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REVIEW ARTICLE

Management of diseases, uses, biological and pharmacological activities of essential oil of basil (*Ocimum basilicum* L.): A review

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ABSTRACT

Ocimum spp. is native of Asian countries such as India, Iran, Pakistan, Thailand etc, it can be easily grown in tropical and sub-tropical part of the world also. Ocimum is the largest genus of family Lamiaceae and this genus is also known for its largest morphological and chemical diversity. Ocimum spp. are known as "King of the Herbs". Its common name 'Basil' is derived from Greek word "basileus" which means 'King' or "basilikon" means 'Royal'. Genus Ocimum comprises about more than 150 species out of which some are commercially grown in various parts of the world; it is also grown as ornamental plant. Some species are commercially cultivated for its medicinal properties but sweet basil (Ocimum basilicum) is commercially cultivated for its essential oil. Ocimum basilicum is native of Asia (India) and commercially cultivated in various part of the world like USA, France, South Africa, Bulgaria, Turkey, Iran, Japan, China and Italy. Major chemical active constituents of basil oil are methyl chavicol, linalool, methyl cinnamate etc.

INTRODUCTION

Ocimum basilicum is popularly known as sweet basil, which is universally cultivated herbaceous, perennial plant. *Ocimum basilicum* is used as kitchen herb, ornamental herb as well as culinary herb (Figure 1). Essential oil of sweet basil is used for its flavour and fragrance respectively in food and fragrance industry; it is also used in food products for increasing shelf-life (Nguyen and Niemeyer, 2008; Suppakul et al., 2003; Balakrishnan et al., 2018). Since ancient time in Ayurveda and Unani medical therapy basil extract is used for curing skin related diseases such as rashes and ringworm. The infusions of *O. Basilicum* (Sweet basil) widely used as old-style medicine to shrink plasma lipid content in Mediterranean areas (Bravo et al., 2008). *O. basilicum* frequently used in food, cosmetics, pharmaceutical, aromatherapy and perfumery industry. Taxonomical classification of *O. basilicum* is as:

Kingdom	:	Plantae
Phylum	:	Magnoliophyta
Class	:	Magnoliopsida
Order	:	Lamiales
Family	:	Lamiaceae
Genus	:	*Ocimum*
Species	:	*basilicum*

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Figure 1: Field view of *Ocimum basilicum*

CHEMICAL CONSTITUENT OF *O. BASILICUM*

Essential oil of *O. basilicum* contains many compounds which is identified by GC-MS analysis; about 20 major chemical compounds are Linalool, Eugenol, 1,8-cineole, Limonene, Bornyl acetate, α-bergamotene, β-elemene, Methyl eugenol, Camphor, α-copaene, β-caryophyllene, α-bisabolol, Germacrene, Menthyl acetate, β-cadinene, Farnesene, Chicoric acid, δ-cadinene, δ-gurjunene, Pulegone, Guaiene, Estragole and Neo isomenthol.

BIOLOGICAL ACTIVITY OF ESSENTIAL OIL OF *O. BASILICUM*

Active constituent of basil essential oil shows some biological activities (Table 1) such as Eugenol used as local anaesthetic and it shows neuro-protective and anti-cancer activity (Pramod et al., 2010). Linalool shows anti hyperalgesic properties, 1,8-cineol has wound healing and antiulcer characteristics. Anti-inflammatory activity has been shown by limonene and bornyl acetate; while bornyl acetate shows analgesic properties. β-caryophyllene shows antibiotic, antioxidant and anti carcinogenic properties. Farnesene are anti-oxidant and anti-insecticidal; δ-cadinene is anti-microbial and antioxidant in nature. α-bisabolol is antibiotic, anticancer and analgesic in nature. Menthyl acetate has antibacterial and anti-oxidant properties; Chicoric acid belongs to class phenyl propanoid has immuno stimulatory and antioxidant properties (Kuban-Jankowska et al., 2016).

PHARMACOLOGICAL ACTIVITIES

Whole basil plant, its essential oil and active constituents has vast pharmacological value and used for treatment of fever, cough, cold, anxiety,

Table 1: Biological activity, class of compound of *O. basilicum* chemical constituents

Chemical Compounds	Class of Compound	Biological Activity	References
Eugenol	Phenylpropanoid	Local anaesthetic, neuro-protective, anti-cancer	(Pramod et al., 2010)
Limonene	Monoterpene	Anti-inflammatory, motor-relaxant	(Vale et al., 2002)
1,8-cineole	Monoterpenoid	Wound healing, antiulcer	(Rocha Caldas et al., 2015)
Bornyl Acetate	Acetate ester	Analgesic, anti-inflammatory	(Wu et al., 2005)
Menthol	Alcohol	Anaesthetic	(Galeotti et al., 2001, Balakrishnan et al., 2018)
Camphor	Terpenoid	Antipruritic, decongesting	(Zuccarini, 2009)
Chicoric Acid	Phenylpropanoid	Immunostimulatory, antioxidant	(Kuban-Jankowska et al., 2016)
Linalool	Monoterpene alcohol	Antihyperalgesic, antinociceptive	(Kim et al., 2015)
Farnesene	Sesquiterpene	Anti-insecticidal, antioxidant	(Sun et al., 2011)
β-cadinene	Bicyclic sesquiterpene	Antiproliferative	(Cascaes et al., 2015)
Menthyl acetate	Monoterpene	Antioxidant, Antibacterial	(Muftah and Shushni, 2015)
Germacrene	Sesquiterpene	Antiinflammatory, analgesic	(Del-Vechio-Vieira et al., 2009), (SilvErio et al., 2013)
α-bisabolol	Sesquiterpene alcohol	Analgesic, Antibiotic, Anticancer	(Queiroz and Cajaiba, 2015), (Kamatou and Viljoen, 2010)
δ-cadinene	Bicyclic sesquiterpene	Antioxidant, antimicrobial	(Scura et al., 2016)
Guaiene	Sesquiterpene	Antithrombotic, Antiplatelet, Antidepressant	(Swamy and Sinniah, 2015)
Estragole	Phenylpropene	Neuronal excitability	(Silva-Alves et al., 2013)

skin related diseases, cardiovascular pain, nerve disease, sinusitis, diabetes, menstrual cramps and in insect biting. Basil also acts as anti-oxidant, anti-microbial, anti-bacterial, anti-inflammatory and insecticidal (Figure 2). It is used in digestive disorder as well as neural disorders (Balakrishnan et al., 2018).

Antioxidant

Essential oil of *O. basilicum* contains antioxidant properties for assistance of sperm to enhance the quality of sperm in rats to uptake spermatogenesis (Khalil, 2013), (Marinava and Ynishlieva, 1997).

Antimicrobial

O. basilicum oil has large flavour potential and oil is highly volatile in nature; it means very reactive against the temperature and pressure. Oil has lot of chemical compounds and these compounds shows anti-microbial activity; basil oil shows inhibitory effect against *Aspergillus ochraceus* (Basilico and Basilico, 1999).

Antiinflammatory

Methanolic extraction of aerial parts of sweet basil shows anti-inflammatory effect against human chondrosarcoma (SW1353) and macrophage (RAW264.7) (Raina et al., 2016).

Anticonvulsant

Hydro leaf crude extraction of basil has high concentration of eugenol compound, due to this it shows strong anticonvulsant activities (Freire et al., 2006).

Insecticidal activity

Essential oil of sweet basil was evaluated against *Culex tritaeniorhynchus, Aedesalbopictus* and *Anopheles subpictus* to predict the larvicidal activity by LC_{50} @ 9.75 ppm and LC_{90} values @ 23.44, 21.17 and 18.56 ppm respectively (Hossain et al., 2010), (Kathirvel and Ravi, 2012).

Antiplatelets

Aqueous extract of basil leaf when concentrated in vacuum by rotatory evaporator @ 65^0 C temperature then it shows anti platelet activity against thrombint (0.5 U/ml) and ADP (5 µM) as agonists. It inhibits ADP induced platelet aggregation by 13%, 28.2%, 30.5%, 44.7% and 53% @ dose of 1,2,3,4 and 5 g/l respectively (Amrani et al., 2009).

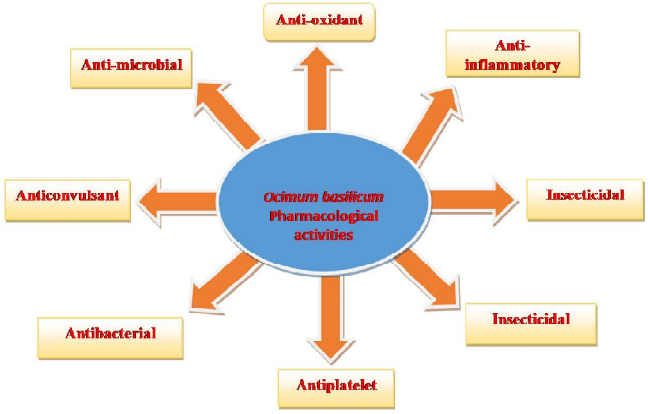

Figure 2: Pharmacological activities essential oil of sweet basil and its components

USES OF *O. BASILICUM*

O. basilicum oil is good source of some isolates and semi synthetic chemicals like linalool, anethol; Estragol (Methyl chavicol) and linalool are present in this oil after conversion of estragol in anethol. Anethol is used for anise flavour while linalool for flavour and fragrance both. In India since ancient time, it is used for curing fever, flu, cough, anxiety, and digestive disorders (Figure 3). Oil is also used for aromatherapy, as insect repellent and insect bites. In Spain oil is used as sedative;

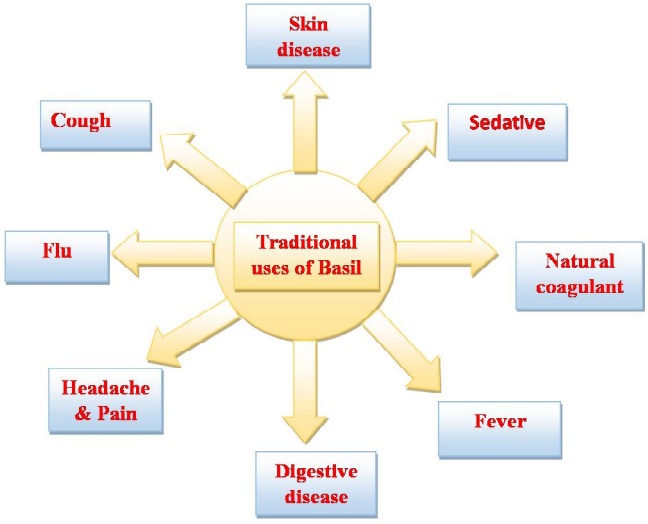

Figure 3: Traditional uses of *O. basilicum*

traditionally in Turkey used as folk medicine for cardiovascular and diabetic problems. Seed is used for biosorption of copper and have potential bio-sorbent for chromium uptake. Essential oil is used in perfumery due to its aroma. Traditionally in India leaf extract is used for treatment of face disease like pimples (Balakrishnan et al., 2018), (Freire et al., 2006), (Melo and Souza, 2004). Traditionally *O. basilicum* was used for the treatment of textile waste water as natural coagulant (Sarwan et al., 2012).

PEST AND DISEASES OF *OCIMUM*

Literature reveals that number of pest and diseases have already been reported in *Ocimum* species. Some of the common pest and disease are summarised as fallows-

FUNGAL DISEASE IN *OCIMUM*

- ***Cercospora* leaf spot:** *Cercospora* leaf spot disease is caused by fungi *Cercospora ocimicola.* On leaves light circular, irregular, or oval shape spots are present (Taie et al., 2010).
- **Downy mildew:** Downy mildew disease in basil leaves caused by fungi *Peronospora belbahrii.* Leaves become yellowish in colour, around the mid veins generally decolourisation starts. *Downy growth* on the lower surface of the leaf angular necrotic patches on the plant (Tran, 2011), (Balakrishnan et al., 2018).
- **Fusarium wilt:** *Fusarium oxysporum* fungi cause the disease fusarium wilt. Symptom of this disease: leaves become yellowish in colour, wilt, stunted growth and finally death of plant takes place (Taie et al., 2010).
- **Gray mold:** This disease is also caused by fungi *Botrytis cinereal.* Symptom of this disease are leaves dying and dropping from the plant, severe lesions on stem may cause plant death (Tran, 2011), (Balakrishnan et al., 2018).
- **Root rot:** This disease is also caused by fungi *Rhizoctonia solani, Pythium spp.* symptoms are failure of seed germination, shrivelled area at base of stem, roots become brown and water-soaked (Tran, 2011), (Balakrishnan et al., 2018).
- **Leaf spot:** This disease is caused by fungi *Colletotrichum spp.* on plant leaves (Tran, 2011), (Balakrishnan et al., 2018).
- **Black spot:** This fungal disease is caused by pathogen *Colletotrichum* species on leaves and stem of *Ocimum* plants (Balakrishnan et al., 2018).
- **Basal rot:** Basal rot disease of basil is found on the leaves of *Ocimum* plant and caused by fungal pathogen *Rhizoctonia solani* (Gamliel and Yarden, 1998).

DISEASE CAUSED BY BACTERIA

- **Leaf spot:** This disease is caused by bacteria *Pseudomonas cichorii,* symptom of this disease are irregular brown or black water-soaked spots on leaves; streaks on stems.

DISEASE CAUSED BY NEMATODES

- **Root knot:** This disease is caused by nematode *Meloidogyne spp.* Symptoms of this disease are galls on roots which can be upto 3.3 cm (1 in) in diameter but are usually smaller, reduction in plant vigour, yellowing plants which wilt in hot weather.

DISEASES CAUSED BY INSECTS

- **Japanese beetle:** Japanese beetle disease are caused by insect *Popillia japonica.* Symptoms shows skeletonized leaves, flowers and buds damaged. Larvae are cream-white grubs which develop in the soil, adult beetles are approximately 13 mm in length. For management of this disease use floating row covers to protect plants or spray kaolin clay if in previous years beetle damaged the crops.
- **Leaf miner:** This disease is caused by insect *Liriomyza spp.* Prior to planting saplings signs of leaf miner damage should be checked.

- **Flea beetle:** Flea beetle causing agent is *Phylotreta spp*. and it damages the leaf of the *Ocimum* plant. Symptoms shows small holes or pits on leaves that give the foliage a characteristic "shot hole" appearance. The young plants and seedlings are particularly susceptible which causes reduction in plant growth.
- **Cutworms, loopers, owlet moths, and underwings:** Causing agent**:** *Spodoptera exigua, Trichoplusiani and others.* In this disease insect has a wide range of hosts. The young stage larvae feed on terminal clusters. Later stage larvae skeletonize the leaves. Also, they cut the seedling stem close to the base resulting in heavy damage or loss.
- Various species of grasshopper cause disease in *Ocimum* sp. The adult and nymph both feed foliage, buds and tender stems. In the first stage nymphs feed on leaves by forming circular holes.

MANAGEMENT PRACTISES

Fungal disease management

As per the literature, number of researches has already been made on the management of fungal disease in *Ocimum.* Some of the researchers reported the fungal disease management using synthetic fungicide, however some of them natural fungicides.

***Cercospora* leaf spot:** *Cercospora ocimicola*

Chemical management- Small infections can be controlled by spraying fungicide containing potassium bicarbonate Weekly.

Physical management- Remove and destroy all symptomatic leaves from infected plant of *Ocimum.*

Downy mildew: *Peronospora belbahrii*

Chemical treatment- For the management of downy mildew disease application of the fungicide (potassium bicarbonate) is best suited method beside this try to grow tolerant varieties.

***Fusarium* wilt disease:** *Fusarium oxysporum*

Physical management- For management of the *fusarium* wilt disease use of the disease-free seed or before planting treat the seed with hot water to kill fungi, and rotate the crop after 2-3 years (Garibaldi et al., 1997).

Biological control: It can be controlled by using *Trichoderma spp.* and some antagonistic strains of *Fusarium* spp. (Garibaldi et al., 1997).

Gray mold: *Botrytis cinerea.*

Chemical management- no chemical treatment.

Physical management- Complete eradication of the infected plant from the field, in rainy conditions avoid working in field (Garibaldi et al., 1997).

Biological control- It can be controlled by using *Trichoderma spp.* and some antagonistic strains of *Fusarium spp.* (Garibaldi et al., 1997).

Leaf spot: *Colletotrichum spp.*

Physical management- Remove diseased leaves from plant and soil surface immediately, try to develop disease free seeds or transplant (Garibaldi et al., 1997).

Root rot: *Rhizoctonia solani, Pythium spp.*

Physical management- Grow the seed in well-drain and sterile soil (Garibaldi et al., 1997).

Biological control- It can be controlled by using *Trichoderma spp.* and some antagonistic strains of *Fusarium spp.* Drench the nursery beds with Bavistin @1% (Garibaldi et al., 1997), (Srivastava et al., 2018).

MANAGEMENT OF NEMATODE DISEASES IN OCIMUM

Root knot: *Meloidogyne spp.*

Physical management- Use nematode resistant varieties, check roots of plants mid-season or sooner if symptoms indicate nematodes, solarizing soil can reduce nematode populations in the soil (Garibaldi et al., 1997)**.**

MANAGEMENT OF INSECT DISEASE IN OCIMUM

Japanese beetle: *Popillia japonica*

Chemical management- Insecticidal soap can be best to reduce beetle populations.

Natural management- Neem oil is also very effective for the treatment of Japanese beetle disease of *Ocimum sp.*

Physical management- Adult beetle can be captured by hand and destroyed by putting in soapy water.

Leaf miner disease of Basil – *Liriomyza spp.*

Chemical management- Use insecticides (potassium bicarbonate) when leafminer damage is identified. Unnecessary spraying reduces the populations of their natural enemies.

Biological control– In the field if the ratio of insect/ grasshopper infected plants is high then encourage birds in the field for control of insect and grasshoppers. Spraying of Azadirachtin 10000ppm @5ml/l remains effective for the control of insect diseases (Srivastava et al., 2018).

Flea beetle disease of basil: *Phylotreta spp*.

Physical management- floating row covers may be used prior to the emergence of the beetles to provide a physical barrier to protect young plants.

Chemical management- application of insecticides containing carbaryl, Spinosad, bifenthrin and permethrin can provide adequate control of beetles up to a week but will need reapplied.

Management by natural product- Application on dematiaceous earth or oils such as neem oil are effective control methods for organic growers.

Cutworms, loopers, owlet moths and underwings- *Spodoptera exigua, Trichoplusiani e*tc.

Physical management- Pick the beetle and destroyed it or remove the infected plant from the field (Garibaldi et al., 1997).

Biological management– Use of fungi such as *Trichoderma* spp. as biocontrol agent (Garibaldi et al., 1997).

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