13.	Leaf	Chloroform, hexane and pure oil leaf extract	Antimicrobial activity	Mittal et al., 2018 <sup>16</sup>
14.	Aerial part	Essential oil (Eugenol)	Antimicrobial activity and food-borne infection preventing activity	Saharkhiz et al., 2015 <sup>18</sup>
15.	Seed	Fixed oil extract	Anti-inflammatory activity	Singh et al., 1996 <sup>50</sup>

16.	Leaf	Alcoholic leaf extract	Antinociceptive (analgesic) activity	Khanna and Bhatia 2003 <sup>51</sup>
17.	Leaves	Ethanol leaves extract	Toxicological study	Gautam and Goel 2014 <sup>22</sup>
18.	Leaves	Methanol extract	Anticandidal synergistic activity	Zaidi et al., 2018 <sup>52</sup>
19.	Whole plant	Methanol extract	Anti-stress activity	Richard et al., 2016 <sup>53</sup>
20.	Leaves	Alcohol and aqueous extract	Wound healing effect and antioxidant effect	Shetty et al., 2008 <sup>19</sup>
21.	Leaves	Cold aqueous extract	Wound healing property and cytokine induction	Goel et al., 2010 <sup>54</sup>
22.	Leaf and flower	Chloroform and methanol extract (Gluanol)	Larvicidal activity	Anees 2008 <sup>55</sup>
23.	Leaves	Ethanol extract	Anti-arthritic activity	Prasad et al., 2018 <sup>56</sup>
24.	Leaves	Ethanol extract	Anti-ulcerogenic and ulcer healing activity	Dharmani et al., 2004 <sup>57</sup>
25.	Seed	Petroleum ether extract	Immunomodulatory activity	Mediratta et al., 2002 <sup>58</sup>
26.	Leaves	Methanol extract and aqueous suspension	Anti-inflammatory, analgesic and antipyretic activity	Godhwani et al., 1987 <sup>59</sup>
27.	Whole plant	Ethanol extract	Hair growth activity	Rathi et al., 2017 <sup>60</sup>
28.	Leaves	Aqueous extract	Hypoglycemic, hypolipidemic, antioxidant activity	Hussain et al., 2001 <sup>61</sup>
29.	Leaf	Aqueous extract	Immunostimulatory effect	Logambal et al., 2000 <sup>62</sup>
30.	Leaf	Petroleum ether and ethanol extract	Anti-HIV activity	Rege et al., 2010 <sup>63</sup>
31.	Leaves and Stems	Hexane extract (triglyceride, 1,3-dilinoleoyl-2-palmitin)	Mosquitocidal activity	Kelm and Nair 1998 <sup>45</sup>
32.	-	Vicenin-2, orientin, luteolin	Anticancer activity	Nagaprashantha et al., 2011 <sup>64</sup>
33.	Leaves	Dichloromethane extract (Betulinic acid, Oleanolic acid, Ursolic acid, Pomolic acid, Stigmasterol)	Anti-HIV 1 activity	Sonar et al., 2017 <sup>65</sup>
34.	Aerial plant	n-hexane, ethyl acetate and Ethanol extract	Skin anti-ageing activity	Chaiyanaa et al.,

		(Rosmarinic acid)		2019 <sup>66</sup>
35.	Leaves	Ethanol extract	Central nervous system psychotic activity	Sakina et al., 1990 <sup>67</sup>
36.	Leaves	Hot-water extract	Antimicrobial activity	Shokeen et al., 2005 <sup>68</sup>
37.	Leaves	Methanol and ethyl acetate extract	Leishmanicidal activity	Suzuki et al., 2009 <sup>42</sup>
38.	Leaves	Aqueous extract	Antibacterial activity	Ramteke et al., 2013 <sup>29</sup>
39.	Leaf	Aqueous leaf extract	Antimicrobial activity	Singhal et al., 2011 <sup>32</sup>
40.	Leaves	Aqueous extract (Eugenol)	Antifungal activity	Khan et al., 2010 <sup>14</sup>
41.	Leaf	Ethanol extract and fractions	Stimulatory effect and anti-diabetic activity	Hannan et al., 2006 <sup>69</sup>
42.	Leaves	Hexane extract	Anti-hyperlipidemic and cardioprotective effect	Suanarunsawat et al., 2010 <sup>70</sup>
43.	Leaves	Aqueous and alcohol extract	Anti-cataleptic activity	Aswar and Joshi 2010 <sup>63</sup>
44.	Leaves	Alcohol extract	Anti-asthmatic activity	Singh and Agrawal 1991 <sup>71</sup>
		Coconut oil extract	Anti-inflammatory activity	Singh and Agrawal 1991 <sup>71</sup>
45.	Root, Stem, Leaf and Flower	Ethanol extract	Antiplasmodial effect	Inbaneson et al., 2012 <sup>72</sup>
46.	Leaves	Alcohol extract	Hepatoprotective activity	Lahon and Das 2011 <sup>73</sup>
47.	Whole plant	Aqueous extract	Memory enhancer activity	Joshi and Parle 2006 <sup>74</sup>
48.	Leaves	Alcohol extract	Anti-carcinogenic property	Banerjee et al., 1996 <sup>75</sup>
49.	Leaf	Aqueous extract	Anti-thyroid activity	Panda and kar 1998 <sup>76</sup>

50.	Leaves	Ethanol extract	Antianxiety and antidepressant activity	Chatterjee et al., 2011 <sup>77</sup>
51.	Leaves	Aqueous extract (Orientin and Vicenin)	Radiation protective activity	Umadevi et al., 2000 <sup>78</sup>
52.	Leaves	Aqueous extract	Radioprotective, anti-carcinogenic and antioxidant property	Umadevi et al., 2000 <sup>78</sup>
53.	Aerial part	Hydro alcoholic extract (tetracyclic triterpenoid)	Antidiabetic activity	Patil et al., 2011 <sup>79</sup>

### **Immuno regulatory activity**

Recent reports on *O. sanctum* by Godhwani et al., 1998, have suggested that the humoral reaction or response is stimulated by the *O. sanctum* methanolic extract and aqueous suspension as a proof by an increase antibody titre in rats. The conclusion of the study indicates that the test of erythrocyte agglutination increases the antibody titer in the Widal and Sheep and formation of E-rosette and lymphocytosis represents a cellular immunologic response<sup>2</sup>. Mediratta et al., 2002, have reported the immunomodulatory effect of *O. sanctum* seed oil (OSSO) examined on the immunological parameters in stressed animals as well as non-stressed animals and estimated that these immunomodulatory effects of OSSO may be applying by regulating GABAnergic pathway<sup>58</sup>.

### **Anticancer activity**

Joseph and Nair (2013) have reported the anti-cancer influence of *O. sanctum* in skin, oral, gastric, lung, breast, cervical and prostate<sup>80</sup>. From the research work of Khanna and Bhatia (2003), the biological and clinical models were studied for the evaluation of the efficiency of *O. sanctum* in treatment of cancer and its effects on radiation induced changes<sup>50</sup>. Bhattacharyya et al., 2013, studied the current information on the chemo-preventive and therapeutic applications of *O. sanctum*. They also investigate the molecular and biochemical mechanisms included in the antitumor effects of *O. sanctum* and discuss the current limitations, role of synergy, and forthcoming directions of research over the efficacious use of *O. sanctum* plant to cure and prevent cancer<sup>9</sup>.

### **Antibacterial activity**

Rathnayaka (2013) reported that the various leaves extracts of *O. sanctum* like chloroform extract, aqueous extract, oil extract and alcohol extract showed antibacterial activity against four infectious food-borne microorganisms i.e. *Salmonella enteritica*, *Escherichia coli*, *Vibrio parahaemolyticus* and *Listeria monocytogenes*. Extracts acquired by all extraction methods produced antimicrobial activity with all tested microorganisms<sup>17</sup>. A research report on antibacterial activity of *O. sanctum* suggests that the antibacterial activity of ethanolic extracts of *O. sanctum* plant were foundless active against Gram-negative bacteria as compare to that of Gram-positive bacteria<sup>10</sup>.

### **Antioxidant activity**

Research reports on antioxidant activity of *O. sanctum* suggests that the various antioxidant effect of different extracts acquire from different parts of plant have been noted in several investigations. Aqueous extract of *O. sanctum* leaf have been originate to show antioxidant activity<sup>61</sup>. Similarly, Suanarunsawat et al., 2016 and Kalagatur et al., 2015 have been found out that the essential oil and

fixed oil extracts of aerial part and leaves have also shown the antioxidative effects of *O. sanctum* plant on *F. graminearum* and inhibitory effect of the anti-oxidative enzymes in the cardiac tissues and rat liver respectively <sup>21, 49</sup>. Kelm et al., 2000, reported the antioxidant inhibitory activity of phenolic compounds (Eugenol, Cirsilineol, Cirsimaritin, Isothymusin, Apigenin, Isothymunin and rosmarinic acid) obtained from the ethyl acetate and methanolic extracts of *O. sanctum* leaves and stems <sup>13</sup>.

#### **Antidiabetic activity**

From the research work of Patil et al., 2011 and group, the isolation and characterization of antidiabetic compound from the aerial part of *O. sanctum* hydro alcoholic extract found to have great antidiabetic effect <sup>79</sup>. Suanarunsawat et al., 2016, found out that the extract of fixed oil obtained from the leaves of *O. sanctum* plant have antidiabetic activity in diabetic rats <sup>21</sup>. Ahmad et al., 2012, have reported the effect of methanolic extract of *O. sanctum* roots in streptozotocin induced antidiabetic rat with the help of nuclear magnetic resonance spectroscopy <sup>44</sup>.

#### **Antiemetic activity**

Khedekar et al., 2016 have reported that the leaves of *O. sanctum* used in vomiting and exhibit antiemetic action <sup>37</sup>.

#### **Hepatoprotective activity**

Lahon and Das (2011) found out the hepatoprotective activity of alcoholic extract of *O. sanctum* leaf against paracetamol-induced liver damage in Albino rats due to the synergistic activity with silymarin. They concluded that alcoholic extract of *O. sanctum* leaf showed particular hepatoprotective activity and interaction with silymarin <sup>73</sup>.

#### **Anti stress activity**

Jothie et al., 2016, reported the anti-stress activity of methanolic extract of *O. sanctum*, whole plant in chronic variable stress (CVS) model. It has been reported that due to the blocking of CRHR1 receptor and cortisol release inhibition, the *O. sanctum* was found to be more effective in the controlling of stress effects and anti-stress activity <sup>11</sup>. Chatterjee et al, 2011 have reported that the ethanolic extract of *O. sanctum* leaves lowers the anxiety and depression properties at the constant dose and can be a potential medicinal agent against miscellaneous anxiety and depressive syndrome <sup>77</sup>. Gupta et al., 2007 have reported the new constituents of Tulsi (Ocimumosides A and B and Ocimarin) were obtained from the *O. sanctum* leaves extract which showed the potential anti stress activity <sup>5</sup>.

#### **Anti-inflammatory activity**

Research reports on anti-inflammatory activity of *O. sanctum* suggests that the evaluation of useful anti-inflammatory compound obtained from fixed oil extract of *O. sanctum* seed which blocks the cyclooxygenase and lipoxygenase pathway for metabolism of arachidonic acid against the carrageenan and other mediator-induced paw edema in the rats <sup>50</sup>.

## CONCLUSION

The detailed data summarized in this article suggest that many compounds derived from various parts of *O. sanctum* plant exert different potential pharmacological properties. Various literatures have reported the different pharmacological activities like anti-inflammatory, anti arthmatic, antibacterial, hypotensive etc. are due to the fixed oil content of the plant. The synergistic actions of many active compounds may be responsible for the nutritional and pharmacological properties of whole plant. Recent studies on the compounds isolated from *O. sanctum* suggest its potential use against complex diseases such as cancer and HIV. Research in the recent year suggests that the compounds isolated from the plant would be a “lead” to synthesize new pharmacologically active compounds. Although the potential activities of *O. sanctum* extract, obtained from different extraction processes, have been proved in various researches; it will still open new venues for therapeutic interventions.

## AUTHORS CONTRIBUTION STATEMENTS

The manuscript was written through contributions of all authors. All authors have given approval to the final version of the manuscript.

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