REVIEW OF LITERATURE
Ocimum sanctum Linn - an important medicinal herb:

Ocimum sanctum Linn. (Tulsi, Family - Lamiaceae / Labiatae) is queen of herbs, the legendary “incomparable one” of India, is one of the holiest and most cherished of the many healing and health-giving herbs of the orient. Since time immemorial the Ocimum sanctum Linn, known as ‘Sacred Herb’ (Holy Basil) in India. The earliest description on the medicinal utilities of Tulsi were documented in 5000 B.C. in ‘Rigveda’, an ancient Indian Vedic literature of historical importance. In 800 B.C. therapeutic use of this plant was further revised in an important Ayurvedic medicinal text ‘Nighantu Adarsha’. In 600 B.C. two important Sanskrit holy Ayurvedic medicine book ‘Charak Samhita’ and ‘Susruta Samhita’ described the curative and medicinal importance of Tulsi (O. sanctum) (Singh et al., 2002; Maimes, 2004).

An impressive array of health promoting, disease preventing and life prolonging properties of Tulsi have been described and documented over five millennia. More contemporary texts such as ‘Bharatiya Banoushadhi’ (Biswas and Ghosh, 1952), ‘Glossary of Indian Medicinal Plants’ (Chopra et al., 1956), ‘Indian Medicinal Plants’ (Kirtikar and Basu 1975), ‘Indian Materia Medica’ (Nadkarni, 1995) showed that Tulsi is used for variety of health problems and diseases of different system e.g. heart, blood, digestive, respiratory, skin and CNS etc.

‘Tulsi’ is classified as a ‘Rasayana’, a herb that nourishes a person’s growth to perfect health and promotes long-life. Holy Basil or O. sanctum has been used in the traditional systems of Siddha (based largely on Ayurveda) and Unani (founded by Hakim Ibn Sina) (Maimes, 2004).

Due to its vast significance, Tulsi is given the titles: “The incomparable one”, “The mother medicine of nature”, “The elixir of life”, “The queen of herbs” (Maimes, 2004).
Vernacular Names of *Ocimum sanctum* Linn.:

According to Chopra *et al.*, 1956; Biswas and Ghosh, 1973; Kirtikar and Basu, 1975; Nadkarni, 1995; Joshi, 2000; Kapoor, 2001; Oudhia, 2003 *O. sanctum* is known with its specific name in different languages:

**In India:**


**Hindi**: Kala Tulsi, Tulsi, Varanda.

**English**: Holy Basil, Sacred Basil, Monk's basil.

**Bengali**: Krishna Tulsi, Kala Tulsi, Kural.

**Tamil**: Tulasi, Karut tulasi, Alingai, Kullai.

**Malayalam**: Trittavu, Karuttattravu, Kunnakam, Punya, Shiva tulasi.

**Kannada** : Kari tulsi, Pavitra tulsi, Shri tulsi.

**Telegu**: Gaggera, Brynda, Krishna tulsi.

**Punjabi**: Bantulsi, Tulsi.

**Marathi**: Krushna tulas.

**Gujarati**: Tulsi, Talasi.

**Nepalese**: Newari tulsi
German : Basstikum.
French : Basilic odorant
Arabian : Rayhan, Badrut, Shasafaram, Dohsh, Schadjant, Vasub.
Burmese : Lum.
Malaysian : Krishna tulsi.
Sinhalese : Madurutala, Madura tulla.

Botanical identity of *Ocimum sanctum* Linn. :


Kingdom : Plantae
Division : Magnoliophyta
Class : Magnoliopsida
Order : Lamiales
Family : Lamiaceae (Labiatae)
Genus : Ocimum
Species : sanctum

Habitat : The natural habitat of the Tulsi varies from sea level to a level representing an altitude of 2000 metre (above sea level). It is found to grow naturally in moist soil nearly all over the world.

Pharmacognostical characteristics : A strongly scented, bushy, perennial, upright 30-60 cm annual shrub much branched with soft hairs. The stems are square in transaction. Usually cultivated annually from seed although it can be propagated from tip or root cuttings. It is usually planted (or transplanted) immediately after the rainy season ends. In good soil and hot sunny weather, Tulsi may grow to a metre or more in height and be
ready for harvest in a few months. Much larger specimens have been noted and under special circumstances an individual plant may live for a decade or more.

**Leaves:** The leaves are nearly round and up to 2.7-7.5 cm. long with the margin entire or toothed. Leaves are opposite, elliptical, oblong with relatively long petioles. The calyx is 0.2-0.4 cm. long with or without long or short hairs, ciliate, densely glandulose and aromatic, for presence of volatile essential and scented oil. Colour of leaves varies from light green to deep purple.

**Flowers:** The flowers of the herb vary in colour from white to red. Flowers appear in racemes arising in whorls on the stems upon the cylindrical spikes, usually bilaterally symmetrical and purplish in colour. The tinge of purple colour appears from June to September.

**Fruits:** The fruits are small in size, nutlets, smooth and yellow with brown or black marking, 1-2 mm long and pericarp swells into a slimy mass when moistened.

**Seeds:** The seeds are yellow to reddish in colour. The seeds contain some fixed oils which consist of some fatty acids.

*O. sanctum* emits a spicy scent when bruised. It is believed to purify air by emitting negative ions.

As maximum beneficial therapeutic values of this plant were documented for its leaves, microscopical structure of leaves was searched for its detailed study.

**Microscopic characteristics of leaves:**

Transverse section of the leaf through its midrib: upper epidermis consists of a layer of small, transparent cells with thin walls and thin smooth cuticle. On tangential view, these cells are polygonal with straight or wavy walls. Lower epidermis consists of a layer of small, quadrangular transparent cells with thin walls and smooth cuticle. Trichomes bent, consisting of 2-6 cells; glandular trichomes short, Lamiaceae type, consisting of 1 stalk cell and 2-4 cells with rounded heads. Palisade parenchyma consists of layer of long cylindrical cells containing chlorophyll; spongy parenchyma consists of polygonal cell with thin, straight or slightly wavy side walls. Vascular bundles collateral type with collenchymas cells. Stomata diacytic, on upper and lower epidermis.
Distribution:

*O. sanctum* is native to tropical Asia, likely having originated in India. Robust tulsi varieties readily grow in many areas of Asia and Africa. In fact, the medicinal, religious and culinary uses of holy basil have been documented for centuries in Asia, China, Middle East, North Africa, Austria and Europe. The plant grows abundantly in different countries e.g. India, Malaysia, Australia, Central and South America, Puerto Rico and Western Asia. Presently, *O. sanctum* is also cultivated in Egypt, France, Italy, Morocco, Hungary, USA etc.

Constituents of *Ocimum sanctum* Linn.:

The chemical composition of *O. sanctum* is highly complex, containing many nutrients and biologically active compounds, the proportions of which may vary considerably between strains and even among plants within the same field. The nutritional and pharmacological properties of the whole herb in its natural form, as it has been traditionally used, result from synergistic interaction of many active Phytochemicals. The chemical composition of *O. sanctum* change throughout the seasons and are affected by the conditions of soil, growth, harvest, processing and storage (Singh et al., 1996 b; Singh et al., 2002 and Maimes, 2004).

Physio-chemical composition: (Singh et al., 1996 b; Roberto et al., 2000)

Solubility:
- A) In water- NLT 60%
- B) In alcohol- NLT 40%

pH: 5.0-7.0

Moisture content: NMT 5%

Ash content: NMT 5%

Heavy metal content:
- A) Arsenic-NMT 1 ppm
- B) Lead-NMT 5 ppm

Organic properties: (Ghosh, 1995)

Odour: Characteristic, aromatic

Taste: Slightly pungent
**Essential oil present in* O. sanctum* leaves:** (Roberto *et al.*, 2000)

The leaves of *O. sanctum* contain a bright yellow volatile oil, which is actually the essential oil present in the plant. The leaves contain the highest percentage of the essential oil, followed by the inflorescence and the skin. The roots are devoid of any oil.

**Characteristics of essential oil:** (Singh *et al.*, 1996 b)

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yield</td>
<td>17.50% v/w with reference to dried seeds</td>
</tr>
<tr>
<td>Colour</td>
<td>Pale yellow</td>
</tr>
<tr>
<td>Consistency</td>
<td>Viscous liquid</td>
</tr>
<tr>
<td>Wt/ml(at 25°C)</td>
<td>0.8750 gm/cc</td>
</tr>
<tr>
<td>Refractive index</td>
<td>1.472</td>
</tr>
<tr>
<td>Acid value</td>
<td>2.067</td>
</tr>
<tr>
<td>Iodine value</td>
<td>179.38</td>
</tr>
<tr>
<td>Saponification value</td>
<td>178.50</td>
</tr>
<tr>
<td>Ester value</td>
<td>176.43</td>
</tr>
<tr>
<td>Unsaponifiable matter</td>
<td>2.818%</td>
</tr>
</tbody>
</table>

**Active compounds of* O. sanctum*:** (Prakash and Gupta, 2005)

The leading phyto-chemical compounds in holy basil leaf include the following:

- Eugenol (volatile oil)
- Ursolic acid (triterpenoid)
- Rosamarinic acid (phenyl propanoid)
- Caryophyllene
- Oleanoic acid

**Chemical constituent of different parts of herb* O. sanctum* Linn:**

1. Essential oil from leaves:
   - α-Thujene, Octane, Nonane, Benzene, (Z)-3-Hexanol, Ethyl 2-methyl butyrate,
   - α-pinene, β-pinene, Toluene, Citronellal, Camphene, Sabinene, Dimethyl

2. Alcoholic extract of leaves / aerial parts:
Ursolic acid, Apigenin, Luteolin, Apigenin-7-0-glucuronide, Luteolin-7-0-glucuronide, Isorontin, Molludistin, Stigmasterol, Triacontanol ferulate, Vicenin-2, Vitexin, Isovitexin, Aesculin, Chlorogenic acid, Galuteolin, Circineol, Gallic acid methyl ester, Gallic acid ethyl ester, Pro catechuic acid, Vallinol acid, 4-hydroxybenzoic acid, Vallinin, Caffic acid, Chlorogenic acid, Phenylpropane glucosides, β-stigmasterol (Norr and Wanger, 1992; Nguyen et al., 1993; Sukari et al., 1995; Skaltsa et al., 1999).

3. Fixed oil from seeds:
Palmitic acid, stearic acid, Linolenic acid, Linoleic acid, Oleic acid, Sitosterol, Dilinolenololins, Linolenodilinolin, Hexourenin acid (Singh et al., 1996 b).

4. Mineral content of leaves (microgram/gram):
Cl (9,355), K (18,991), Ca (4,031), Cr (176.1), Mn (48.1), Fe (372), Ni (33.7), Cu (28.8), Zn (Below detection limit), Br (25.4), Sr (Below detection limit) (Naredhirakannan et al., 2005; Gourishankar et al., 2010).

5. Vitamin content of leaves (per 100 gm):
Vitamin C (83 mg), Carotene (2.5 mg) (Anonymous, 1991; Naredhirakannan et al., 2005).
Structure of some important chemical constituents present in *O. sanctum* leaves:

(Chem. abstr, 1983; The Merck index, 1996; Kapoor, 2001)

<table>
<thead>
<tr>
<th>Chemical constituents</th>
<th>Structure</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Eugenol (24.2% - 38.2%)</td>
<td><img src="image" alt="Eugenol structure" /></td>
</tr>
<tr>
<td>2) Methyl eugenol (4.8%)</td>
<td><img src="image" alt="Methyl eugenol structure" /></td>
</tr>
<tr>
<td>3) Methyl cinnamate</td>
<td><img src="image" alt="Methyl cinnamate structure" /></td>
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<tr>
<td>4) Methyl chavicol</td>
<td><img src="image" alt="Methyl chavicol structure" /></td>
</tr>
<tr>
<td>5) Carvacrol</td>
<td><img src="image" alt="Carvacrol structure" /></td>
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<tr>
<td>Chemical constituents</td>
<td>Structure</td>
</tr>
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</tr>
<tr>
<td>6) Linalool</td>
<td><img src="image" alt="Linalool Structure" /></td>
</tr>
<tr>
<td>7) Citronellol</td>
<td><img src="image" alt="Citronellol Structure" /></td>
</tr>
<tr>
<td>8) Citronellal</td>
<td><img src="image" alt="Citronellal Structure" /></td>
</tr>
<tr>
<td>10) Caryophyllene (7.5%)</td>
<td><img src="image" alt="Caryophyllene Structure" /></td>
</tr>
<tr>
<td>11) Camphor</td>
<td><img src="image" alt="Camphor Structure" /></td>
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<tr>
<td>Chemical constituents</td>
<td>Structure</td>
</tr>
<tr>
<td>-----------------------</td>
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</tr>
<tr>
<td>12) Ursolic acid</td>
<td><img src="image" alt="Ursolic acid structure" /></td>
</tr>
<tr>
<td>13) alpha-pinene (3.5%)</td>
<td><img src="image" alt="alpha-pinene structure" /></td>
</tr>
<tr>
<td>14) beta-pinene (0.4%)</td>
<td><img src="image" alt="beta-pinene structure" /></td>
</tr>
<tr>
<td>15) Apigenin</td>
<td><img src="image" alt="Apigenin structure" /></td>
</tr>
<tr>
<td>16) alpha-Humulene</td>
<td><img src="image" alt="alpha-Humulene structure" /></td>
</tr>
<tr>
<td>Chemical constituents</td>
<td>Structure</td>
</tr>
<tr>
<td>-----------------------</td>
<td>-----------</td>
</tr>
<tr>
<td>17) E-β-Ocimene (4.0% - 4.7%)</td>
<td><img src="image" alt="Structure 17) E-β-Ocimene" /></td>
</tr>
<tr>
<td>18) Luteolin</td>
<td><img src="image" alt="Structure 18) Luteolin" /></td>
</tr>
<tr>
<td>19) Nerol</td>
<td><img src="image" alt="Structure 19) Nerol" /></td>
</tr>
<tr>
<td>23) Ascorbic acid</td>
<td><img src="image" alt="Structure 23) Ascorbic acid" /></td>
</tr>
<tr>
<td>24) Carotene</td>
<td><img src="image" alt="Structure 24) Carotene" /></td>
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</tbody>
</table>
Therapeutic uses of *Ocimum sanctum* Linn:

'Tulsi' or Holy Basil is one of the well known, ancient, eminent medicinal plant whose various medicinal uses were found since the ages of Ayurveda, Siddha, Greek, Roman and Unani system of medicine for numerous diseases or ailments. The uses of various parts of the ‘Tulsi’ plant (e.g. leaf, stem, flower, roots, seeds etc.) were found among the traditional medical practitioners. (Gupta *et al.*, 2002; Prakash and Gupta, 2005).

This plant have been recommended for the treatment of bronchitis, bronchial asthma, malaria, diarrhoea, dysentery, skin diseases, arthritis, painful eye diseases, chronic fever, insect bite etc. (Singh *et al.*, 2002; Prakash and Gupta, 2005).

Scientific evidences are available on various medicinal aspects i.e., anticancer, antidiabetic, antifungal, antimicrobial, hepatoprotective, cardioprotective, antiemetic, antispasmodic, analgesic, anti-inflammatory, adaptogenic, radioprotective, immunomodulatory, neuro-protective, diaphoretic and antifertility actions. Most of these evidences are based on in–vitro, experimental and a few human studies (Mondal *et al.*, 2009).

Sacred versatility and traditional uses:

Traditionally, juice of the leaves of Tulsi plant was used as demulcent, stimulant, expectorant. Tulsi was also used in the cure of upper respiratory tract infections, bronchitis, skin infections and earache (Harsa *et al.*, 2003). An infusion of leaf had been used as anti-spasmodic in gastric disorders of children. A concoction of root of Tulsi is still being used as a diaphoretic in malarial fevers in remote areas. The seeds are mucilaginous and demulcent and are given in different ailments of genito-urinary system (Anonymous, 1991). Tulsi is good for heart, stimulates digestion, reduces breathing difficulties and cough (Ghosh, 1995). It had also been used in the treatment of snake–bite and scorpion–sting as described in ancient texts by Charaka and Susruta (Kirtikar and Basu, 1975). Thus, every part of the plant has useful application. Even today people use different parts of this plant for treatment of various ailments based on traditional knowledge.
Toxicological properties:

Tulsi is being used as medicinal herb for thousand years without any known adverse effects. There have been number of scientific studies conducted to evaluate the toxic effects of the plant. Bhargava and Singh (1981) studied the toxicity to find out the lethal dose of ethanolic extract of Tulsi in adult mice. Approximate LD$_{50}$ of *O. sanctum* was found to be 4505 ± 80 mg/kg body weight on administration by oral route and 3241 ± 71 mg/kg, body weight by intra-peritoneal (ip) routes. The administration of aqueous extract did not produce any acute toxic symptoms (100% survival) at doses up to 5g/kg body weight and the alcoholic extract was well tolerated (80% survival) up to dose of 4 g/kg body weight. The acute LD$_{50}$ values for aqueous and alcoholic extracts were found to be 6200 mg/kg, body weight and 4600 mg/kg, body weight respectively (Devi and Ganasoundari, 1995). Shetty and Coworkers (2008) have demonstrated acute toxicity study of aqueous and alcoholic extract of *O. sanctum* and have shown that doses up to 4 g/kg body weight did not produce any toxicity and mortality. Kumar et al., (2009) suggested presence of eugenol in *O. sanctum* acts as plant based safe preservatives against fungal spoilage of food stuffs during storage.

Antimicrobial properties:

The essential oil of *O. sanctum* was reported to possess antibacterial and insecticidal properties and it had been observed that *O. sanctum* induced an inhibitory effects on growth of *Mycobacterium tuberculosis* and *Micrococcus pyogens* var aureus. It had one-tenth anti-tubercular potency of streptomycin and one-fourth that of isoniazid (Anonymous, 1991). Aqueous and acetone extracts of *Ocimum sanctum* were also found to be sensitive to many plant fungi, *Alternaria tenuis*, *Helminthosporium spp.*, and *Curvularia penniseli* (Rao and Nigam, 1970; Sekhawat and Prasada, 1971; Dey and Chowdhury, 1984). The essential oils of Tulsi have been effective against both Gram-positive and Gram-negative bacteria and the properties were comparable with the effectiveness of clove oil (Prasad et al., 1986; Phadke and Kulkarni, 1989). The leaf extracts of *O. sanctum* found to inhibit both malate dehydrogenase and malic enzymes of filarial worm *Setaria digitata* (Banu et al., 1992). Aqueous extract, alcoholic extract and seed oil of Tulsi shown antimicrobial properties against enteric pathogens.
Higher content of linoleic acid in *O. sanctum* fixed oil could contribute towards its antibacterial activity and also exhibited significant antimicrobial activity against multi-drug resistant *Neisseria gonorrhoeae* (Singh et al., 2005; Shoken et al., 2005; Shoken et al., 2008). Essential oil of *O. sanctum* could show anti-microbial effect against *Staphylococcus aureus* and *Propionibacterium acues* (Aquil et al., 2005; Viyoch et al., 2006). Fresh leaves essential oil had shown more antibacterial properties compared to dried leaves essential oil of Tulsi and in case of fungus the property is just the reverse (Mondal et al., 2007). The highest larval mortality was found in leaf extract of *O. sanctum* against the larvae of *A. aegyti* and *C. quinquefasciatus*. (Anees and Mohamed, 2008). Essential oil of *O. Sanctum* and its major components eugenol were found efficacious in checking growth of *Aspergillus flavus*. (Kumar et al., 2009). Recently few endophytic bacteria have been identified and isolated from *O. sanctum* plant which found to have growth promoting effect as they significantly enhanced fresh herbage yield as well as essential oil content of *O. sanctum* (Tiwari et al., 2010).

**Adaptogenic (anti-stress) properties**:

A battery of stress tests which includes swimming endurance test, milk induced leukocytosis, aspirin induced ulcers and carbon tetrachloride induced hepatotoxicity have been tested in animals (Bhargava and Singh, 1981). The treatment with ethanolic extract of *O. sanctum* showed increased production of adrenaline, noradrenaline, monoamine oxidase and caused decrease in dopamine and 5-hydroxytryptamine (serotonin) levels in mice following swimming and gravitation induced stresses (Singh et al., 1991). Pretreatment with Tulsi essential oil significantly reduced the LDH and alkaline phosphatase levels, enhanced aspartate transaminase and membrane dynamics of RBC were reversed near normalcy. This reversal gave reasonable ground to speculate that central neurotransmitters are involved in regulation process of stress responses (Sen et al, 1992). Experimental rats could prevent the elevation in plasma corticosterone levels following acute and chronic noise stress when pretreated with 100 mg/kg, body weight ethanolic extracts of *O. sanctum* leaves and also caused significant reduction in total acetylcholine content and increase in the activity of acetylcholinesterase in brain, which
protect brain tissues against the detrimental effect of noise stress. (Sembulingam et al., 1997; Sembulingam et al., 2005). Methanolic extract of fresh leaves of Tulsi has been effective to bring the normal altered values of acute noise induced neutrophil functions (Archana and Namasivayam, 2000). Different types of crude extract of *O. sanctum* were effective upon noise stress. But the potency of the active principle, in cold homogenized leaf extract is higher than that of the hot extracts. (Archana and Namasivayam, 2002). Treatment with the ethanolic extract of the roots of *O. sanctum* (400 mg/kg, body weight) increased the mean swimming time significantly when experimental mice were subjected to swimming stress test (Maity et al., 2000). A polyherbal formulation containing Tulsi along with other plant extracts such as *Withania somnifera, Tribulus territories* and Shilajeet treated animals showed reduction in various induced stress related outcome results and was comparable with the proven adaptogen Ginseng (Bhattacharya et al., 2000). The methanolic extract of Tulsi when given at a dose of 50/100 mg/kg, body weight could significantly reduce the various paradigms of oxidative stress caused by ischemia-reperfusion injury, cigarette smoke, foot shock and iron overload hepatotoxicity (Bhattacharya et al., 2001). Experimental rats treated at dose of 200 or 500 mg/kg, body weight petroleum ether extract of Tulsi 30 minutes before the pentobarbitone induced hypnotization, the treated group did less error to escape from water maze (Maity et al., 2003). In a study conducted on experimental animals by Sethi et al. (2003), it was observed that feeding of 2 g of fresh Tulsi leaves for 30 days, the haemoglobin, serum glucose and plasma melondialdehyde (MDA) levels significantly remained higher when anaemic hypoxia condition was induced. It was also observed that *O. sanctum* administration blunted the cardiorespiratory parameter, decrease blood sugar, increase antioxidant levels in anaemic hypoxia condition. The result suggest potential antistressor activity of *O. sanctum* is partly attributable to its antioxidant properties. (Jyoti et al., 2007). The alcoholic extract of Tulsi and its fraction is found to inhibit lipid peroxidation of erythrocytic membrane in a dose dependant manner. The alcoholic extract produces greater inhibition (IC50 at 16 μg) as compared to aqueous extract (IC50 at 80 μg) (Geeta et al., 2004). Administration of ethanolic extract of *Ocimum sanctum* (100 mg/kg, body weight/ day, i.p. for 15 days) had a normalizing action on discrete regions of brain and controlled the alteration in neurotransmitter levels due to noise stress (Ravindran et al., 2005). The abundance of phytochemicals such as
phenolics and flavonoids in *O. sanctum* may be held responsible for this activity. (Samson et al., 2007).

**Hypoglycemic and hypolipidemic properties:**

The anti-diabetic properties of *O. sanctum* have been evaluated in experimental animal models and very few studies on human are available. Administration of fresh Tulsi leaves (1 and 2 g/day) for four weeks exerted significant hypoglycaemic and uricosuric effects on fasting glucose and 24-hour urine samples in experimental adult albino rabbits (Sarkar et al., 1990). Upon 15 days treatment with Tulsi leaf extract reduction in blood sugar level by 43% were noted in experimental rats with diabetes mellitus induced by alloxan (Giri et al., 1987; Chattopadhyay, 1999). Similarly, oral administration of ethanolic extract of Tulsi to the rats with diabetes, induced by glucose and streptozotocin, showed reduction in serum glucose level (Chattopadhyay, 1993). Administration of fresh leaves of *O. sanctum* mixed diet brought about significant lowering in serum total cholesterol, triglyceride, phospholipid and LDL cholesterol levels and significantly increase the HDL–cholesterol and total faecal sterol contents (Sarkar et al., 1994). Tulsi also showed hypoglycaemic activity along with other herbal formulations. Dry Tulsi leaf powder when fed at 1% of total diet for 30 days to the rats with diabetes induced by alloxan, fasting blood sugar, uronic acid, total amino acids, total cholesterol, triglyceride, phospholipids and total lipids reduced significantly (Rai et al., 1997b). In a similar study the extract also showed a favourable effect on glucose deposition in glucose fed hyperglycemic rats (Vats et al., 2002). Similarly, methanolic extract of Tulsi when given to experimental animals at a dose of 200 mg/kg, body eight for 30 days, the activities of glucokinase and hexokinase was increased significantly (Vats et al., 2004). Oral administration of 200 mg/kg body weight of the aqueous extract of *O. sanctum* to streptozotocin induced diabetic rat significantly lower blood glucose and serum lipid profile (Halim et al., 2001; Nayak and Roy, 2004). The seed oil of Tulsi when given 800 mg/kg, body weight/day to experimentally induced hyperglycaemic and hypercholesterolaemic rabbits for four weeks, cholesterol levels reduced significantly with no significant effects on blood sugar level (Gupta et al., 2006). 500 mg/kg, body weight *O. sanctum* extract found to reduce blood glucose and oxidative stress in rats with
streptozotocin-induced diabetes (Chandra et al., 2008). It was also found that feeding of 200 mg/kg, body weight aqueous extract of whole Tulsi plant for 60 days significantly delayed insulin resistance in fructose fed experimental mice (Reddy et al., 2008). The proposed mechanism of action for the secretion of insulin is that, Tulsi extract is able to stimulate adenylate cyclase/ cAMP or the phosphatidylinositol or direct effect on exocytosis that induce mobilization of intracellular Ca++ as well as promoting Ca++ entry (Hannan et al., 2006).

In one of the initial randomized controlled clinical trials, anti-diabetic properties have been studied in 40 non-insulin dependent diabetes mellitus (NIDDM) patients and observed that taking dried Tulsi leaf powder made from 2.5 g fresh leaves per day orally on empty stomach could reduce the fasting glucose level up to 21 mg/dl and postprandial blood glucose by 15.8 mg/dl (Agrawal et al., 1996). In another trial on 27 NIDDM patients, it was observed that supplementation of Tulsi powder along with hypoglycaemic drugs for one month could significantly decrease the blood glucose, glycosylated proteins, total amino acids, uronic acid, triglycerides, low density lipoprotein (LDL) and very low density lipoprotein (VLDL). However, there was no significant change in high density lipoprotein (HDL) level (Rai et al., 1997 a).

**Hepatoprotective properties:**

Tulsi offered liver protection against various experimentally induced damages. Tulsi extract treated group showed no mortality while control group showed 60% mortality in carbon tetrachloride induced liver damage in rats (Bhargava and Singh, 1981). The ethanolic extract of Tulsi treatment prior to paracetamol induced liver damage, have shown to protect the liver. This has been evident by significantly enhanced levels of serum enzymes (aspartate, aminotransferase, alkaline and acid phosphatase) and liver glutathione in experimental rats (Chattopadhyay et al., 1992). In a polyherbal formulation of four plants “Imu-21” including O. sanctum tested for cytotoxicity by measuring splenic leukocyte natural killer (NK) cells activity against K-562 cell line, showed that pretreatment with Imu-21, for seven days, can increase NK cell activity in mice. The possible mechanism is probably due to activation of mature NK cells or precursor cells which were previously not active (Nemmani et al., 2002). The ethanolic
Anti-inflammatory properties:

The aqueous and methanolic suspension of Tulsi had shown to inhibit acute as well as chronic inflammation in rats. This test was conducted by carrageenan induced paw oedema, croton oil induced granuloma and exudates, at a dose of 500 mg/kg, body weight/day (Godhwani et al., 1987). *O. sanctum* had shown to possess anti-inflammatory effects on experimental animal’s hind paw edema induced by carrageenan, serotonin, histamine and prostaglandin-E-2. These experimental rats were administered with essential oil (200 mg/kg, body weight), and fixed oil (0.1 ml/kg, body weight) before injection of phlogistic agents and was compared with standard drug flurbiprofen. It was noted that Tulsi extracts could significantly reduce the edema. However, its effect was less than the standard drug (Singh and Agrawal, 1991). The mechanism of action of the anti-inflammatory effects of Tulsi could be the cyclo-oxygenase and lipooxygenase pathways (Singh et al., 1996 a; Singh and Majumdar, 1997). Fixed oil of Tulsi can inhibit enhanced vascular permeability and leukocyte migration as evidenced by carrageenan induced inflammatory stimulus (Singh et al., 1996 a). Extract of seeds from three plants including *O. sanctum* had been studied for anti-inflammatory effects of carrageenan, leukotrine and arachidonic acid induced paw edema in rats. *Ocimum sanctum* seed oil showed maximum percentage inhibition of leukotrine induced paw edema (Singh et al., 2008).

Anti-carcinogenic properties:

The anti-carcinogenic properties have been evaluated in the experimental animals induced by different type of carcinogens. Tulsi leaves when fed to experimental rats with 600 mg/g diet for ten weeks, significantly reduced the 3, 4 benzo(a)pyrene *[B(a)P]* and 3'-methyl-4dimethylaminoazobenzene (3'MeDAB) induced squamous cell carcinoma and hematoma incidences (Aruna and Sivaramakrishnan, 1992). The anticancer activity of Tulsi has also been reported from Philippines where juice of fresh...
leaves was applied on the skin of experimental mice thrice a week for 20-minutes along with tumor promoter agents. No incidences of tumor were found in 20 weeks follow up period in Tulsi treated group (Serrame and Lim–Sylianco, 1995). The ethanolic extract of Tulsi leaves at a dose of 400 and 800 mg/kg, body weight have found to modulate carcinogen metabolizing enzymes such as cytochrome P-450, cytochrome-b5 and aryl hydrocarbon hydroxylase of mice liver (Banerjee et al., 1996). *O. sanctum* leaf extract blocks or suppresses the events associated with chemical carcinogens by inhibiting metabolic activation of carcinogen. (Prashar et al., 1998). *O. sanctum* has been investigated for its chemopreventive activity against 7, 12 dimethylbenz (a) anthracene (DMBA) induced hamster buccal pouch carcinogenesis. The observation suggest that the orally administered extract of *O. sanctum* may have the ability to prevent the early events of carcinogenesis. (Karthikeyan et al., 1999). The potential chemopreventive activity of the oil is partly attributable to its antioxidant properties. The chemopreventive efficacy of 100 microlitre/kg seed oil was comparable to that of 80 mg/kg of vitamin E (Prakash and Gupta, 2000). Studies have shown that in MNNG(N–methyl – N’ – nitro–N–nitrosoguanidine) induced gastric carcinogenesis, the key proteins involved in the proliferation, invasion, angiogenesis and apoptosis, are viable molecular targets for chemoprevention using ethanolic *O. sanctum* leaf extract. (Manikandan et al., 2007 a)

**Immunomodulatory properties:**

Rats treated with methanolic extract of *O. sanctum* when challenged with typhoid H-antigen and sheep red blood cells (SRBCs) showed a significant rise in antibody titre in both groups as compared to saline treated controls. In the Erythrocyte (E)-rosette formation test, it was observed that E-rosette formation in *O. sanctum* treated groups were significantly higher as compared to controls (Godhwani et al., 1988). Steam distilled extract of fresh leaves of *O. sanctum* enhanced humoral immune responses in experimental rats. Antigen (egg albumin) induced histamine release from peritoneal mast cells of sensitized rats in in-vitro was significantly inhibited by fresh leaves extract of *O. sanctum* (Mediratta et al., 1988). Effect of leaf extract of *O. sanctum* investigated on the specific and non–specific immune responses and disease resistance against *Aeromonas hydrophilia*. The result indicated the possibility of using *O. sanctum* as
immuno-stimulant in the maintenance of fin fish health in intensive fresh water aquaculture (Logambal et al., 2000). The *O. sanctum* seed oil has shown immunomodulatory potential. Humoral and cellular immunity were found to be increased in non-stressed and restrain-stressed experimental rats (Mediratta et al., 2002). Therapeutic efficacy of *O. sanctum* seed oil was studied in 23 confirmed cases of bovine mastitis in buffaloes. The result suggests that fixed oil also have the properties to cure the bovine mastitis (Singh et al., 1995). Use of 100 mg/teat/day aqueous extract infusion of *O. sanctum* for seven days reduced total bacterial count (TBC) in the milk and increased neutrophil and lymphocyte counts with enhanced phagocytic activities and phagocytic index. It was suggested that the bioactive constituents could be urosolic acid, oleanolic acid and sarigenin, which may possess immunomodulatory potential indicated by percentage increase in lymphocyte, enhanced activity of the phagocytosis of PMN cells in the bovine mammary gland, and the reduction in TBC in the milk (Mukherjee et al., 2005).

**Radio-protective properties:**

Uma Devi and her group have established a domain in pioneering the research on radio-protective properties of Tulsi extracts on experimental animals. They established that water extract of Tulsi is more radio-protective than the alcoholic extract (Devi and Ganasoundari, 1995). It was also observed that the Tulsi extract had no toxic effects compared to synthetic radio-protector WR-2712 (Ganasoundari et al., 1997). Radio-protection efficacy of two flavonoids, orientin and vicenin, isolated from leaves of Tulsi (administered i.p. 10 mg/kg, body weight/day to mice for five days) were compared with synthetic radio-protector aminothiol, 2-mercaptopropionyl-glycerine ‘MPG’ (20 mg/kg, body weight), WR-2721 (150 mg/kg, body weight). It was observed that vicenin provided maximum protection from radiation induced chromosomal aberrations and MPG the least, while orientin and WR-2721 provided almost similar effects (Uma Devi et al., 1998). WR-2721 and aqueous extract of Tulsi showed synergistic effects when compared with the individual effects of these compounds (Ganasoundari et al., 1998). Uma Devi and Ganasoundari (1999) further explored the possible protection against radiations induced lipid peroxidation in liver of adult Swiss mice. It was found that
pretreatment with water extract of Tulsi significantly reduced the lipid peroxidation compared to the controls. It also accelerated the recovery of antioxidant enzymes to normal levels. The proposed mechanism of this protection is the free radical scavenging capacity of flavonoids of Tulsi plant (Uma Devi et al., 2000). Flavonoids of Tulsi (orientin and vicenin) also exhibited radio-protective effects on human lymphocyte chromosomes (Vrinda and Uma Devi, 2001). The polysaccharides isolated from *O. sanctum* also prevented radiation mediated cell death in experimental mice (Subramanian et al., 2005). Another study indicated the possibility of using aqueous extract of *O. sanctum* for ameliorating 131 Iodine induced damage to the salivary glands. (Bhartiya et al., 2006).

**Anti-oxidant properties:**

Holy basil consists of a volatile compound called rosaminic acid which is a strong antioxidant. (Rai, et al., 1997 b; Hakkim et al., 2007). Another compound ursolic acid was found to be a mild protector against adrimycin induced lipid peroxidation in liver and heart microsomes of the rats (Balanehru and Nagarajan, 1991; Balanehru and Nagarajan, 1992). Further, antioxidant bioassay–directed extraction of the fresh leaves and stems of *O. sanctum* yielded cirsilineol, cirsimaritin, isothesmusin, isothymonin, apigenin, rosaminic acid and appreciable quantities of eugenol. (Kelm et al., 2000). Antioxidant effectiveness also established by (Moulik et al., 1997) due to the free radical scavenging capacity of *O. sanctum*. Uma Devi and Ganasoundari (1999) studied the role of *O. sanctum* in modulation of glutathione and antioxidant enzymes. An increased activity of antioxidant enzymes such as SOD, catalase level observed in wounded rat with aqueous extract of *O. sanctum* (Shetty et al., 2006). In another study, lowered level of malondialdehyde and increased level of SOD signify antioxidant activity of hydroalcoholic extract of *O. sanctum* (Kath and Gupta, 2006). Ethanolic extract of *O. sanctum* also posses antioxidant property by reducing oxidative stress through modulating xenobiotic –metabolizing enzymes, reducing the extent of lipid and protein oxidation and up-regulating antioxidant defenses. (Manikandan et al., 2007 b). Studies also indicate that *O. sanctum* has the potential for further evaluation as an ideal antioxidant for the noise induced oxidative stress in discrete brain regions. (Samson et
al., 2007). Wound healing effect of alcoholic and aqueous extract also has been shown due to the antioxidant properties of Tulsi (Shetty et al., 2008).

Cardioprotective properties:

Oral administration of hydroalcoholic extract of *O. sanctum* at different doses augments cardiac endogenous antioxidants and prevents isoproterenol induced myocardial infraction in rat (Sharma et al., 2001). This observation was further confirmed by Sood and co-workers (2005). The anti-atherogenic effect of herbal formulation Caps HT2 which contains methanolic extract of *O. sanctum* was evaluated. The result revealed the therapeutic potential of the formulation against vascular internal damage and atherogenesis leading to various types of cardiovascular problems (Mary et al., 2003). Effect of *O. sanctum* was studied on myocardial apoptosis and cardiac function in an ischemia and reperfusion model of myocardial injury. Significant cardioprotection and functional recovery demonstrated, which may be attributed to its anti-apoptotic property (Mohanty et al., 2006).

Anti-ulcer and wound healing properties:

Modern researches find Holy Basil to have potent therapeutic potential for gastric ulcer for its antiulcerogenic properties due to its ability to reduce acid secretion and increase mucous secretion (Mandal et al., 1993). The fixed oil of *O. sanctum* was found to possess significant anti-ulcer activity against aspirin, indomethocin, alcohol, reserpine, histamine etc. in animal models, specially in aspirin induced gastric ulcer. (Singh and Majumder, 1999). Intra gastric administration of a 70% ethanol extract of the leaves to rats, in various doses prevented ulcers induced by cold and acetyl salicylic acid and stress (Zhang, 1999). A hydro-alcoholic extract of *O. sanctum* leaves also found to be effective for healing of peptic ulcer possibly due to its antioxidant activity (Kath and Gupta, 2006). The effectiveness of *O. sanctum* extract in dexamethasone suppressed wound healing due to the increased activity of antioxidant enzymes have been shown (Udupa et al., 2006; Shetty et al., 2008).
Lung and bronchial supportive properties:

Tulsi has been shown to be useful in the treatment of a variety of serious allergic, inflammatory and infectious disorders affecting the lungs and related tissues. The herb is used in treating various diseases related to the respiratory system. Oral administration of an aqueous extract of dried *O. sanctum* to 20 patients with asthma was found to increase lung vital capacity and relieve the labour of breathing. (Sharma, 1983; Kirtikar and Basu, 1975; Sarkar and Pant, 1989; Singh and Majumder, 1996).

Analgesic and antipyretic properties:

The methanol extract and aqueous suspension of *O. sanctum* were tested for analgesic and antipyretic activity in animals. Both preparation reduced typhoid – paratyphoid A/B vaccine induced pyrexia. Intragastric hydroalcoholic extract administration to rabbits (10 mg) did not suppress the fever induced by yeast (Godhwani *et al*, 1987). The analgesic action of *O. sanctum* is exerted both centrally as well as peripherally and involves an interplay between various neurotransmitter systems (Khanna and Bhatia, 2003). *O. sanctum* has been declared to be a genuine remedy for malaria in the Imperial Malaria Conference. It is also helpful in curing fever, viral encephelitis etc (Maimes, 2004).

Anticataract properties:

Cataract is the leading cause of blindness world over. Diabetes is one of the major risk factors for cataracto-genesis and aldose reductase (AR) has been reported to play an important role in sugar – induced cataract. *O. sanctum* possesses a significant activity in vitro and its anticataract potential could be related with its AR inhibitory effect (Halder *et al*, 2003). Hydrogen peroxide (H\(_2\)O\(_2\)) is the major oxidant involved in cataract formation. Halder et al (2009) have reported *O. sanctum* extract have an important role against H\(_2\)O\(_2\) injury in human lens epithelial cell by maintaining the normal cellular architecture.
Psychopharmacological and neuroprotective properties:

An ethanol extract of the leaves of *O. sanctum* was screened for its effects on the Central Nervous System. It prolonged the time of lost reflex in mice due to pentobarbital, decreased the recovery time and severity of electroshock and pentylenetetrazole-induced convulsions and decreased apomorphine-induced fighting time and ambulation in “Open field” studies. Using a behavioural despair model involving forced swimming the extract lowered immobility in a manner comparable to imipramine, indicating a possible action involving dopaminergic neurones (Sakina et al., 1990). Neuroprotective effect of *O. sanctum* was evaluated on transient cerebral ischemia and long-term cerebral hypoperfusion (Yanpallewar et al., 2004). *O. sanctum* also had been evaluated as nootropic agent, which was used in situation where there was organic disorder in learning abilities. Therefore, Tulsi preparations could be beneficial in the treatment of cognitive disorders such as dimentia and Alzheimer’s disease (Joshi and Parle, 2006). Administration of methanolic extract of *O. sanctum* have ameliorated sciatic nerve transaction induced neuropathy which may be due to anti-oxidant and calcium attenuating action of the extract (Muthuraman et al, 2008).

Antithyroidic properties:

*O. sanctum* extract at a dose of 0.5 gm/kg body weight for 15 days significantly decreased serum T4 concentrations, but no marked changes were observed in T3 level, T3/T4 ratio. It appears that *O. sanctum* leaf extract is antithyroidic in nature (Panda and Kar, 1998).

Antigenotoxic properties:

*O. sanctum* leaf extract possesses the protective effect against chromium / mercury induced genetic damage in Allium Cepa root tip cells (Babu and Maheswari, 2006). *O. sanctum* extract treated human lymphocyte culture could reduce experimentally norethynodrel or cyproterone acetate induced genotoxic effects i.e.
chromosomal aberrations, mitotic index, sister chromatid exchange and replication index in a dose dependent manner (Siddique et al, 2006, Siddique et al, 2007).

Mosquito-repellent/larvicidal properties:

Mosquitocidal activity of Tulsi was investigated using its eugenol and triglyceride (isolated from Tulsi's hexane extract) on fourth instars *Aedes aegypti* larvae (Kelm and Nair, 1998). When 100 larvae of *Culex fatigans* was spread over water for 48 h, 100% mortality was observed in 75 seeds/m² of water while 65% and 89% mortality observed in 25 and 50 seeds/m² of water respectively (Hasan and Deo, 1994). Mosquitocidal efficacy of essential oil of *O. sanctum* against adult mosquitoes of different species viz. *Anopheles stephensi*, *Aedes aegypti*, *Culex quinquefasciatus* were investigated and 100% mortality observed in *A. stephensi* (Bhatnagar et al., 1993). Anees (2008) has studied the mosquito larvicidal property of both leaf and flower extract of *O. sanctum* against 4th instar larvae of *Aedes aegypti* and *Culex quinquefasciatus*. In search of plant based insecticides, the anti-feedant and larvicidal properties of four plants including *O. sanctum* against gram pod borer *Helicoverpa armigera*, cotton leaf roller *Sylepta derogata*, and mosquito *Anopheles stephensi* have been studied. Organic solvent extract of *O. sanctum* were able to kill the larvae of tested pests and vector (Kamaraj et al., 2008).

Miscellaneous properties:

It has been found that Tulsi can reduce the negative and dangerous side effects of many standard modern medical treatments. *O. sanctum* contains some nutrients like vitamin A, C, calcium, Zinc, Iron and other phytonutrients. It also enhances the efficiency of digestion, absorption and use of nutrients from food and other herbs (Singh, et al., 2002).

*O. sanctum* protect the integumentary system by reducing eczema, psoriasis, leprosy and various other skin disorders. Ursolic acid in Tulsi in one of the favourite component in cosmetic industry which not only quickly heals skin, retains elasticity and
removes wrinkles but also good at preventing and reducing skin cancer. (Maimes, 2004).

In search of potential herbal remedy for catalepsy, it was found that a polyherbal formulation, which also contained Tulsi extract, fed mice group improved catalepsy score and super oxide dismutase activity (Nair et al., 2007).

Juntachote and Berghonfer (2005) have studied the antioxidant activities of *O. sanctum* in order to preserve the packed food from rancidity. By taking battery to tests of assess the state of rancidity, it was found that Tulsi extract can be used as a preservative. To improve shelf life of a soyabean product called ‘Tofu’, aqueous extract of Tulsi was added to it. The shelf-life of ‘Tofu’ increased from normal 3-4 days to 7-8 days. (Anbarasu and Vijayalaksmi, 2007).

It was found in a transdermal drug (Flurbiprofen) delivery study on abdominal skin of rat a combination of natural product, Tulsi oil and Terpentine oil, demonstrated significantly higher drug delivery than the synthetic combination such as isopropylene and propylene glycol (Charoo et al, 2008).

**Reproductive behavioural modulatory properties:**

The use of many plants and herbs for preventive or abortive purposes of fertility has been prevalent in India for many centuries. Some plants with known antifertility properties include *Aborma augasta* Linn., *Michaelia champaka* Linn., *Plumbago rosea* Linn., *Cassia fistula* Linn., *Carcica papaya* Linn., *Azadirachta indica* and *Hibiscus rosa-sinensis* (Vohora et al., 1969; Lohiya and Goyal, 1992; Yadav and Jain, 1999; Ganguly et al., 2007; Gbotolorun et al., 2008; Sheeja et al., 2009). Many scientists have documented the role of *O. sanctum* on reproductory behaviour of adult male animal with discrete information about fertility effect of *O. sanctum* on female system.

In male *O. sanctum* causes some behavioural, biochemical as well as certain histological changes in fertility control behaviour of male reproductive organs of experimental animals. Seth and co–workers (1981) reported a dose dependent effect on
the weight of testes, significant reduction in sperm count, motility and androgen level. This observation was supported by Kasinathan and co-workers (1981) who observed significant histopathological and biochemical changes in spermatogenic cells leading to formation of non-viable sperm in albino rat with *O. sanctum* leaf extract. Fransworth and Waller (1982) also have shown the sperm inhibitory activity of *O. sanctum* extract. Khanna *et al.* (1986) have shown significant decrease in sperm count and motility as well as significant decrease in weight of testes, epididymis, seminal vesicles and ventral prostate after long term feeding of *O. sanctum* leaves. They have suggested the decreased levels of testosterone directly or indirectly brings the decreased mating behaviour in male rats. Kantak and Gogate (1992) supported the observation of Khanna *et al.* (1986) and reported the significant decrease in sexual behavioural score in *O. sanctum* treated male rats in presence of receptive females. Reghunandan and co-workers (1997) showed a severe degeneration of spermatogenic element with disturbance in spermatogenesis and reduction in activity of GTP, a marker of sartoli cell function in *O. sanctum* leaves extract treated male rabbit. Result indicated degeneration of seminiferous epithelium and sartoli cells as well as reduced leydig cell count. Lining of the duct of epididymis showed degenerative changes with less number of spermatozoa in it. These changes were thought to be reversible as female rabbits became pregnant, when allowed to mate, after one month of stopping the feeding of *O. sanctum* leaves. Ahmed *et al.* (2002a) showed decreased total sperm count, motility and forward velocity of sperm. The percentage of abnormal sperm increased in caudal epididymal fluid, with decreased fructose content, decrease in the caudal plasma of the epididymis and the seminal vesicles. Further Ahmed *et al.* (2009) reported that the size of liquid droplets, mitochondria, Golgi complex, endoplasmic reticulum were gradually decreased in sperm cell, with an accumulation of lysosomal bodies. The fertility performance test showed no implantation in female rats mated with *O. sanctum* treated male rats with low androgen level. It is suggested that such effects are due to androgen deprivation caused by the anti–androgenic properly of *O. sanctum* leaves. They also suggested that the effect was reversible because all parameters returned to normal 2 weeks after withdrawal of treatment. All these observation indicated reproductive modulatory effect of *O. sanctum* on male reproductive system.
In many relevant books on Indian Medicinal Plants, it is documented that *O. sanctum* leaves possess different modulatory effects on female reproductive function. Anti-zygotic, anti-implantation, and early abortification effects were observed in both human and experimental animal models (Chopra *et al.*, 1958; Vohora *et al.*, 1969; Batta and Santhakumari, 1970; Nadkarni, 1995; Ahmed *et al.*, 2002b). In mammals, particular anti-fertility efficacy of *O. sanctum* has been associated with its anti-implantation or abortification effect in female animals. Vohora *et al.* (1969), Batta and Santhakumari (1970) observed that 50% to 80% reduction in implantation sites in uterus on 10^th^ day of pregnancy. However, Reghunandan and co-workers (1997) showed the reversible nature of the above-mentioned reproductive process in both male and female rabbits when they demonstrated pregnancy in female rabbits by allowing them to mate after one month stopping of *O. sanctum* leaves feeding. Kasinathan and co-workers (1981) have reported the formation of vaginal plug in some *O. sanctum* treated animals. Though, formation of vaginal plug required certain optimum levels of mucoproteins but they showed consistent reduction in mucoproteins level of this plug. The reproductory behavior in terms of “Lordosis Quotient (LQ)” in *O. sanctum* treated animals was assessed by Sardessai *et al.* (1999). Lordosis behavior is a sequence of sensorimotor reflexes and dopamine system in striatum and forebrain and is believed to inhibit the Lordosis response. LQ was markedly decreased after administration of *O. sanctum* leaves extract to female adult rats which was postulated as the inhibition of the effect of ovarian hormones on dopamine system. In their study, the LQ remains suppressed for 2 weeks even after discontinuing the *O. sanctum* leaves feeding. Khanna *et al.* (1986) have also shown almost similar mating response where mating behavior was significantly decreased in both male and female rats, fed with *O. sanctum* leaves. They suggested the probability of disturbance in LHRH surge which was responsible for producing persistent estrous stage and lack of sexual receptivity and suppression in mating behavior in rats rather than bringing about azoospernia. The earlier report of Vohora *et al.* (1969) about fewer births per pregnant rat after *O. sanctum* feeding may be due to the fact of reduction in mating as well as anti-implantation and abortifacient actions.

Kage *et al.* (2009) observed that ovarian enzyme activities and serum FSH, LH levels were significantly reduced with *Trichosanthes cucumerina* var. *cucumerina* L.
induced antiovulatory activity of female albino rat. The onset of maternal behaviour of mammals towards young is not a spontaneous event but rather required hormonal induction. Estrogen, progesterone exposure during pregnancy sensitize the neural substrate to the subsequent action of oxytocin and prolactin which act in the brain to induce maternal behaviour (Champagne et al., 2001). Loundas and Bridges (1986) suggested length of prolactin priming differentially affected maternal behaviour of female rat. Bridges et al. (1990) and Ganong (2001) also found that central prolactin infusion stimulate maternal behaviour in steroid treated nulliporous female rat. Inhibition of the maternal behaviour was observed with reduced LH in indigenous mineral lithium treated rat (Roy et al., 1999). De Sousa et al. (2010) indicated that gonadal hormones after parturition seem necessary for the development of maternal aggressive behaviour and increase in progesterone level throughout the postpartum period could be one of the cause of natural reduction of the aggressive behaviour in lactating rat. It has been observed by Oliveira et al. (2010) that maternal indigenous nicotine exposure during lactation result in important changes in nutritional, biochemical and hormonal parameters in dams and offspring.

The exact mechanism for the fertility and maternal behavioural efficacy of *O. sanctum* in female rat yet to be studied for further exploration. All the earlier studies provided the incentive for further experiments. Validation of the potential effect of *O. sanctum* on reproductive function of mammal which may produce some informative observation on fertility effect of *O. sanctum* leaf extract.