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A review on phytochemical and pharmacological properties of Holy basil (*Ocimum sanctum* L.)

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ABSTRACT

Ocimum sanctum Linn. commonly known as *Holy Basil* or *Tulsi* is an Ayurvedic herb of Southeast Asia with a long history of traditional use. The culinary, medicinal and industrial importance of this plant led to explore its chemical and pharmacological properties. Here, we provide a comprehensive review on scientific findings of *O. sanctum* chemical constituents and their related anticancer, antioxidant, anti-inflammatory, antistress, γ-irradiation protection, antidiabetic and antileishmanicidal activities. More than 60 chemical compounds have been reported from *O. sanctum*, including phenolics, flavonoids, phenyl propanoids, terpenoids, fatty acid derivatives, essential oil, fixed oil, and steroids. The pharmacological activities of *O. sanctum* compounds reflect their medicinal importance and in the standardization of medicinal products. This compilation will be helpful in the development of new active principle and nutraceuticals in the area of drug resistance and emerging chronic disease vectors.

1. Introduction

The genus *Ocimum* belongs to the family Lamiaceae, comprises about 68 species indigenous to tropical regions of Asia, Africa and, central and south America (ThePlantList, 2013). *Ocimum sanctum* Linn. (*Os*) synonym *Ocimum tenuiflorum* L. (Lamiaceae), the most prominent species of the genera is cultivated worldwide for its medicinal, perfumery, religious, ceremonial, food and essential oil importance (Nadkarni, 1976). *Os* is a short-lived perennial shrub of 30–60 cm height with hairy stems and sparsely hairy leaves, which distributed in the Himalayas up to an altitude of 6000 feet (Watt, 1972). This aromatic shrub is commonly known as *Holy Basil* or *Tulsi* and identified as two common cultivars, *Rama Tulsi* with green leaves and *Krishna Tulsi* with purple leaves (Vani et al., 2009; Darrah, 1974). *Os* have been reported for antidiabetic, wound healing, antioxidant, radiation protective, immunomodulatory, antifertility, anti-inflammatory, antimicrobial, antistress and anticancer activities (Gholap and Kar, 2004; Vats et al., 2004; Udupa et al., 2006; Trevisan et al., 2006; Gupta et al., 2006; Geetha and Vasudevan, 2004; Yanpallewar et al., 2004; Bhartiya et al., 2006; Subramanian et al., 2005; Mukherjee et al., 2005; Godhwani et al., 1988; Ahmed et al., 2002; Kelm et al., 2000; Karthikeyan et al., 1999; Prashar et al., 1998; Prakash and Gupta, 2000; Singh et al., 2005). The toxicity studies suggest that *Os* is a nontoxic herb and safe to human use (Gautum and Goel, 2014; Sadashiv, 2010). The essential oil is one of the chemosystematic features of *Os* and a good natural source of eugenol. *Os* essential oil has commercial importance in various industries including pharmaceutical, cosmetics and food as an antiallergic and antimicrobial agent (Kumar et al., 2010).

The present review on *Os* aims to provide a comprehensive study on its traditional uses, chemical constituents, nutritional values and pharmacological activities of *Os* secondary metabolites. So far, no such systematic study has been carried out on the commercially and medicinally important herb *Os*. Hence, this study on phytochemical constituents and their reported pharmacological activities will serve as a chemical database for future research as well as enable to understand the research gap and outlook for future prospects.

2. Traditional uses and ayurvedic recommendations

Os, known as *Tulsi* (the incomparable one, Hindi) has been described as *Rasayana* drug in the ancient texts of Ayurveda including Charak Samhita, Susrut Samhita and Rigveda (3500–1600 BCE) to treat cough, respiratory disorders, poisoning, impotence and arthritis (Bano et al., 2017). It is considered as one of the sacred plants in India. *Os* is used as a nervine tonic, adaptogen, improving health during cancer and has beneficial effects in stress release (Chulet and Pradhan, 2009; Balachandran and Govindarajan, 2005). The therapeutic potential of *Os* has been well documented in Ayurveda and Siddha for healing properties as well as in Greek, Roman and Unani system of medicines for the treatment of skin diseases, common cold, headaches, coughs, malarial

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Table 1
Traditional uses of *O. sanctum*.

Plant parts (preparation used)	Ethnomedicinal uses	Region/Country	References
Fresh leaf with water	Enhancing mental power	Himachal Pradesh (India)	Vidyarthi et al. (2013)
Leaves with *Bruguiera gymnorrhiza* and coconut oil (pounded and rubbed on body)	Renovating from tiredness	Nicobar Island (India)	Dagar (1989)
Leaves pounded with onion bulbs (juice taken orally)	Cough, cold and headache	Tamil Nadu (India)	Muthu et al. (2006)
Leaves	Cough, cold, leg swelling and fever	Bangladesh	Chowdhury and Koike (2010)
Leaves (juice)	Cough, cold, bronchitis and gastric disorders	Bangladesh	Sharkar et al. (2013)
Whole plant	Cough, cold, headache, nausea, fever and skin diseases	Chuadanga, (Bangladesh)	Rahman et al. (2013)
Leaves pounded with garlic, leaves of *Achyranthes aspera* and pepper	Typhoid fever	Andhra Pradesh, India	Reddy et al. (1988)
Leaves pounded with fruits of *Tricosanthes diocia*, flowers of *Leucas indica* and leaves of *Aristolochia bracteata*	Typhoid fever	Andhra Pradesh (India)	Reddy et al. (1989)
Leaf decoction with flower heads of *Leucas cephalotes*	Fever	Makawanpur (Nepal)	Bhattarai (1991)
Leaf decoction with *Piper nigrum* and palmgur	Fever	India	Nazar et al. (2008)
Leaves paste with black pepper	Diarrhea and fever	Central Himalaya (India)	Kandari et al. (2012)
Leaves (juice)	Diarrhoea and dysentery	Tripura (India)	Sen et al. (2011)
Dried leaves with ghee	Dysentery, colic and piles	Central Himalaya (India)	Kandari et al. (2012)
Leaves (paste and decoction)	Stomach disorder, inflammations and wound cuts	Arunachal Pradesh (India)	Namsa et al. (2011)
Leaves (crushed and filtered extract)	Stomach ache and head ache	Assam (India)	Sajem and Gosai (2006)
Flowers juice with honey, ginger and onion juice	Bronchitis	India	Watt (1972)
Leaves (juice)	Bronchitis and catarrh	India	Watt (1972); Sharkar et al. (2013)
Dried leaves (vegetable)	Blood purification	Central Himalaya (India)	Kandari et al. (2012)
Leaves (juice)	To treat ringworm	Uttar Pradesh (India)	Siddiqui et al. (1989)
Leaves crushed in goat's urine and mixed with coconut oil	Skin allergy	Karnataka (India)	Shivanna and Rajakumar (2011)
Plant (paste)	Skin infection	Tripura (India)	Sen et al. (2011)
Leaves pounded with *Catharanthus roseus* leaves and mild heated	Ear boils	Karnataka (India)	Shivanna and Rajakumar (2011)
Leaves powder with honey	Diabetes	Assam (India)	Chakravarty and Kalita (2012)
Leave, flower top and roots (juice)	Antidote in snake poisoning	India	Watt (1972)
Leaves paste	Antidote for scorpion bite	Andhra Pradesh (India)	Reddy et al. (1988)

fever, diarrhoea, constipation and as an antidote for snake bite (Mondal et al., 2009; Uma Devi, 2001; Javanmardi et al., 2002). *Os* leaves have expectorant, carminative, refrigerant, febrifuge, laxative properties and their infusion is used as a stomachic in gastric disorders of children (Watt, 1972). Juice of fresh *Os* leaves is used as the first-aid remedy for earache. *Os* seeds are mucilaginous and demulcent and useful in the treatment of genitor-urinary disorders (Watt, 1972).

Os can be consumed as herbal tea, decoction (leaves and roots) to treat cough, cold and malarial fever (Prakash and Gupta, 2005). The paste of green or dried powdered leaves is used to treat ring-worm, skin diseases and vitalizing effect, whereas essential oil as larvicidal (Nadkarni, 1976). In Ayurvedic Pharmacopeia of India (1999), *Os* is recommended to treat pratishyaya (common cold), hikka (respiratory disorders), kasa (cough), aruci (loss of taste), kustha (skin disorders), krimiroga (treatment of worms) and parsva sula (chest pain) with a therapeutic dose of 2–3 g leaf powder. The available literature on the traditional uses of *Os* is limited to Asian countries, which compiled in Table 1.

3. Nutraceutical value (minerals, pigments and mucilage)

Minerals in routine intake of diet play an important role in food and nutraceutical industry. Herb *Os* has been used to add distinctive flavor in food and as a home remedy in various health conditions. The recent growing interest on the nutraceutical values of *Os* revealed that it is a rich source of vitamins, minerals, fat, protein, polysaccharide, fiber, pigments and mucilage (Pattanayak et al., 2010; Koche et al., 2011; Vidhani et al., 2016; Gowrishankar et al., 2010; Pachkore and Dhale, 2012). The macro and micro contents of *Os* are compiled in Table 2. The elemental analysis on macro and micro contents of *Os* leaves using Laser Induced Breakdown Spectroscopy (LIBS) and Inductively Coupled Argon Plasma Atomic Spectroscopy (ICAP-AES) techniques revealed the presence of almost all nutritionally important elements and interestingly high concentration of potassium (10521.477 ± 391.7 mg/kg leaves) (Tripathi et al., 2015). Presence of high concentration of potassium and lighter elements like C, H, O and N suggest the application of *Os* in maintaining electrolytic balance and source of organic compounds, respectively.

Os contains vitamin A, vitamin C, β-carotene, chlorophyll, insoluble oxalates, protein (30 Kcal), fat (0.5 g), carbohydrate (2.3 g), minerals and other phytonutrients. Each 100 g of leaf contain vitamin C (83 μg), carotene (2.5 μg), Ca (3.15%), P (0.34%), Cr (2.9 μg), Cu (0.4 μg), Zn (0.15 μg), V (0.54 μg), Fe (2.32 μg) and Ni (0.73 μg) (Pattanayak et al., 2010). Bhattacharya et al. (2014) analyzed the antioxidant contents in *Os* leaves and found the total carotenoid content (19.77 ± 0.01 g/100 g), total phenolic content (2.09 ± 0.10 g/100 g) and total flavonoid content (1.87 ± 0.02 g/100 g) of dry weights. The presence of ascorbic acid (8.21 mg/100 g), riboflavin (0.06 mg/100 g) and thiamine (0.3 mg/100 g) contents further suggest that *Os* leaves can intake as a dietary supplement, an alternative economic source of vitamins and natural antioxidant.

Basil seed gum or mucilage is composed of two major components (i) an acid stable core gluco mannan and (ii) α-linked xylan including acidic side chains at C-2 and C-3 of xylosyl residues in acid-soluble portion (Naji-Tabasi and Razavi, 2017). The seed mucilage of *Os* (yield ~30%), is a natural polymer that contains hexouronic acid (27.25%), pentoses (38.9%) and ash (0.2%) (Khare, 2016). *Os* seed mucilage has shown protein and amino acids on phytochemical evaluation, and possess swelling index 20 ml (water) with low ash value (Kadam et al., 2012). These physicochemical properties of mucilage direct towards its pharmaceutical excipient potential.

4. Chemical constituents of *Os*

Os leaves are rich in volatile oil (0.7%), phenolics, flavonoids, neolignans, terpenoids and fatty acid derivatives. *Os* seeds contain fixed