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REVIEW ARTICLE

A Review on Therapeutic potential of *Ocimum basilicum.*l

[1] Atena Alaghemand , [2]Behnaz Moghaddasian, [3]Shahab Khaghani
[1] Young Researchers and Elite club, Arak Branch, Islamic Azad University, Arak, Iran
[2] Department of Horticulture Sciences, Science and Research Branch, Islamic Azad University, Tehran, Iran
Department of Crop Production and Plant Breeding Faculty of Agriculture, Islamic Azad University, Arak, , Iran
Corresponding author: sun_sasha2002@yahoo.com

ABSTRACT
This review almost covers what is actually known to date about the basil and its constituents. Plants are one of the most important sources of medicines. Basil (Ocimum basilicum Linn.) is a widely used medicinal plant throughout the world. It is very popular in various traditional systems of medicine like Unani and Tibb. The objective of this paper is to review the literature regarding Ocimum basilicum, specifically for its chemical properties, therapeutic benefits and scientific studies. This review consists of all publications relevant to O. basilicum، that were identified by the authors through a systemic search of major computerized medical database. Studies indicate O. basilicum to possess, antioxidant, anticancer activities. The drug was also searched for its folkloric claims. It is used in traditional medicine as a tonic and vermifuge, and Basil tea taken hot is good for treating nausea, flatulence, and dysentery. This is also revealed that most of the therapeutic properties of this plant are due to the presence of thymoquinone which is major bioactive component of the essential oil. The present review is an effort to provide a detailed survey of the literature on scientific researches of pharmacognostical characteristics, chemical composition and pharmacological activities of this plant.
Keywords*: Basil, Pharmacological studies, Phytochemical studies, antioxidant, anticancer*

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INTRODUCTION

Medicinal plants have been used for curing diseases for many centuries in different indigenous systems of medicine as well as folk medicines that are also considered to be safe as compared to modern allopathic medicines. Many researchers are focusing on medicinal plants since only a few plant species have been thoroughly investigated for their medicinal properties, potential, mechanism of action, safety evaluation and toxicological studies. *Ocimum basilicum* Linn.(Family *Lamiaceae*) is emerging as a miracle herb researches revealed its wide spectrum of pharmacological potential, that is commonly known as Sweet basil" is used in both Unani and Ayurvedic system of medicine[39]. Moreover, among more than 150 species of the genus, *O. Basil* is the major essential oil crop which is cultivated commercially in many countries[23]. *O. basilicum* or sweet basil, is a culinary herb. Most culinary and ornamental basils are hybrids between species [22]. It has been used as a folk remedy for an enormous number of ailments, including boredom, cancer, convulsion, deafness, diarrhea, epilepsy, gout, hiccup, impotency, insanity, nausea, sore throat, toothaches, and whooping cough. Basil has been reported in herbal publications as an insect repellent [18].It is a popular herb, valued for its rich and spicy, mildly peppery flavor with a trace of mint and clove and has been used widely as a food ingredient for flavoring confectionary, baked foods and meat products[9]. It is used both as a culinary and an ornamental herb [22].

PHARMACOGNOSTICAL CHARACTERISTICS

Morphology of the plant

O. basilicum is known by different names in different languages around the world including the Indian subcontinent. In English, it is known as Basil, Common Basil or Sweet Basil[24]whereas in Hindi[40]and Bengali[10], it is called BabuiTulsi. The plant is known as Badrooj, Hebak or Rihan in Arabic; as Nasabo or Sabje in Gujrati and as JangliTulsi in Urdu. Tohrakhurasaniand Okimon are the ascribed names of the plant in Persian and Unani languages[29]. O. basilicum is an annual flowering plant which grows to 0.6 to 0.9 m tall, with simple, opposite, leaves[29]، Some cultivars, such as the 'Dark Opal', have leaves and stems deep purple in colour. The leaves are ovate, often puckered, flowers white or pink, and fruits have four small nutlets, that are about 2 mm long, ellipsoid, black and pitted [28].which are mucilaginous when wet.. The bracts are stalked, shorter than the calyx, ovate and acute Calyx is five mm long, enlarging in fruit and very shortly pedicel led. Its lower lip with the two central teeth is longer than the rounded upper lip. Corolla being 8-13 mm long are white, pink or purplish in color, glabrous or variously pubescent. The upper filaments of slightly exerted stamen are toothed at the base. Sepals of flower are five and remain fused into a 2-lipped calyx. Ovary is superior and there is a 2-carpellary, 4-locular and a 4-partite fruit of four achiness[25]. *O. basilicum* is closely related to and frequently confused with *O. africanum* and *O. americanum*, but they can be identified on the basis of indumentum (hair distribution) and flower size. Lemon-scented cultivars are usually the result of crosses between *O. basilicum* and *O. africanum* [21].

TRADITIONAL USES OF FOLK REMEDIES

O.basilicum has been traditionally used for the treatment of a variety of disorders, diseases of heart and blood, biliousness kapha and Vata, leukoderma etc, and conditions pertaining to respiratory system, digestive tract, kidney and liver function, cardio vascular system and immune system support, as well as for general well-being[39][29].Basil cures headache, aids digestion[28]and acts as a mild laxative.The warm leaves juice of this plant along with honey is used to treat croup. The juice of the leaves is also used to treat otitis [37]. The roots of this plant are used to treat bowel complaints of children. A cold infusion of it is said to relieve the after pain of parturition [25][38]. They are also given internally to treat cystitis, nephritis and in internal piles. Due to the mucilaginous and cooling effect, an infusion of basil seed is given to treat gonorrhoea, diarrhoea and chronic dysentery[38][39]. In traditional medicine, there is an attempt to introduce suitable alternatives to synthetic drugs by means of the chemical compounds existing in plants or through combining different parts of a number of plants. In other words, the purpose in traditional medicine is to improve the function of a system in relation to other systems and hence herbal medicines enjoy a more extensive range of effects than existing synthetic ones in pharmacotherapy[64]. Use of antiepileptic drugs can lead to numerous complications including decreased white blood cells and hepatic toxicity. Also, taking these drugs in pregnancy can have teratogenic effects and cause fetal anomalies. Therefore, herbal medicines with fewer complications could be a very appropriate alternative for treating this disease [14].*O.basilicum* has long been used as sedative, analgesic, and anticonvulsant [28]. In India, *O. basilicum* leaves are used as smoothing and their sap as febrifuge and drug bust in bronchitis. The powder of its dried leaves is blown into the nose for atrophic rhinitis which is manifested by excessive dryness of the nose, ample and smelly scabs, and broad nasal acavity[28].Sweet basil (*O.basilicum*) has been studied in humans for acne vulgaris, although a mechanism of action is unclear[4].

CHEMICAL COMPOSITION OF *O. basilicum*

Many active compounds have been isolated, identified and reported so far in different varieties of basil.The most important active compounds are Linalool. Analyzed essential oils mainly consists oxygenated monoterpenes (60.7-68.9%) followed by sesquiterpenes hydrocarbons (16.0-24.3%) and oxygenated sesquiterpenes(12.0-14.4%)also contain some other compounds. oxygenated monoterpenes are: linalool, camphor, cis-geraniol and 1,8-cineole. Based on one laboratory study, *O. basilicum* L. contains linalol (54.95%), methylchavikol (11.98%), methylcinnamat (7.24%), and linolen (0.14%)[14]. Essential oil is also found in sweet basil[18], along with rosmarinic acid[32][9], citral, eugenol, and geraniol[49].

Metabolism

Linalool is the chief component of European basil. The biosynthesis of this compound proceeds by way of mevalonic acid, and starts with three molecules of acetic acid (more precisely, acetyl coenzyme A). With the aid of the enzyme mevalonate-5-diphosphate carboxylase, and elimination of CO2, isopentenyl pyrophosphate [IPP, (6)] is produced. (Pyrophosphoric acid (HO)2-P(O)-O-P(O)(OH)2 is today referred to as diphosphoric acid, but the old abbreviation PP is still in use.)Part of the IPP, in the presence of IPP-isomerase, is rearranged to the isomeric dimethylallyl pyrophosphate [DMAPP, (7)]. The enzyme IPP-

isomerase establishes equilibrium between the two isomers, where DMAPP is the thermodynamically more stable. Only DMAPP can produce, through elimination of a diphosphate anion, a resonance-stablilized carbocation [8]. This, despite its resonance stabilization, is highly reactive, reacting in uncontrolled fashion with both water and numerous other substrates present in aqueous solution. For this reason, the a cation is formed only in a deep pocket in the prenyltransferase enzyme, where it is protected from undesired contact with water or other bases. Shielded within this enzyme pocket, the cation attacks in electrophilic fashion the double bond of an IPP molecule. Although attack of the cation is predisposed within the enzyme complex to occur at the terminal carbon as a consequence of steric conditions, this mode of reaction is also consistent with the familiar Markownikov rule. Two of the basic units are joined by a C–C bond to produce a C10 molecule (geranyl pyrophosphate). Another C5 cation is able to attack geranyl pyrophosphate electrophilically, leading to the carbon skeleton of a sesquiterpene, consisting of 15 carbon atoms. In the plant world, a great many fragrant substances can be generated in a few simple reaction steps starting with geranyl pyrophosphate, including geraniol (geranium), citronellol (rose), and geranial (lemon).The basil plant isomerizes geranyl diphosphate first to linaldoyl pyrophosphate, which then undergoes hydrolysis to linalool[27]. Biosyntesis of linalool was shown in figure 1.

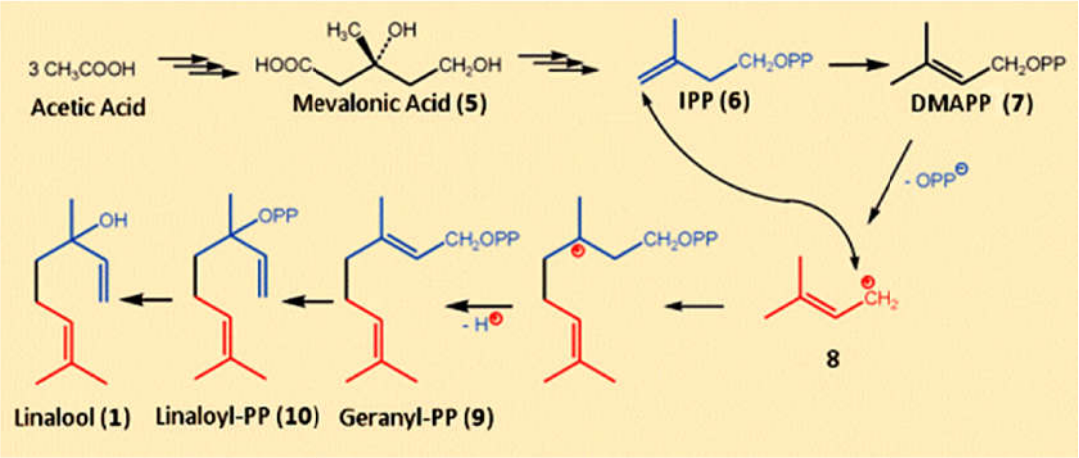

Figure 1: Biosynthesis of linalool

SCIENTIFIC RESEARCHES AND PHARMACOLOGICAL POTENTIALS

The extensive researches using modern scientific techniques were carried out by various researchers on *O. basilicum* since it is believed to be a miraculous herb that can cure multiple ailments and disorders. A number of pharmacological actions of *o. basilicum* have been investigated in the past few decades. Methanolic extract of *O. basilicum* was evaluated for its analgesic activity by tail immersion method in Swiss mice. The extract was able to show analgesic activity at 200 mg/kg concentration which was well comparable with the standard drug, aspirin[9].

Antioxidant activity

The antioxidant activity of essential oils is another biological property of great interest because they may preserve foods from the toxic effects of oxidants[41]. The antioxidant and antiarthritic activity of TQ in Wistar rat by collagen induced arthritis was evaluated. TQ was administered at a dose of 5 mg/kg body weight once daily for 21 d. The effects of treatment in the rats were assessed by biochemical (articular elastase, myeloperoxdase (MPO), LPO, glutathione (GSH), catalase (CAT), SOD and NO),inflammatory mediators [IL-1β, IL-6, TNF-α, IL-10, IFN-γ and PGE(2)] and histological studies in joints. TQ was effective in bringing significant changes on all the parameters (articular elastase, MPO, LPO, GSH, CAT, SOD and NO) studied. Oral administration of TQ resulted in significantly reduced the levels of pro-inflammatory mediators [IL-1β, IL-6, TNF-α,IFN-γ and PGE (2)] and increased level of IL-10[42]. Basils is one of the plant sources in flavonoid compounds rutin (or rutoside) and quercetin[18][38][59][60]. Flavonoids, as a major active constituent, display a remarkable role in various pharmacological activities including antiallergic, anti-inflammatory and antioxidant effects[39][18][60][45].In recent years, scientists have accomplished extensive research on the flavonoid biological activities such as antibacterial, antifungal, antiviral, anticancer and anti-inflammatory effects [28][38].In vitro antioxidant activities of 50% hydroalcoholic extract of *Ocimum* species namely *O.basilicum* and *O. sanctum* were achieved at varying concentrations (10-50µg/ml) using DPPH radical scavenging activity. The results showed that

*O.basilicum*had more antioxidant activity than *O. sanctum*[48].The ethanolic extract of O.basilicumexhibited potent antioxidant effects[48]. Investigating the essential oil from the aerial parts of Basil which exhibited good antioxidant activity as measured by 2,2'-diphenyl-1-picrylhydrazyl DPPH, free radical-scavenging ability, bleaching β-carotene in linoleic acid oxidation[49].examined twelve aroma constituents of basil for its antioxidant activity using the aldehyde/carboxylic acid assay. Eugenol, thymol, carvacrol, and 4-allylphenol showed stronger antioxidant activities than did the other components tested in the assay. They all inhibited the oxidation of hexanal by almost 100% for a period of 30 days at a concentration of 5μg/ml. Their antioxidant activities were comparable to those of the known antioxidants, α-tocopherol and butylated hydroxytoluene[35]. The anthocyani-dins compounds show various functions in counteracting the negative effects of nitrogen and oxygen reactive species, maintaining the redox homeostasis of biological fluids and preventing human disease such as athero-sclerosis, ardiovascular and other degenerative pathologies such as diabetes, cancer, Parkinson's and Alzheimer's diseases[181].In a study of patients with chronic bronchitis, exposure to essential oils of basil caused lowering of plasma levels of dienic conjugates and ketons and activation of catalase in red cells characteristic of antioxidant effects[52].Moreover the extracts from sweet basil were able to raise O6-methylguanine-DNA-methyltransferase (MGMT) levels[47]. Increased levels of MGMT mRNA accounted at least, in part, for the increased activity of the DNA repair protein. Sweet basil also increased glutathione S-transferase-pi (GSTP1) expression, albeit to a lesser extent than MGMT. The authors concluded that plant constituents upregulate human MGMT and raise the possibility of rational dietary approaches for attenuating alkylation-induced carcinogenesis. Further, they revealed the putative antioxidant responsiveness of the MGMT gene in human cells [48].

Anticancer activity

In vitro study of TQ to determine whether or not TQ can increase survival and sustain the expression of the homingreceptor CD62L in antigen-specific T cells. The results showed that stimulation of OT-1 (transgenic CD+) T cells with OVA antigen resulted in activation, as shown by adecrease in the surface expression of CD62L which coincided with significant apoptosis measured three and five daysafter antigen stimulation. Addition of low concentrations of TQ during CD85+ T-cell activation resulted in enhanced survival of the activated T cells and sustained expression of CD62L. These effects coincided with enhancement in the capability of CD8+ T cells to produce the effector cytokine interferon-gamma (IFNgamma). This is concluded that TQ has a beneficial effect in conditioning T cells in vitro for adoptive T-cell therapy against cancer and infectious disease[54]. The anticancer activity of *O. basilicum* extract and its fractions was evaluated using human cancer cell lines; active compound(s) residing in it were identified and mechanism of their anti-proliferative action was explored. Methanolic extract was fractionated into petroleum ether soluble (PE-S) and insoluble (PE-I) fractions. These were evaluated on HT-144, MCF-7, NCI-H460 and SF-268 cell lines using SulforhodamineB assay. Immuno fluorescence microscopy was employed to study their effects on the cytoskeleton and nuclei of MCF-7 cells. Fractionation of PE-I (GI50: 5 μg/ml; LC50: 71μg/ml against MCF-7) led to the isolation of four compounds, mainly ursolic acid (LC50: 18.6 μg/ml). Ursolic acid (100 μM) induced a significant decrease in the percentage of cells in anaphase/telophase stages along with F-actin aggregation and mitotic spindle distortion. These results support anti-proliferative activity of O. basilicum extract against MCF-7 cells which may partly be due to effects of ursolic acid on F-actin and microtubules[28].

Antibacterial activity

In a laboratory study, *O. basilicum* var. *citratum* showed promising antibacterial activity against Salmonella spp., Escherichai coli O157, Campylobacter jejunii, and Clostridium perferingens[64]. The essential oil of basil, obtained from the aerial parts of *O.basilicum* L., also showed activity against multidrug resistant clinical isolates from the genera Staphylococcus, Enterococcus, and Pseudomonas[47].The minimum inhibitory concentrations (MICs) were reported between 0.0030% and 0.0007% (v/v). Sweet basil is used for dental ailments due to its proposed antimicrobial effects; the mechanism of action is unclear[47]. Investigating anti microbial properties of sweet basil revealed that none of the ethanol, methanol and hexane extract from *O.basilicum* showed antifungal activities but anti candidal and anti bacterial effects[24]. Both the hexane and methanol extracts, but not the ethanol extracts, inhibited three isolates out of 23 strains of Candida albicans. The hexane extract showed a strong and broader spectrum of antibacterial activity followed by methanol and ethanol extracts. The minimal inhibition zones of the hexane, methanol and ethanol extracts ranged from 125 to 250 μl/ml, respectively.Somewhere in other part of the world, researcher investigated the Rosmarinic acid (RA), a multifunctional caffeic acid ester present in sweet basil and found that RA shows antimicrobial activity against a range of soil-borne microorganisms, with its most deleterious effects against Pseudomonas aeruginosa[59].

Anticonvulsant activity

The antioxidant effects of curcumin, NSO and valproateon the levels of malondialdehyde, nitric oxide, reduced glutathione and the activities of CAT, Na^+, K^+-ATPase andacetylcholinesterase in the hippocampus of pilocarpine-induced animal model of epilepsy was evaluated and left for22 d to establish the chronic phase of epilepsy. The animals were then treated with curcumin, NSO or valproate for 21 d. Treatment with curcumin, NSO or valproate ameliorated most of the changes induced by pilocarpine and restored Na^+,K^+-ATPase activity in the hippocampus to control levels. Results indicated the anticonvulsant and potent antioxidanteffects of curcumin and NSO in reducing oxidative stress,excitability and the induction of seizures in epilepticanimals and improving some of the adverse effects ofantiepileptic drugs[15]. Linalool is a monoterpene which is present in many aromatic oil essences as a main component and could be a candidate for antiepileptic effect of *O. basilicum*. Many of the plants containing linalool are used as antiepileptic agents in traditional medicine, of which juniper, scientifically named Aeollanthus from family *Labiatae*, could be mentioned. Also, oil essence of Laurusnobilis leaves containing linalool was demonstrated to be effective on PTZ-induced seizure. Linalool exerts its antiepileptic effect through inhibiting glutamate binding in rats' cortex and impacting GABAergic and glutamatergic connections Linalool is one of the main components of the extract and has dose-dependent effects [16]. This component has been used for dyspepsia and epilepsy, which its effects were attributed to its local anesthetic activity [14].

CONCLUSION

The use of herbal drugs as complementary medicine is prevalent and gaining world wide popularity. Many drugs are derived directly from plants; while the others are chemically modified natural products. The original research articles published so far have confirmed the pharmacological potential of *O. basilicum*. This is an attempt to compile and document information on different aspects of the plant and highlight the need for research and development.

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