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Anti-fungal properties of *Ocimum sanctum* Linn: A short review

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Abstract
Fungal infections are increasingly becoming common today. Humans have only a limited arsenal against such infections and the resistant strains of fungi only make matters worse. *Ocimum sanctum* Linn. (Tulsi) has long been known as a medicinal plant and now, its effects have also encompassed anti-fungal properties. New research in the field only indicates that Tulsi extract is a viable alternative to other fungicides and can be used as a drug to combat infection. New research should be directed towards this bend, and investigate the extract as a drug to be used against fungal infections. This will ensure that, people who require this extract can be administered with it as soon as possible. In this review, a short summary of the recent advances in the field is given as well areas of possible research.

Keywords: Antifungal; *Ocimum sanctum* L; Tulsi; Medicinal Plant; Botany

1. Introduction
Ocimum sanctum Linn. (Tulsi) is an erect, branched sub-shrub about 30-60 cm tall, with simple opposite green or purple leaves. It has strongly scented leaves and hairy stems. Leaves have petioles and are ovate, up to 5 cm long, usually somewhat toothed. Flowers are purplish in elongate racemes in closed whorls. Tulsi is native throughout the world tropics and widespread as a cultivated plant and a weed. It is cultivated for religious and medicinal purposes and for its essential oil [1].

A plant with a long and drawn out history, the Tulsi has fascinated Indian researchers for decades, partly due to its significance in Indian 'Ayurveda' and its links to the traditional Indian household. The plant extract has been proved to possess various properties including anti-diabetic, antioxidant, and antimicrobial as well as wound healing properties [1].

The chemical composition of the *Ocimum sanctum* L. is very complex and thus, the plant has many active phytochemicals such as cirsilineol, cirsimaritin, isothymusin, isothymonin, apigenin, rosmarinic acid and eugenol [2] along with others. It is the action of these phytochemicals that give Tulsi its medicinal value and therefore, the importance of Tulsi keeps growing in today's world as more research is conducted in the field.

2. Anti-fungal nature
Fungi are increasingly becoming prominent in the world today. Species such as those of *Candida* are now recognised to be a major source of hospital-acquired infections [3]. Not much is effective in combating these; medicines such as polyenes cause severe host toxicity [4] whereas prolonged usage of azoles is leading to drug resistance in C.albicans and other species [5]. The most widely used drug in both the treatment and prevention of candidiasis is fluconazole (FLC) [6].

Therapies for fungal infections target the ergosterol biosynthesis pathway or its end product, ergosterol, a membrane sterol that is unique to fungi. Ergosterol is necessary for growth and normal membrane function of cells. It serves as a bioregulator of membrane fluidity, asymmetry and membrane integrity. Moreover, ergosterol also contributes to the proper function of membrane-bound enzymes. (Lupetti *et al*., 2002) [11].

In experiments conducted by (Amber, Aijaz, Immaculata, Luqman, & Nikhat, 2010; Khan *et al*., 2010), the anti-fungal nature of Tulsi was tested, by testing its synergistic action with azoles as well as the anti-fungal nature of two of the main components of Tulsi extract- methyl chavicol and linalool. In both the experiments, fungal strains, both fluconazole resistant and non-resistant, were taken and exposed to *Ocimum sanctum L.* extract, methyl chavicol and linalool. The experiments resulted in results that saw the action of Tulsi extract to be

synergistic with fluconazole and to be effective against strains of *C. albicans, C. tropicalis, C. glabrata, C. parapsilosis* and *C. krusei* [12, 13].

Tulsi extract has also been shown to be effective against filamentous fungi such as *Aspergillus Niger, Aspergillus fumigatus* (Dharmagadda *et al*., 2005 [7]; Bansod and Rai, 2008 [8]), *Aspergillus flavus* (Kumar *et al*., 2010 [9]) *Rhizopus stolonifera* and *Penicillium digitatum* (Grover and Rao, 1977 [10]). Other clinically important filamentous fungi like *Fusarium solani, Penicillium funiculosum, Rhizomucor tauricus* and *Trichoderma reesi* are also susceptible to Tulsi extract. (Dharmagadda *et al*., 2005 [7]). The leaf extract has also been effective against fungi such as *Rizopous, Cladosporium, Curvularia* and *Lunata.* [14] Finally, dermatophytic fungi were also found to be susceptible to Tulsi extract [15].

3. Analysis

Recent research in the field has opened up a huge plethora of possibilities in anti-fungal remedies with *Ocimum sanctum* L. extract being one of the top considerations. The experiment conducted by (Khan *et al*., 2010) studied the effect of the extract, methyl chavicol and linalool using flow cytometry, confocal imaging and determination of the levels of ergosterol. It was found that fungicidal activity resulted from lesions to the plasma membrane of the fungal cells. It thus, reduced the amount of ergosterol.

New research in the field should concentrate on the fungicidal properties of the other components of *O. sanctum Linn.* Extract as there only methyl chavicol and linalool have been properly explored. Moreover, the effect of Tulsi extract can also be explored on previously unexplored fungal species; this will generate more in-depth knowledge of the anti-fungal properties of Tulsi. New drug possibilities should be explored involving the use of Tulsi extract components.

Another possible avenue for research is whether the fungi become resistant to Tulsi extract over the long run. This has profound implications as to whether *O. Sanctum* Linn. can be a viable drug for use against fungal infections.

4. References

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