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Biological and Pharmacological Properties of the Sweet Basil (*Ocimum basilicum*)

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Authors' contributions

This work was carried out in collaboration between all authors. Author MAC designed the study and wrote the draft of the manuscript in collaboration with author SBN. Authors AS and MA managed the literature searches. Author MAS segregated the literature and also helped in manuscript writing. All authors read and approved the final manuscript.

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ABSTRACT

Ocimum basilicum L. (sweet basil) a member of *Lamiaceae* family, is native throughout the old World and cultivated for religious and medicinal purposes. Basil was originated in Asia and Africa. Basil is used in both Ayurvedic and Unani system of medicine and is also popular for its culinary and ornamental uses. Various parts of the plant of sweet basil have been widely used in traditional medicine. The leaves and flowers of basil are used in folk medicine as a tonic and vermifuge. Basil tea is good for treating nausea, flatulence and dysentery. The oil of the plant has been found to be beneficial for the alleviation of mental fatigue, colds, spasm, rhinitis, and as a first aid treatment for wasp stings and snakebites.

Studies showed that basil possesses central nervous system (CNS) depressant, anticancer, cardiac stimulant, hepatoprotective, hypoglycemic, hypolipidemic, immunomodulator, analgesic, anti-inflammatory, antimicrobial, antioxidant, antiulcerogenic, chemomodulatory and larvicidal activities. The present review article provides up-to-date information on basil chemical properties, therapeutic benefits and pharmacological studies.

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1. INTRODUCTION

Plants are of the important sources of medicine and a large numbers of drugs in use today are derived from plants. *O. basilicum* L. commonly known as Sweet basil (*Lamiaceae*) is used in both Ayurvedic and Unani system of medicine [1]. It is also popular as ornamental crop [2]. Sweet basil is indigenous to lower hills of Punjab in India, Persia and Sindh but also grown in several Mediterranean countries including Turkey [3]. *O. basilicum* is being known by different names in different languages around the world. In Hindi and Bengali, it is known as Babui Tulsi [3,4]. In English, it is known as Basil, Common Basil or Sweet Basil [5]. In Arabic the plant is known as Badrooj, Hebak or Rihan; as Nasabo or Sabje in Gujrati and as Jangli Tulsi in Urdu. Tohrakhurasani and Okimon are the names of the plant in Persian and Unani languages respectively [6].

1.1 Etymology and History of Basil

Basil was originated in Asia and Africa [7]. In Hindu houses, basil is used to protect the family from evil spirits [8]. In early 1600s, the English used basil in their food and in doorways to ward off uninvited pests, such as flies as well as evil spirits. Sweet basil has been grown and sold in New York State since the end of the 18th century [9].

1.2 Botanical Description of Basil

Sweet basil is an autogamous, aromatic and herbaceous plant that is annual and perennial [10], grows 1-2 feet in height [11]. Basil produced large green leaves around 2 inches in length, throughout the summer [12]. Basil flowers are commonly removed to increase yield of leaves [13]. Calyx is five mm long, enlarging in fruit and very shortly pedicels. Its lower lip with the two central teeth is longer than the rounded upper lip. The bracts are stalked (shorter than the calyx), ovate and acute. Corolla is 8-13 mm long and white, pink or purplish in color. Nut lets are about two mm long, ellipsoid, black and pitted [6]. Sepals of flower are five and remain fused into a 2-lipped calyx. Ovary is superior and is a 2-carpellary, 4-locular and a 4-partite fruit of four achiness [5].

1.3 Traditional Uses

Basil is well-known for its folk medicinal value and is accepted officially in a number of countries [14]. The leaves and flowers of basil are used in folk medicine as a tonic and vermifuge, and basil tea is good for treating dysentery, nausea and flatulence. The oil of the plant is beneficial for the alleviation of spasm, rhinitis mental fatigue, cold, and as a first aid treatment for wasp stings and snakebites [15]. It has been used as a folk remedy for boredom and convulsion [16,17,18]. Basil cures headache, improves digestion and is also good for toothache, earache and for curing epistaxis when used with camphor. Infusion of plant is effective in cephalagia, gouty joints, fever, otitis and snake bite [6]. The plant is effective in treatment of stomach problems, fever, cough, gout and given internally to treat cystitis, nephritis and in internal piles [3]. Infusion of basil seed is used to treat gonorrhea, chronic diarrhea and dysentery. Plant is also used to keep away insects and snakes [19].

2. PHARMACOLOGICAL PROPERTIES

2.1 Analgesic and Anti-inflammatory Activity

Methanolic extract of *O. basilicum* leaves showed analgesic activity at 200 mg/Kg concentration evaluated in Swiss Albino mice and its analgesic activities was comparable with aspirin [20]. In another study evaluating the antinociceptive effects of *O. basilicum's* essential oil in mice by acetic acid-induced writhing test, it was observed a reduction of the abdominal contraction at 50, 100 and 200 mg/Kg body weight. In hot plate test, essential oil at 50 mg/body wt. increased the latency of pain. The results of peripheral and central antinociceptive effects of essential oils are related to the inhibition of the biosynthesis of pain mediators, such as prostaglandins, prostacyclins and opioid receptors interaction [21].

The effects of *O. basilicum* tincture (1:10) in acute inflammation induced with turpentine oil in Wistar male rats were examined and compared with diclofenac. *O. basilicum* tincture markedly suppressed the total leukocyte count, activation of circulating phagocytes and monocyte percentage but had a mild inhibitory effect on NO

synthesis. *O. basilicum* tincture presented a smaller inhibitory effect on all tested parameters as compared to diclofenac [22].

2.2 Hypoglycemic and Hepato-protective Activity

In-vitro hypoglycemic activity of basil aqueous extract in mice was investigated. The extract showed significant dose-dependent inhibition against rat intestinal sucrose, maltose and porcine pancreatic α-amylase. The inhibition was marked against maltose as compared to sucrose. These effects may be due to the high level of total polyphenol content and flavonoid contents. The results showed that basil aqueous extract via antioxidant and possibly α-glucosidase and α-amylase inhibiting activities, offered good response to control diabetes [23].

The ethanolic extract of leaves of *O. basilicum* showed hepatoprotective effects against H_2O_2 and CCl_4 induced liver damage. The extract exhibiting significant activity in superoxide radical and nitric oxide radical scavenging, indicated their potent antioxidant effects and also showed significant anti-lipid peroxidation effects [24].

The effect of methanolic leaf extract of *O. basilicum* after induction of hematotoxicity by benzene in Swiss albino mice, was evaluated by following the hematological parameters (Hb%, RBC and WBC counts), cell cycle regulatory proteins expression and DNA fragmentation analysis of bone marrow cells. It was observed an up-regulation of p53 and p21 and down-regulation of levels of CDK2, CDK4, CDK6 and cyclins D1 and E. DNA was less fragmented. The secondary metabolites of basil leaf extract, comprising essential oil monoterpene geraniol and its oxidized form citral as major constituents, presented modulatory effect in hematological abnormalities and cell cycle deregulation induced by benzene in mice [25].

2.3 Antihyperlipidemic and Anti-Ulcerative Activity

Lipid lowering effects of aqueous *O. basilicum* extract in Triton induced hyperlipidemic rats were investigated. At 24 hr following *O. basilicum* administration, total cholesterol, LDL-cholesterol and triglycerides levels decreased by 56%, 68% and 63%, respectively in comparison with the Triton treated group, but HDL-cholesterol was not increased markedly. The antihyperlipidemic effect exerted by *O. basilicum* extract was significantly stronger than the effect induced by Fenofibrate treatments. Moreover, *O. basilicum* aqueous extract also showed a very high antioxidant property [26].

Ethanolic and aqueous extracts of *O. basilicum* whole plant prevented the development of cysteamine hydrochloride induced gastric and duodenal ulceration and increased healing of gastric ulceration in rat models [27]. In experimental animal models, *O. basilicum*'s fixed oil presented significant antiulcer activity against aspirin, indomethacin, alcohol, histamine, reserpine, serotonin and stress-induced ulceration. It was found that antiulcer activity could be due to the lipoxygenase inhibiting, histamine antagonistic and anti-secretory effects of the oil [28]. Methanolic and aqueous extract of Aerial parts of *O. basilicum* reduced the ulcer index in aspirin induced gastric ulcer in rats. Gastric mucosal strength is enhanced due to reduction in acid and pepsin outputs [29].

2.4 Cardioprotective and Stimulant Activity

The effects of ethanolic extract of aerial parts of basil on cardiac functions and histopathological changes produced in isoproterenol-induced myocardial infarction (MI) were examined. All doses of the extract notably reduced the ST-segment elevation induced by isoproterenol. Basil extract markedly improved fibrosis and myocardial necrosis, suppressed left ventricular contractility and significantly increase left ventricular end-diastolic pressure. In addition to *in vitro* antioxidant activity, the extract significantly reduced the elevation of malondialdehyde levels both in the myocardium and the serum. The results of the study showed that basil strongly protected the myocardium against isoproterenol-induced infarction and explain that the cardioprotective effects could be related to antioxidative activities [30].

The alcoholic extract of aerial parts of basil produced marked negative chronotropic and positive ionotropic actions on frog heart. A notable decrease in membrane Mg^{+2}ATPase and increase in Ca^{+2} and Na^{+}/K^{+} ATPase are the basis for the cardiotonic effect. The aqueous extract produced positive ionotropic and positive chronotropic effects. The cardiotonic and ß-adrenergic effects were produced by the aqueous and alcoholic extracts respectively [1].

2.5 Sedative, Hypnotic and Anticonvulsant Activity

The aerial part essential oil of *O. basilicum* was screened for its sedative, hypnotic, anticonvulsant and local anesthetic activities in mice. Motor impairment was produced at higher doses. The convulsions and percent of colonic seizures increased in a dose-dependent manner of *O. basilicum* oil. All doses of the essential oil higher than 0.2 ml/Kg increased Pentobarbitone sleeping time in mice. The ED_{50} values of the basil oil were 1.27 ml/Kg, 0.43 ml/Kg, and 0.61 ml/Kg, against convulsions induced by strychnine, picrotoxin and pentylene tetrazole, respectively. A nerve block model was used in study to evaluate local anesthetic activity of the *O. basilicum* oil by using frog, revealed that it had no local anesthetic effect [16]. In another study essential oil did not interfere with the convulsions induced by strychnine. An interaction with central GABAergic receptors could be responsible for CNS depressant and anticonvulsant properties [17]. The effects of essential oils fragrance on humans inhaling was observed by a sensory test, a portable forehead surface electro-encephalographic (IBVA-EEG) measurement and a multi-channel skin thermometer study. Impression of basil was more effective after work than before work, leading to decreased arousal response [31].

2.6 Memory Retention and Stroke Preventive Activity

Hydroalcoholic extract of green basil markedly increased memory retention and retrieve memory in mice with 400 mg/kg. The results showed that memory enhancing effects of basil are due to antioxidant activity of flavonoids, tannins and terpenoids [32].

The effects of ethyl acetate extract of *O. basilicum* leaves on ischemia and reperfusion-induced cerebral damage and motor dysfunctions in mice, were investigated. Pre-treatment with basil extract significantly reduced lipid peroxidation and cerebral infarct size, restored glutathione (GSH) content and attenuated impairment in motor coordination and short-term memory. The results of this study suggested that basil could be useful clinically in the prevention of stroke [33].

2.7 Antimicrobial Activity

The antibacterial activity of the essential oils was examined against multi resistant *Escherichia coli* strain ATCC 25922, as well as 60 other clinical strains of *Escherichia coli* also including extended spectrum β-lactamase positive bacteria. Test showed that basil oil has a greater ability to inhibit bacterial growth but not effective in resistant strains in nosocomial infections [22]. In another study, methanolic, ethanolic and aqueous extracts of *O. basilicum* stem bark elicited antimicrobial activities with zones of inhibition ranging from 8 to 20, 5 to 12 and 0 to 8 mm for methanol, ethanol and water extracts, respectively. The minimum inhibitory concentration (MIC) of the ethanol extract ranged from 0.5 to 6.25 mg/ml and methanol extract was between 0.5 to 10 mg/ml. The minimum bactericidal concentration (MBC) for methanol extract ranged between 2.0 and 20 mg/ml, while for ethanol ranged from 2.0 to 12.50 mg/ml. All the extracts exhibited significant activity against *Candida albicans* is an indication of their broad spectrum antimicrobial potential [34]. Ethanol, methanol, and hexane extracts from *O. basilicum* were examined for their *in vitro* antimicrobial properties. Out of three extracts of *O. basilicum,* hexane extract showed a greater and broader spectrum of antibacterial activity [34]. The antibacterial activity of essential oils and methanol extract of leaves and stem of *O. basilicum* was examined for controlling the growth of food-borne pathogenic bacteria. *O. basilicum* displayed a greater potential of antibacterial activity against *Bacillius cereus, B. subtilis, B. megaterium, Staphylococcus aureus, Listeria monocytogenes, Escherichia coli, Shigella boydii, S. dysenteriae, Vibrio parahaemolyticus, V. mimicus, and Salmonella typhi* [36]. In another study, essential oil obtained from the aerial parts of *O. basilicum* showed a strong inhibitory effect against multidrug resistant clinical isolates from the genera *Staphylococcus, Pseudomonas and Enterococcus* [37]. Essential oils and linalool, the most abundant component, exhibited antibacterial activity against bacterial strains: *S. aureus, E. coli, Mucor mucedo, Fusarium solani, Botryodiplodia theobromae, B. subtilis, Pasteurella multocida* and pathogenic fungi *Aspergillus niger, Rhizopus solani* [38]. In other study, essential oils from leaves of basil plant were found effective against *B. cereus* and *S. aureus* with MICs ranging 36-18 µg/mL and 18 µg/mL and *E. coli* and *P. aeruginosa* 18-9 µg/mL [39]. Gel formulations of essential oils and acetic acid and keratolytic medication were examined in different combinations for their antimicrobial effectiveness in patients affected by acne. The results were found good especially for the acetic acid mixture, which achieved improvements of

75%. This appeared to be a result of their joint keratolytic activity and antiseptic [40].

2.8 Antimycobacterial and Antiviral Activity

The crude methanolic extract from the aerial parts and nine compounds were investigated for antituberculosis activity against *Mycobacterium tuberculosis* H37Rv that exhibited up to 49% inhibition of *M. tuberculosis* at 6.25 µg/ml, supports the use of this plant in ethnomedicine as a treatment for symptoms of tuberculosis [41].

Crude aqueous and ethanolic extracts of *O. basilicum* and its selected purified components, namely linalool, apigenin and ursolic acid, exhibited a broad spectrum of antiviral activity. Among these compounds, ursolic acid showed the greatest activity against DNA viruses: herpes viruses-1, enterovirus71 and RNA viruses: coxsackie virus B1 and adenoviruses-8. Linalool showed strongest activity against AVD-II, while apigenin exhibited increased activity against HSV-2, ADV-3, hepatitis B surface antigen and hepatitis B antigen [42]. In another study the aqueous extracts of *O. basilicum* showed potent anti-HIV-1 activity with an ED_{50} of 16 µg/ml [43].

2.9 Larvicidal and Antiparasitic Activity

85% mortality was observed in case of *O. basilicum* against the malarial vector and the methanolic extract can be used as bio-pesticide [18]. Repellency against the adult females of *Culex pipiens* was observed by essential oils extracted from the dried foliage of *O. basilicum* [44]. Significant toxic effect was observed by the essential oil against late third-stage larvae of *Culex tritaeniorhynchus*, *Aedes albopictus* and *Anopheles subpictus* with LC_{90} values of 23.44, 21.17 and 18.56 ppm and LC_{50} values of 14.01, 11.97 and 9.75 ppm respectively [45].

The effects of *O. basilicum* essential oil on *Giardia lamblia* and interaction of these parasites by peritoneal mouse macrophage were examined. The essential oil (2 mg/ml) and its purified substances; Linalool (300 µg/ml) exhibited antigiardial activity by clearly inhibiting cysteine proteases [46]. In another study, the effects of *O. basilicum* oil on *Trichomonas vaginalis* trophozoites were examined. The minimal lethal concentration of *O. basilicum* oil was 30 µg/ml after 24 hr incubation, 20 µg/ml after 48 hr and 10 µg/ml after 96 hr. Basil oil was responsible for significant damage of the membrane system of the trophozoites and extensive vacuolization of the cytoplasm, leading to inhibition of growth of *T. vaginalis* trophozoites [47].

2.10 Chemopreventative and Chemo-modulatory Activity

Ethanolic and aqueous extract of *O. basilicum* caused the alterations in O,6-methylguanine-DNA methyl transferase (MGMT) activity and expression in human peripheral blood lymphocytes and cancer cell lines. Increased MGMT activity is considered beneficial chemoprevention strategy. It also elevated glutathione S-transferase-pi (GSTP1) expression but to a lesser extent than MGMT [48].

The effects of hydroalcoholic extract of the fresh leaves of *O. basilicum* on the liver of 8-9 weeks old Swiss albino mice were examined. Basil leaf extract, showed anticarcinogenic potential at peri-initiational level and found very effective in inhibiting carcinogen-induced tumor. Basil leaf extract inhibited the Phase I enzyme activity and augmented chiefly the Phase II enzyme activity that is associated with detoxification of xenobiotics. Basil extract induced antioxidant level by prominent reduction of lipid peroxidation and lactate dehydrogenase formation [49].

2.11 Anticancer Activity

The oil samples of *O. basilicum* at different concentrations ranging from 0.019 to 4.962 mg/ml were examined on human mouth epidermal carcinoma (KB) and murine leukemia (P388) cell lines for anti-proliferative activity of essential oil by using MTT assay. The highest anti-proliferative activity was observed with IC_{50} value of 0.0362 mg/ml (12.7 times less potent than 5-fluorouracil (5FU) in P388 cell line [50]. In another study, essential oil against the human cervical cancer cell line (HeLa), human laryngeal epithelial carcinoma cell line (HEp-2) and NIH 3T3 mouse embryonic fibroblasts is investigated by using a methyl thiazol tetrazolium. The IC_{50} values obtained were 90.5 and 96.3 µg/ml, respectively and the results showed that basil oil has potent cytotoxic effect [51].

2.12 Cytoprotective and Immuno-modulatory Activity

The cytoprotective effects of rosmarinic acid against aflatoxin, mycotoxin and ochratoxin

induced cytotoxicity and carcinogenicity was investigated in hepatoma-derived cell line (HepG2) of human. Rosmarinic acid dose dependently inhibited DNA and protein synthesis. Apoptosis cell death was prevented by reduction of DNA fragmentation and inhibition of caspase-3 activation [52].

The aqueous and ethanolic extracts derived from the basil leaves showed a marked increase circulating antibody titer in response to sheep red blood cells (SRBCs) at 400 mg/kg/day in mice. As compared to control group, basil showed a significant increase in both primary and secondary haemagglutination (HA) titer in cyclophosphamide treated group. Basil prominently potentiated the delayed type hypersensitivity (DTH) reaction by favoring the footpad thickness response to SRBCs in sensitized mice. Also basil produced a marked increase in percentage neutrophils adhesion to nylon fibers and phagocytic activity. It was suggested that immunostimulant effect of basil could be due to the flavonoid content [53].

2.13 Antioxidant Activity

In vitro antioxidant activities of ethanolic, carbon tetrachloride and chloroform extract of *O. basilicum* was evaluated by using DPPH, hydroxyl and nitric oxide radical scavenging assay and reducing power assay. Ethanolic extract of *O. basilicum*s showed more antioxidant activity as compared to standard antioxidants [34]. To investigate the formulation antioxidant effect, formulation having 3% of the concentrated extract of Basil was tested. Formulation showed prominent effects on skin moisture volume, skin roughness, skin wrinkles, skin scaliness and skin smoothness and showed a prominent increase in energy. The results elicited that formulation containing extract of Basil exert anti-aging effects after topical application [54]. A similar study was done on ethanolic extract of leaves of *O. basilicum* which display significant nitric oxide and superoxide radical scavenging activity, indicating their potent antioxidant effects [24]. In another study, it was observed that aqueous and ethanolic extracts from *O. basilicum* increased the O6-methylguanine-DNA methyl transferase, responsible for antioxidant effects in human cells, also increased glutathione S-transferase-P1 to a smaller extent [48]. At the doses of 200 and 400 mg/Kg body weight of hydroalcoholic extract of the fresh Basil leaves was very effective in elevating antioxidant enzyme response by prominently increasing the hepatic glutathione reductase, superoxide dismutase and catalase activities. Induction in antioxidant level was also observed that correlates with the significant suppression of lipid peroxidation and lactate dehydrogenase formation [49]. The essential oils from aerial parts of basil exhibited good antioxidant activity as measured by DPPH free radical-scavenging ability, inhibition of linoleic acid oxidation and bleaching β-carotene in linoleic acid system [38]. Water, acetone and ethanolic extracts from leaves and flowers of basil were tested *in vitro* for their antioxidant ability. The results exhibited antioxidant activity which may be due to its lipid peroxidation inhibition, metal chelating activities and radical scavenging properties [55]. The antioxidant properties of five different extracts of *O. basilicum* were studied. Ethyl acetate n-butanol and aqueous extracts showed very strong free radical scavenging activity. The antioxidant activity was also explained by the levels of phenolics and flavonoids contents in the extract [56].

2.14 Effect on Testicular Toxicity and Fertility

The efficacy of *O. basilicum* extracts, with antioxidant properties, against testicular toxicity induced by cadmium was examined. Treatment with aqueous basil extract led to an improvement in morphometrical, immunohistochemical and histological changes induced by cadmium. The beneficial effects of Basil extract could be due to its antioxidant properties [57].

O. basilicum hydroalcoholic extract of leaves at doses 364 mg/Kg and 624 mg/Kg was screened for its anti-ovulatory, anti-implantation and abortifacient activities in adult female cyclic Wistar rats. A prominent increase in duration of diestrus phase and estrus cycle was observed. Ovarian weight decreased and significant increase in ovarian tissue cholesterol level was also observed. Weight of uterus was decreased. According to histological report large corpora lutea in ovarian parenchyma was found. Rats treated with both the doses of extract have no anti-implantation and abortifacient effect. Normal ovulation affected by basil extract was due to changes in estrus cycle and prolonging diestrus phase thus, has a potential of being developed into a female contraceptive [58].

2.15 Acute and Sub-chronic Toxicity of Basil

The safety assessment of *O. basilicum* hydroalcoholic extract in Wister rats was

examined. The results of acute study showed that LD_{50} of *O. basilicum* is greater than 5 mg/Kg. In sub-chronic study, no adverse effects were observed on serum parameters. The hematological results elicited a reduction in the platelets; hematocrit and red blood cells (RBC) [59].

3. CONCLUSION

Plants have been used for the treatment of enormous number of diseases throughout the world. “Sweet basil” is used in both Ayurvedic and Unani system of medicine and also popular for its culinary and ornamental uses. From medicinal point of view, the vast survey of literature showed that *O. basilicum* has a huge spectrum of pharmacological activities. Crude extracts and essential oil of various parts of plants have been used for their antibacterial, anticancer, anticonvulsant, antidiabetic, antihyperlipidemic, anti-inflammatory, anti-oxidant, antistress, hepatoprotective and immunomodulatory properties. Sweet basil with diverse biological potentials has a great scope for further new area of investigations. Future research should be emphasized on *O. basilicum* for evaluation of its pharmacological properties and for control of various diseases especially in cancer, cardiac, neuropsychological disorders for the welfare & service of mankind.

CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Muralidharan A, Dhananjayan R. Cardiac stimulant activity of *Ocimum basilicum* Linn extracts. Indian J Pharmacol. 2004;36: 163-6.
2. Javanmardi J, Khalighi A, Kashi A, Bais HP, Vivanco JM. Chemical characterization of basil (*Ocimum basilicum* L.) found in local accessions and used in traditional medicines in Iran. J Agric Food Chem. 2002;50:5878-83.
3. Nadkarni KM. The Indian Plants and Drugs. New Delhi: Shrishti Book Distributors. 2005;263.
4. Dymock W, Warden CJH, Hooper D. Pharmacographica Indica. A history of the principal drugs of vegetable origin. New Delhi: Shrishti Book Distributors. 2005; 82-5.
5. Jayaweera DMA. Medicinal plants, (indigenous and exotic) used in ceylon. Colombo: The National Science Foundation of Sri Lanka. 1981;101-3.
6. Kirtikar KR, Basu BD. Indian Medicinal Plants with Illustrations. 2nd edition. Uttaranchal, Oriental Enterprises. 2003; 2701-2705.
7. Simon, James E, Alena F, Chadwick and Lyle E, Craker. Herbs: An indexed bibliography 1971-1980: The scientific literature on selected herbs, aromatic and medicinal plants of temperate zone. Archon Books. (HSA Library); 1984.
8. Grieve M. A modern herbal; the medicinal, culinary, cosmetic and economic properties, cultivation and folklore of herbs, grasses, fungi, shrubs & trees with all their modern scientific uses. New York: Dover Publications. 1971;87.
9. Sperry, Jacob. Garden seeds. New York: Daily Gazette. News bank Infoweb-America's Historical Newspapers; 2009.
10. Blank AF, Rosa YR, Carvalho Filho JL, Santos CA, Arrigoni-Blank MF, Niculau ES, et al. A diallel study of yield components and essential oil constituents in basil (*Ocimum basilicum* L.). Ind Crops Prod. 2012;38:93–8.
11. Boxer, Arabella and Philippa Back. The Herb Book. London: Octopus Books Limited; 1980.
12. Muenscher WC, Rice MA. Garden spice and wild pot-herbs. Ithaca, New York: Cornell University Press; 1978.
13. Duke JA. Culinary herbs: A potpourri. Buffalo, New York: Bonch Magazine Limited; 1985.
14. Lawrence BM. A review of the world production of essential oil. Perfumes Flavors. 1985;10:2–16.
15. Baytop T. Treatment with plants in Turkey, Istanbul. Turkey: Istanbul University Publication. 1984;3255.
16. M. Ismail. Central properties and chemical composition of *Ocimum basilicum* essential oil. Pharm Biol. 2006;44(8):619–626.
17. Juliana SO, et al. Phytochemical screening and anticonvulsant property of

Ocimum basilicum leaf essential oil. Latin American and Caribbean J Med and Aromatic Plants. 2009;8(3):195–202.
18. Arthi N, Murugan K. Larvicidal and repellent activity of *Vetiveria zizanioides* L, *Ocimum basilicum* Linn and the microbial pesticide spinosad against malarial vector, *Anopheles stephensi* Liston (Insecta: Diptera: Culicidae). Journal of Biopesticides. 2010;3:199–204.
19. Anonymous. The wealth of India. New Delhi, National Institute of Science Communication and Information Resources. 2003;4:216-218.
20. Choudhury GB, Prabhat KJ, Nayak BS, Panda SK, Tripathy SK. Phytochemical investigation and evaluation of analgesic activity of leafy extracts of various *Ocimum* (TULSI) species. The Indian Pharmacist. 2010;8(12):67-70.
21. Venâncio AM, Onofre AS, Lira AF, Alves PB, Blank AF, Antoniolli AR, Marchioro M, EstevamCdos S, De Araujo BS. Chemical composition, acute toxicity, and anti-nociceptive activity of the essential oil of a plant breeding cultivar of basil (*Ocimum basilicum* L). Planta Med. 2010;77(8): 825-9.
22. Benedec D, Pârvu AE, Oniga I, Toiu A, Tiperciuc B. Effects of *Ocimum basilicum* L. extract on experimental acute inflammation. Rev Med Chir Soc Med Nat Iasi. 2007;111(4):1065-9.
23. El-Beshbishy H, Bahashwan S. Hypoglycemic effect of basil (*Ocimum basilicum*) aqueous extract is mediated through inhibition of α-glucosidase and α-amylase activities: An *In vitro* study. Toxicol Ind Health. 2012;28(1):42-50.
24. Meera R1, Devi P, Kameswari B, Madhumitha B, Merlin NJ. Antioxidant and hepatoprotective activities of *Ocimum basilicum* Linn. And *Trigonellafoenum graecum* Linn against H2O2 and CCL4 induced hepatotoxicity in goat liver. Indian J Exp Biol. 2009;47(7):584-90.
25. Saha S, Mukhopadhyay MK, Ghosh PD, Nath D. Effect of methanolic leaf extract of *Ocimum basilicum* L. on benzene-induced hematotoxicity in mice. Evid Based Complement Alternat Med. 2012;176385.
26. Amrani S, Harnafi H, BouananiNel H, Aziz M, Caid HS, Manfredini S, et al. Hypolipidaemic activity of aqueous *Ocimum basilicum* extract in acute hyperlipidaemia induced by triton WR-1339 in rats and its antioxidant property. Phytother Res. 2006;20(12):1040-5.
27. Das P, Sahoo S, Sethi R. Phytochemical and pharmacological investigation of the plant *Ocimum basilicum* with special reference to its anti ulceration property. J Pharm Res. 2010;3(1):63-66.
28. Singh S. Evaluation of gastric anti-ulcer activity of fixed oil of *Ocimum basilicum* Linn. and its possible mechanism of action. Indian J Exp Biol. 1999;37(3):253-7.
29. Akhtar MS, Munir M. Evaluation of the gastric antiulcerogenic effects of *Solanum nigrum, Brassica oleracea* and *Ocimum basilicum* in rats. J Ethnopharmacol. 1989; 27(1-2):163-76.
30. Fathiazad F, Matlobi A, Khorrami A, Hamedeyazdan S, Soraya H, Hammami M, et al. Phytochemical screening and evaluation of cardioprotective activity of ethanolic extract of *Ocimum basilicum* L. (basil) against isoproterenol induced myocardial infarction in rats. DARU J Pharm Sci. 2012;20:87.
31. Satoh T, Sugawara Y. Effects on humans elicited by inhaling the fragrance of essential oils: Sensory test, multi-channel thermometric study and forehead surface potential wave measurement on basil and peppermint. Anal Sci. 2003;19(1):139-46.
32. Sarahroodi S, Esmaeili S, Mikaili P, Hemmati Z, Saberi Y. The effects of green *Ocimum basilicum* hydroalcoholic extract on retention and retrieval of memory in mice. ANC Sci Life. 2012;31(4):185-9.
33. Bora KS, Arora S, Shri R. Role of *Ocimum basilicum* L. in prevention of ischemia and reperfusion-induced cerebral damage, and motor dysfunctions in mice brain. J Ethnopharmacol. 2011;137(3):1360-5.
34. Khosro I, Pahlaviani MR, Massiha A, Bidarigh S, Giahi M and Muradov PZ. "Analysis of the phytochemical contents and anti-microbial activity of *Ocimum basilicum* L. Int J Mol Clin Microbiol. 2012; 141-147.
35. Dinanath DP, Dnyandeo KM, Gurumeet CW. Antibacterial and antioxidant study of *Ocimum basilicum labiatae* (sweet basil). J Advanced Pharm Edu & Res. 2011;2: 104-112.
36. Hossain MA, Kabir MJ, Salehuddin SM, Rahman SM, Das AK, Singha SK, Alam MK, Rahman A. Antibacterial properties of essential oils and methanol extracts of sweet basil *Ocimum basilicum* occurring in

Bangladesh. Pharm Biol. 2010;48(5): 504-11.
37. Opalchenova G, Obreshkova D. Comparative studies on the activity of basil--an essential oil from *Ocimum basilicum* L. against multidrug resistant clinical isolates of the genera *Staphylococcus, Enterococcus* and *Pseudomonas* by using different test methods. J Microbiol Methods. 2003;54(1): 105-10.
38. Hussain AI, Anwar F, Sherazi STH, Przybylski R. Chemical composition, antioxidant and antimicrobial activities of basil (*Ocimum basilicum*) essential oils depends on seasonal variations. Food Chem. 2008;108:986-995.
39. Amir MDM, Jalal S, Peyman M, Jalil DS. Antimicrobial activity of essential oil extract of *Ocimum basilicum* L. leaves on a variety of pathogenic bacteria. J Med Plants Res. 2011;5(15):3453-3456.
40. Matiz G, Osorio MR, Camacho F, Atencia M, Herazo J. Effectiveness of antimicrobial formulations for acne based on orange (*Citrus sinensis*) and sweet basil (*Ocimum basilicum* L) essential oils. Biomedica. 2012;32(1):125-33.
41. Siddiqui BS, Bhatti HA, Begum S, Perwaiz S. Evaluation of the antimycobacterium activity of the constituents from *Ocimum basilicum* against *Mycobacterium tuberculosis*. J Ethnopharmacol. 2012; 144(1):220-2.
42. Chiang LC, Ng LT, Cheng PW, Chiang W, Lin CC. Antiviral activities of extracts and selected pure constituents of *Ocimum basilicum*. Clin Exp Pharmacol Physiol. 2005;32(10):811-6.
43. Erler F, Ulug I, Yalcinkaya B. Repellent activity of five essential oils against *Culex pipiens*. Fitoterapia. 2006;77(7-8):491-4.
44. Sienkiewicz M, Lysakowska M, Pastuszka M, Bienias W, Kowalczyk E. The potential of use basil and rosemary essential oils as effective antibacterial agents. Molecules. 2013;18(8):9334-51.
45. Govindarajan M, Sivakumar R, Rajeswary M, Yogalakshmi K. Chemical composition and larvicidal activity of essential oil from *Ocimum basilicum* (L.) against *Culex tritaeniorhynchus, Aede salbopictus* and *Anopheles subpictus* (Diptera: Culicidae). Exp Parasitol. 2013;134(1):7-11.
46. De Almeida I, Alviano DS, Vieira DP, Alves PB, Blank AF, Lopes AH, et al. Antigiardial activity of *Ocimum basilicum* essential oil. Parasitol Res. 2007;101(2): 443-5.
47. Hayam MEE, Abeer FB. *In vitro* anti-*Trichomonas vaginalis* activity of *Pistacia lentiscus* mastic and *Ocimum basilicum* essential oil. J Parasitic Diseases; 2013.
48. Niture SK, Rao US, Srivenugopal KS. Chemopreventative strategies targeting the MGMT repair protein: Augmented expression in human lymphocytes and tumor cells by ethanolic and aqueous extracts of several Indian medicinal plants. Int J Oncol. 2006;29(5):1269-78.
49. Dasgupta T, Rao AR, Yadava PK. Chemomodulatory efficacy of basil leaf (*Ocimum basilicum*) on drug metabolizing and antioxidant enzymes and on carcinogen-induced skin and fore stomach papillomagenesis. Phyto Medicine. 2004; 11(2-3):139-51.
50. Manosroi J, Dhumtanom P, Manosroi A. Anti-proliferative activity of essential oil extracted from Thai medicinal plants on KB and P388 cell lines. Cancer Lett. 2006; 235(1):114-20.
51. Kathirvel P, Ravi S. Chemical composition of the essential oil from basil (*Ocimum basilicum* Linn.) and it's *In vitro* cytotoxicity against HeLa and HEp-2 human cancer cell lines and NIH 3T3 mouse embryonic fibroblasts. Nat Prod Res. 2012;26(12): 1112-8.
52. Renzulli C, Galvano F, Pierdomenico L, Speroni E, Guerra MC. Effects of rosmarinic acid against aflatoxin B1 and ochratoxin-A-induced cell damage in a human hepatoma cell line (Hep G2). J Appl Toxicol. 2004;24(4):289-96.
53. Neelam LD, Nilofer SN. Preliminary immunomodulatory activity of aqueous and ethanolic leaves extracts of *Ocimum basilicum* Linn in mice. Int J Pharm Tech Res. 2010;2(2):1342-9.
54. Rasul A, Akhtar N. Formulation and in vivo evaluation for anti-aging effects of an emulsion containing basil extract using non-invasive biophysical techniques. Daru J Pharm Sci. 2011;19(5):344-50.
55. Yeşiloglu Y, Sit L. Antioxidant properties of various solvent extracts from purple basil. Spectrochim Acta A Mol Biomol Spectrosc. 2012;95:100-6.
56. Kaurinovic B, Popovic M, Vlaisavljevic S, Trivic S. Antioxidant capacity of *Ocimum basilicum* L and *Origanum vulgare* L extracts. Molecules. 2011;16(9):7401-14.

57. Sakr SA, Nooh HZ. Effect of *Ocimum basilicum* extract on cadmium-induced testicular histomorphometric and immunohistochemical alterations in albino rats. Anat Cell Biol. 2013;46(2):122-30.
58. Bilal A, Jahan N, Ahmed A, Bilal SN, Habib S. Antifertility activity of hydroalcoholic extract of *Ocimum basilicum* Linn leaves on female wistar rats. J Reproduct Contracept. 2013;24(1):45-54.
59. Rasekh HR, Hosseinzadeh L, Mehri S, Kamli-Nejad M, Aslani M, Tanbakoosazan F. Safety assessment of *Ocimum basilicum* hydroalcoholic extract in wistar rats: Acute and subchronic toxicity studies. Iran J Basic Med Sci. 2012;15(1):645-53.

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