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Ocimum Basilicum: A Review on Phytochemical and Pharmacological Studies

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ABSTRACT
Ocimum basilicum is a common herb that is known for its ornamental and therapeutic importance. The chemical constituents which have been isolated from the plant include terpenoids, alkaloids, flavonoids, tannins, saponin glycosides and ascorbic acid. It has been reported to be hepatoprotective, immunomodulatory, antihyperglycemic, hypolipidemic, antitoxic, anti-inflammatory, antibacterial and antifungal. The present review is aimed to cover the phytochemical study and pharmacological investigations on this important medicinal herb.

Keywords: *Ocimum basilicum*, phytochemical study, pharmacological investigations

1. INTRODUCTION
Plant kingdom presents the richest source of remedies to diverse human ailments. The WHO survey shows that 80% of the populations in the developing countries use herbal medicine for their health needs. Realizing the importance of plants in the discovery of new and safer therapeutic agents, screening of herbs for pharmacological activities and phytochemical constituents is one of the active fields of research round the world today.

Ocimum basilicum L., commonly known as Sweet Basil, belongs to the genus *Ocimum* of the family Lamiaceae. *Ocimum* (from Greek ozo for smell) is appropriate for the genus since its various species are known for their peculiar strong odours. *Basilicum* is the Latin translation of the Greek basilikon meaning king and due perhaps the same reason the herb is called "Herbe Royale" in French. The Urdu/Punjabi name *Niazbo* is also reflective of its pleasant fragrance.

2. TAXONOMICAL CLASSIFICATION
Kingdom: Plantae, Phylum: Magnoliophyta, Class: Magnoliopsida, Order: Lamiales, Family: Lamiacaea, Genus: Ocimum, Species: basilicum

3. VERNACULAR NAMES
English: Sweet basil, Hindi: Bawari bawai, Sanskrit: Berbery, Gujarati: Sabja, Persian: Furrunji-i-mushk, Punjabi: Niazbo, Baluchistan: Drar khatori

4. MORPHOLOGY OF PLANT PARTS
Seed colour: Black, Seed shape: Oval, Leaf colour: Green, Leaf margin: Slightly undulate, **Type of inflorescence**: erticellaster, **Flowering**: October-December, **Parts used**: Leaves, flowering tops, essential oil

Ocimum basilicum is a herb of medium size, strong scent with smooth or velvety touch. Leaves of the herb are opposite, simple, entire and ovate. They are toothed often, 3-5 cm long and petiole is slender. Its flowers are 8-12 mm long in cluster-like circles of 6-10 flowers. The colour of the petals can be white, pink or purplish. Glandular as well as non-glandular hair are found on both sides of the leaves of the herb.

Ocimum basilicum that is considered to have originated in the warmer parts of the Indo-Malayan regions, is abundantly found in tropical and hotter parts of the Indo-Pakistan subcontinent. It grows in habitats like wastelands and on hills and due to its ornamental and therapeutic significance it is also grown as pot plant. The pollination is through the aid of insects (entono-phylical).

Nitrogen fertilization has effect in different stages of development of the herb on the leaves of *O. basilicum*. Mass, chlorophyll and essential oil yield significantly increases with nitrogen fertilization. By using four treatments (i.e. control and irrigated with full soil water capacity (SWC). Treatment 1, 50% SWC, treatment 2, 30% SWC and treatment 3, 10 % SWC) *O. basilicum* was subjected to deficit irrigation control. Reduced irrigation increases oil content to a value of 26.10 % in a very low irrigation rate (10 % SWC) compared to 19.50% of control in seeds. As compared to full irrigation control, photosynthesis pigments and oil content of deficit irrigation treatments did not notably reduce[1].

5. PHYTOCHEMICAL STUDIES
Due to different combinations of the essential oils, various varieties of *O. basilicum* differ in fragrance. Different chemo varieties are found in different regions of the world. According to one study, the essential oil composition of

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O. basilicum was eucalyptol (1.79%), linalool (12.63%), α-terpineol (0.95%), eugenol (19.22%), β-elemene (2.68%), α-bergamotene (3.96%), α-guaiene (2.33%), germacrene D (8.55%), cubenol (1.78%), tau-cadinol (15.13%), camphor (0.70%), bornil acetate (1.97%), β-cariophylene (0.61%), α- cariophylene (1.67%), elixen (2.59%), β-cadinene (0.80%), α-copaene (0.33%), metil eugenol (0.76%), β-farnesene (0.58%), epibiciclosesquiphelandrene (0.76%), tau muralol (0.96%), α-bisabolol (0.35%), δ-gurjunene (5.49%) and δ-cadinene (5.04%)[2]. In leaves extract, the total phenolic content has been found to be 32.23 ± 4.45[3]. From Northwest Iran the hydro distilled essential oil from aerial parts of *O. basilicum* was analyzed by GC/MS. Forty seven components making 97.9% of oil were detected. Among them, monoterpenoids were (77.8%), sesquiterpenoids (12.8%), oxygenated monoterpenes (75.3%), menthone (33.1%), estragol (21.5%), isoneomenthol (7.5%), menthol (6.1%), pulegone (3.7%), Limonene (1.5%), sesquiterpene hydrocarbons (8.8%), trans-caryophyllene (2.2%), germacrene D (1.4%), trans-β-farnesene (1.1%), α-amorphene (1.1%), α-Cadinol (2.9%), menthyl acetate (5.6%) and Methyl eugenol (1%)[4]. Phytochemical screening of aqueous extract and elemental analysis of *O. basilicum* showed the presence of saponins, tannins and cardiac glycosides. There were potassium, calcium, sodium and magnesium in the concentration of 28770mg/kg, 17460mg/kg, 280mg/kg and 266mg/Kg, respectively. It is therefore concluded that, *O. basilicum* contains bioactive compounds and minerals that could enhance the curative process of health[5]. From Togo four chemotypes of estragol, methyl eugenol, linalool/estragol and methyl eugenol/ (E)-anethol have been reported[6]. From Sudan seven chemotypes with major components greater than 50%, their names being linalool/methyl cinnamate, linalool/geraniol, methyl chavicol, linalool, geraniol, methyl cinnamate/linalool and eugenol/linalool have been detected[7]. From Mississippi major chemotypes of the plant reported are bergamotene, methyl cinnamate/linalool, methyl chavicol/linalool, methyl eugenol/linalool, linalool, methyl chavicol, linalool/eugenol[8]. From Hungary, germacrene D and β-elemene were introduced as the main components of sweet basil oil[9]. From China, Croatia, Israel, Republic of Guinea, Nigeria, Egypt, Pakistan and Malaysia, (z)cinnamic acid methyl ester, linalool, eugenol, estragol, bergamotene, 1,8-cineol, α-cadinol, methyl cinnamate and limonene has been listed as major components of the essential oil of sweet basil. Essential oil composition of the sweet basil cultivated in Romania was reported to be constituted of nineteen components. In one sample, linalool was identified as the main component (46.95%) and the other components were elemene (7.84%), farnesene (6.86%) and guaiene (5.26%). Second sample contained epibicyclo sesquiphellandrene, cadinene, farnesene and elemene as the major sesquiterpenoid hydrocarbons (52.97%) [10]. For the first time, the presence of chicoric acid (dicaffeoyltartaric acid), which is a caffeic acid derivatized with tartaric acid, in basil leaves was reported[11]. Oil composition and yield of 38 basil genotypes in Mississippi was reported. In dry herbage, oil content varied from 0.07% to 1.92% and on the ground of oil constituents seven classes were made[12]. Chicoric acid levels in commercially available *O. basilicum* and the products of *Echinacea purpurea* were found. In fresh leaves, dried leaves and capsules and extracts of *E. purpurea* the concentration of chicoric acid varied from 6.48-242.50 mg/100 or 100 ml. It was found that basil was an economical source of the specified acid[13]. The phenolic compounds known to be reported the most in basil are phenolic acids and flavonol-glycosides[14]. Phenolic acid class in the form of caffeic acid derivatives has been identified in sweet basil[14,15,16].

6. PHARMACOLOGICAL STUDIES

Compounds extracted from plants have been used in medicine, either as they are or after chemical modification[17]. *O. basilicum* has immense ethnomedicinal applications. The essential oil of *O. basilicum* was tested against bacterial strains *S.aureus*, *E. faecalis*, *E. coli*, *P. aeruginosa* and the yeast *Candida albicans*. Among other *Ocimum* species the oil of *O. basilicum* showed best MIC against *C.*albicans[18]. It has been reported to be Antiviral, larvicidal, antinociceptive, antimicrobial[18, 19, 20].It has been used for thousands of years for the treatment of digestive and nervous disorders and has been found to be anthelmintic, antipyretic, stomachic, taste improving agent, cardioprotective and cure for blood diseases[21]. It is also known for its use in different ailments such as muscle cramps, insecticidal, diabetes and respiratory disorders. It is active as an antioxidant[22, 23], anti-inflammatory agent, feverish illness, nausea, migraine, abdominal cramps, gonorrhea, dysentery, headache, colic, dizziness, piles, cough, paralysis, nervous temperament and numbness[24]. The essential oil is used for acne, snake bites and insect stings. It is known to be antitoxic and cure for kidney and respiratory ailments. Basil tea cures diarrhea, vomiting, constipation and for mental fatigue and hyssop for cough[25]. The chemical composition of the essential oil of *O. basilicum* has been under study since 1930s[26] and more than 200 chemical components have been identified.

6.1 *Immunomodulatory Activity*

O. basilicum was administrated in wister albino rat in low and high dose. SRBC titre method was applied for antibody titre. RBC, WBC, Haemoglobin count and antibody titre value was increased. For immunomodulatory effect, *O. basilicum* showed increase in body weight than the control animal[27]. Immunomodulatory activity of ethanolic and aqueous extracts of the leaves of *O. basilicum* in rats was reported. Both types of extracts were given orally at the level of 400 mg/kg/day body weight. Delayed type hypersensitivity (DTH), haemagglutination antibody (HA) titer, neutrophil adhesion test and carbon clearance test were used for checking immunomodulatory activity for both specific and non-specific immunity. Immunostimulating agents used were cyclophosphamide (100 mg/kg/day, p.o.)

and levamisole (50 mg/kg/day, p.o.). A noteable increase in circulating antibody titer production in comparison to sheep red blood cells (SRBC's) was seen when given orally. In primary and secondary HA titer an increase was observed ($p<0.01$), higher than control group. In mice, *O. basilicum* potentiated the DTH reaction. It also showed increase ($p<0.01$) in percentage neutrophil adhesion to nylon fibres along with increase in phagocytic activity. The immunostimulant activity of *O. basilicum* is due to the flavonoid content[28]. Lymphocyte proliferation in rats induced by methanolic and aqueous extracts of the Mexican plants has been reported. *Persea americana*, *Plantago virginica*, *Rosa spp*. and *O. basilicum*. Methanolic extracts of *P. americana*, *P. virginica*, *Rosa spp*. and *O. basilicum* showed lymphoproliferation up to 16%, 69%, 66% and 80% respectively and for aqueous extracts it was 48%, 31%, 83% and 83% respectively in comparison to untreated controls. The effect of *O. basilicum* aqueous extract at concentrations of 31.25, 62.5, 125 and 250 µg/ml was different than that for *Persea americana* at the same concentrations. The solvents had no effect on lymphocyte proliferation activity. The Immunostimulating effect had benefit in increasing lymphocytes in patients suffering from immune deficiency[29].

6.2 *Antioxidant Activity*

Methanolic extracts of *O. gratissimum* and *O. basillicum* were studied for antioxidant potential by using standard methods. *O. basillicum* showed very weak activity in DPPH assay as compared to *O. gratissimum*. Percentage radical scavenging activity was concentration dependent[30]. Acetone and ethanol extracts of *A. indica*, and *O. basilicum* were studied for antioxidant activity at concentrations of 50, 100, 250 and 500 in µg/mL. Antioxidant activities were concentration dependent. By ferric thiocynate (FTC) ethanol extract of *O. basilicum* at the concentration of 500 µg/mL showed 75.87%, an antioxidant activity very close to that of 500 µg/mL of α-tocopherol (82.14%), the reference compound[31]. Antioxidant activity of basil by different methods like 1,1-diphenyl-2-picryl-hydrazyl (DPPH) free radical scavenging, hydrogen peroxide scavenging, ferric thiocyanate method, reducing power, scavenging of superoxide anion radical-generated non-enzymatic system, reducing power and metal chelating activities was studied. Two types of extracts were investigated: water extracts (WEB) and ethanol extracts (EEB). The antioxidant effects were found to be concentration dependent. Ferric thiocyanate method was used for total antioxidant activity. The inhibition effect of WEB on peroxidation of linoleic acid emulsion for the concentration of 50 µg/ml came to be 94.8%. For the same concentration, it was 97.5% for EEB. With the concentration of 50 µg/ml for BHT, BHA and α-tocopherol it came to be 98.5%, 97.1% and 70.4% , respectively. Other assays also gave effective results. Reference antioxidants used were BHA, BHT and α-tocopherol. Total phenolic content was analysed as gallic acid equivalent and was determined as equivalent[32].

6.3 *Antihyperglycemic and Hypolipidemic Activity*

Prevention of induced hyperlipidemia in Wister albino rats by *O. suave* (OS) and *O. basilicum* (OB) was investigated. High fat diet, constituting 31% fat, was given to groups of rats daily oral doses being 800 mg/kg of extracts of *O. suave* or *O. basilicum* for 21 days period. In the HFD control rats, as compared to the normal feed fed rats (7% fat) significant ($p < 0.05$) increases in serum levels of total cholesterol (HDL and LDL), was seen but significantly ($p < 0.05$) reduced the serum triacylglycerols. Significant prevention of HFD induced increases in serum total cholesterol and partial decrease of the HFD induced decrease in serum triacylglycerols was noticed by the administration of aqueous extract of *O. suave* or *O. basilicum*. Lipitor® the standard hypolipidemic drug was used to compare the results[33]. Anti-hyperglycemic and hypolipidemic effects of the aqueous extracts from *O. basilicum* in rats were reported. Aqueous extract of the whole plant was taken and both the effects were analysed in normal rats as well as streptozotocin (STZ) diabetic rats. One oral dose of *O. basilicum* lowered blood glucose level in normal ($p<0.01$) and diabetic rats ($p<0.001$). For 15 days this oral administration was carried out. It was seen that in diabetic rats there was considerable reduction in blood glucose level ($p<0.001$) and less reduction in normal rats ($p<0.05$). By this repeated practice, plasma cholesterol levels and triglyceride levels were also reduced. Besides that body weight and plasma insulin levels remained unaffected. Hence, it was seen that aqueous extract showed anti-hyperglycemic and hypolipidemic effects without affecting body weight and insulin levels[34].

6.4 *Anti-herpes Simplex Virus Activity*

Anti-herpes simplex virus activity of dichloromethane and methanol extracts of *O. sanctum*, *O. basilicum* and *O. americanum* was studied. Before viral infection, dichloromethane extract of *O. americanum* and the methanol extract of *O. sanctum* had protective effect on green monkey kidney cells against HSV-2 infection. The therapeutic indexes (TI) values of 1.865 and 1.644, respectively, were noted. Treatment of cells with methanol extracts of *O. americanum*, *O. sanctum* and *O. basilicum* inhibited HSV-2 infection. TI values noted were 2.345, 2.473 and 1.563, respectively. With dichloromethane extracts of *O. americanum* and *O. basilicum* TI values noted were 2.623 and 1.835, respectively. After viral adsorption the methanol extract of *O. americanum* and the dichloromethane extract of *O. basilicum* inhibited HSV-1F. TI values noted were 1.63 and 2.215, respectively. At other stages of viral replication, the extracts of the three plants exhibited their anti-viral potential[35].

6.5 *Anti-inflammatory Activity*

Petroleum ether fraction (400mg/kg, p.o) and ethanolic fraction (400mg/ kg, p.o) of the seeds of *O. basilicum* were used to cure inflammation induced by histamine and prostaglandins in 60 rats divided in 10 groups. The index of inflammation used was the increase in paw edema. Significant inhibition of the paw edema produced by histamine and PGF2-a proved that the seeds of *O. basilicum* possess potential anti-inflammatory activity[36]. Anti-inflammatory activity of the alcoholic extract of *O. basilicum* in peripheral blood mononuclear cells (PBMC) of human was reported. PBMC of healthy individuals were taken and anti-inflammatory activity of crude methanolic extracts was tested. In mitogenic lymphocyte proliferation assays, the extract showed significant inhibitory effect on proliferative response of PBMC. Besides that, gene expression studies were also carried out on lipopolysaccharide (LPS) induced production of proinflammatory cytokines such as Interleukin-1 β (IL-IB), Tumor necrosis factor –α (TNF- α). Down regulation of the markers was shown by IL-2. The induction of the inducible nitric oxide synthase (iNOS) along with production of nitric oxide (NO) in LPS-stimulated RAW 264.7 macrophages was suppressed by it in a time-dependent manner. The result was drawn that crude methanolic extracts inhibit proinflammatory cytokines and mediators, which shows that the extracts have anti-inflammatory activity[37].

6.6 *Hepatoprotective and Lipid Peroxidation Activity*

Hepatoprotective and antioxidant activities of *O. basilicum* and *Trigonella foenum-graecum* was reported against hepatotoxicity in liver of goat which was induced by H_2O_2 and CCl_4. Leaves of both the plants were dried and ground. Extracts were prepared in petroleum ether, chloroform, alcohol and water. Ethanolic extracts were dried in rotary evaporator and were reconstituted in 0.5% Tween-80 up to the strength expected. They were named as OB and TF, respectively. The extracts were screened for analyzing the constituents present. Goat liver was washed in saline solution to remove the fat present. Liver (0.25 g) was cut into rectangular slices about 8-9 mm each. The pieces were washed in Hank's balanced salt solution (HBSS) using suitable buffer. The slices were treated with oxidants in presence as well as absence of extracts. After incubating for an hour at 37°C, the components were analysed. Hepatotoxicity was induced by H_2O_2 by first dividing the animals in 5 groups. Group 1 was called normal control, group 2 was toxin control which was treated with H_2O_2 (2 ml/kg), Groups 3 and 4 were given OB/TF (100 mg/kg, po) and finally group 5 was given Silymarin (hepatoprotective agent) for a period of 6 days. H_2O_2 (2 ml/kg) was given to groups 2-6 on the fifth day. Hepatotoxicity was also induced by CCl_4. Five groups of animals were made. Group 1 was called the normal group and was given a single dose of 0.5% Tween-80 (1 ml) on a daily basis for the first five days and then was given olive oil (1 ml/kg) on second and third day. Group 2 was called the CCl_4 control group and was given a single dose of 0.5% Tween-80 (1 ml) po everyday, except for second and third day when they were given 2 ml/kg of CCl_4: olive oil 1:1 mixture. Groups 3 and 4 were given OB/TF (100 mg/kg, po) for all the five days and on second and third days they were given a single dose of 2 ml/kg CCl_4 : olive oil in the ratio of 1:1 in the form of mixture, but they were given OB/TF 30 minutes before. For five days group five was given Silymarin (100 mg/kg, po) and on second and third days it was given a single dose of CCl_4: olive oil 1:1 mixture after 30 minutes of Silymarin intake. After 48 hours passed, the animals were sacrificed and blood samples were collected for anti-oxidant studies and liver slices for histopathological analysis. The activities of catalase (CAT) peroxidase (PEO), glutathione reductase (GTR), superoxide dismutase (SOD), polyphenol oxidase (PPO), glutathiones transferase (GST), ascorbic acid (Vit C), tocopherol (Vit E), vitamin A, total phenols, carotenoids and lycopenes were determined and analysed. Liver function marker enzymes like alanine aminotransferase (ALT), aspartate aminotransferase (ALT) etc were also analysed. For determination of lipid peroxidation liver tissue was weighed up to 0.5 g. Then it was mixed in 10 ml of 150 mM KCl-Tris-HCl buffer which had pH of 7.2. The final reaction mixture contained 50 µl liver homogenate, buffer, 3 mM FeSO4 and 0.05 ml of the extracts from both plants which were of varying concentrations. A blank was also prepared. The experimental medium had liver homogenate whereas the assay medium had all the constituents except plant extract and it corresponded to 100% oxidation. The tubes were incubated for an hour at 37°C. Along with incubation 500 µl of 70% ethanol was added in every tube to hold the reaction. 1 ml of 1% TBA was added in tubes which were kept for boiling in a water bath for a period of 20 min. The tubes were then cooled and centrifuged to get supernatants. To the supernatants 50 µl of acetone was added and for determination of thiobarbituric acid reactive substances (TBARS) it was run at 535nm in a spectrophotometer. The hepatotoxins caused significant damage to the liver. It was shown by an increase in the level of antioxidant enzymes of the toxin groups. The extracts reduced the high values of these enzymes and the hepatoprotective activity was comparable to that of silymarin. The extracts showed inhibition of lipid peroxidation at 100 µg/ml in comparison to normal controls. Glutathione activities were reduced in intoxicated goat liver as compared to normal control groups. Maximum inhibition of superoxide free radical (88.02%) and nitric oxide free radical (85.47%) was observed at 400 µg/ml[38].

6.7 *Insect Repellent and Larvicidal Activity*

Larvicidal activity of *O. basilicum* was noted by combining, in varying ratios, its petroleum ether leaf extract with synthetic nicotinoid insecticide, imidacloprid against malaria vector, *Anopheles stephensi*. Binary mixture of 1:1 ratio was most effective as compared to 1:2 and 1:4 against mosquito larvae. This effective ratio was safe for aquatic

mosquito predator, *Anisops bouvieri* and Cyclops with LC_{50} values 12.351 and 5.290 ppm, respectively, after 24 h of exposure. Individual constituents were not that effective as compared to the tested combination[39]. Larvicidal and repellent activity of *O. basilicum* along with *Vetveria zizanioides* and the pesticide spinosad against *Anopheles* mosquito which is known as a vector against malaria was observed. Synthetic pesticides cause a lot of hazards both to environment and human beings. Therefore, microbial insecticides are recommended as they are non-toxic to other animals and human beings. The above mentioned plants showed considerable repellent activity against the malarial vector, *Anopheles stephensi Liston*, which showed 85% mortality rate. This rate supports the use of extracts of the plants as bio-insecticides[40]. Repellent activity against malarial vector *Anopheles* of the essential oil of *O. basilicum* four Sudanese accessions was also reported. Accessions were taken as seeds and these seeds were then sown at the University of Gezira farm, Wad Medani, Sudan. Human-bait technique confirmed all four essential oils to be mosquito repellent. 0.1 ml of the essential oil applied at the volunteer's arm showed repellency against mosquito for 1.5 to 2.5 hours. Bioassay time affected the repellency. Quantity of 0.1 ml of essential oil was considered ideal as mosquito repellent[41].

6.8 *Central Nervous System Activity*

Protection of central nervous system against oxidative damages of electromagnetic field (EMF) by using *O. basilicum* has been reported. Forced swimming test was used to check antidepressant activity of *O. basilicum* extract in 30 albino male Wistar rats that were exposed to 50 Hz, electromagnetic field for a period of 8 weeks. After eight weeks, rats which were fed with *O. basilicum* extract (1.5 g/kg body weight), showed decreased immobility score ($P < 0.001$) and increased swimming ($P < 0.001$), as compared to control group. Hence, basil proved to have CNS activity[42]. Anticonvulsant activity of the essential oil of *Ocimum basilicum* leaves was reported. *Ocimum basilicum* and many other herbs belonging to the genus *Ocimum* are used as treatment for the diseases related to the central nervous system. Varieties of experimental models have been used to analyze the CNS depressant and anticonvulsant activity of the essential oil obtained from leaves. GC/MS and GC-FID showed seven compounds which constituted 98.8% of the oil as a whole. Linalool, geraniol and 1, 8-cineole was the major constituents which were present up to 92.9%. Decrease of spontaneous activity, sedation, ataxia and ptosis was seen at all doses of the oil along with a considerable increase of sleep time ($p<0.05$) and decrease in latency to sleep ($p<0.01$). The latency for development of convulsions in pentylenetetrazol (PTZ) and picrotoxin tests was increased ($p<0.05$). Flumazenil reversed the effects of oils in case of PTZ. For strychnine no interference was seen with the convulsions. So, essential oils were active as CNS depressant and this activity could be mediated by central GABAergic receptors[43].

6.9 *Antimicrobial Activity*

The antibacterial activity of *O. basilicum* essential oil extracted from leaves was studied against gram-negative and gram-positive bacteria including *Escherichia coli*, *Pseudomonas aeruginosa*, *Bacillus cereus*, *Staphylococcus aureus*, respectively. Minimal inhibition concentration (MIC), Agar disk diffusion and minimum bactericidal concentration (MBC) were detected. For *P. aeruginosa* the maximum inhibition zones were noted by agar disk diffusion tests. *S. aureus* showed 29.20-30.56 mm, *B. cereus* 10.66-16.11 mm and *E. coli* 17.48-23.58 mm inhibition zones. For gram-positive bacteria the MICs were: *B. cereus* ranging 36-18 μg/mL, *S. aureus* 18 μg/mL, and for gram-negative bacteria the MICs were: *E. coli* and *P. aeruginosa* were 18-9 μg/Ml[44]. Alcoholic, hydroalcoholic and aqueous extracts from *O. basilicum, Satureja hortensis* and *Anethum graveolens* were tested against pathogenic microorganisms *Escherichia coli, Staphyloccocus aureus, Streptococcus cricetus* and *Candida albicans* and inhibitory zone diameter was the evaluation indicator for antimicrobial activity. Except *Satureja hortensis* aqueous extract for *Streptococcus cricetus*, for all aqueous extracts *Staphylococcus aureus* and *Streptococcus cricetus* showed resistance. When *O. basilicum* aqueous extract was evaporated at 80°C the largest inhibition zone diameter was noted for *Escherichia coli* and in case of alcoholic extracts for *Candida albicans*. average inhibitory zone diameter for tested pathogenic microorganisms was noted for other extracts[45]. By using agar diffusion and agar dilution methods the antimicrobial activities of the volatile oils of *O. basilicum* and *O. gratissimum* were recorded. At a concentration of 0.51% in the agar, the volatile oils of both plants separately inhibited the growth of *Streptococcus viridian ;Staphylococcus albus*; and *Klebisiella pneumonia Pseudomonas aeruginosa* at 10.0%. *Proteus vulgaris* was inhibited at 0.67% by *O. basilicum* and 0.53% by *O. gratissimum*. By using volatile oil of both herbs separately in tooth pastes (2 and 5 %), antibacterial activities comparable to a commercial tooth paste were shown. at a concentration of 0.5% in mouth washes, complete inhibition of the growth of organisms was observed[46]. By using disk-diffusion and minimal inhibition concentration (MIC) method ethanol, methanol, and hexane extracts from *O. basilicum* were tested for antimicrobial potential. The three extracts varied in terms of their antimicrobial potential. The hexane extract showed the strongest spectrum of antimicrobial activity[47].

6.10 *Antifungal Activity*

O. basilicum extract [0.35 and 0.70% (v/v)] proved to have antifungal potential against *Fusarium oxysporum*, *F. proliferatum* (33.37 and 44.30%, respectively), *F. subglutinans* (24.74 and 29.27%, respectively), and *F. verticillioides*. The fungal strains were isolated from cakes by the agar plate method. At the concentration of 1.50%

(v/v) the growth of *Fusarium* spp. was completely inhibited and at concentrations of 0.35 and 0.70% (v/v) aerial mycelium growth reduced over all. Hyphae deformations, thickenings, fragmentations and diminished sporulation were also observed[48]. Antifungal activity of *O. basilicum* and *O. gratissimum* oil was tested against seven species of rice pathogenic fungi namely *Alternaria brassicicola*, *Aspergillus flavus*, *Bipolaris oryzae*, *Fusarium moniliforme*, *Fusarium proliferatum*, *Pyricularia grisea* and *Rhizoctonia solani*. The techniques used were mycelium growth and spore germination inhibition. Unused oil was used as control and the efficiency of essential oils was recorded at 0.4, 0.6, 0.8, 1.0 and 2.0% v/v. In vitro study was carried out using potato dextrose agar (PDA) with 3 replications. The data of mycelium growth inhibition showed that sweet basil oil showed inhibition of *F. moniliforme* (100%), *F. proliferatum* (49.6%) and *P. grisea* (100%) at a concentration of 0.6% v/v. *B. oryzae*, *A. brassicicola* and *A. flavus* was inhibited up to 97.40%, 94.62% and 59.25% respectively at 2.0% v/v. The result recorded for spore germination inhibition showed that *F. moniliforme* was inhibited up to 91.31% and *A. brassicicola* 99.74% at 0.8% v/v. *F. proliferatum*, *P. grisea*, *B. oryzae*, *R. solani* and *A. flavus* were inhibited at 2.0% v/v. *O. gratissimum* also showed inhibition of fungi strains by both methods. Hence, the plants had antifungal activity which depended on testing conditions[49].

6.11 *Antimutagenic Activity*

Antimutagenic property of *O. basilicum* essential oil and pure substances linalool, 1,8-cineole and β-myrcene in *Salmonella typhimurium* TA 100, TA 98 and TA 102 with and without using microsomal fraction of rat liver (S9 mix) was reported. No activity was observed in any strain tested and then Ames test was carried out using *S. typhimurium* TA 100. Mutagenesis was induced by chemical mutagens namely 4-nitroquinoline-N-oxide (4NQO), 2-nitropropene (2-NP) and benzo (a) pyrene (B (a) P) and UVC irradiation. All derivatives of basil reduced mutations induced by UV radiations, maximum inhibition recorded to be 64-77%. 4NQO inhibitory potential was similar to UV (52-67%). Moderate inhibition of 2-NP induced mutagenesis was shown by essential oil and 1, 8-cineole while the latter showed moderate inhibition against B(a)P induced mutagenesis and linalool showed high co-mutagenic effect with B(a)P. Essential oil and β-myrcene showed no effect against B(a)P induced mutagenesis[50].

6.12 *Antierythmic and Depigmenting Activity*

Topical cream (with 3% concentrated extract of basil) of *O. basilicum* against its base (without extract) as control on skin erythma and skin melanin was tested on the cheeks of 11 healthy human volunteers for a period of 12 weeks. After every two weeks time, pigment (melanin) and erythma was noticed. The formulation showed statistically significant result whereas the base proved to be insignificant ($p \geq 0.05$) against skin erythma. Similar results were noticed for skin pigmentation (melanin) thus proving the efficacy of new formulation[51].

6.13 *Antitoxic Activity*

In albino rats deltamethrin induced several histopathological alterations in the kidney like degeneration of epithelial lining cells, dilation and congestion of renal blood vessels, infiltration of intertubular spaces by inflammatory leucocytic cells and elevation in urea and serum creatinine. Superoxide dismutase (SOD) and catalase (CAT) in renal tissue became more or less inactive and the concentration of malondialdehyde (MDA) increased remarkably. The animals were then treated with aqueous extract of basil along with deltamethrin. It led to curing histopathological ailments. Activities of CAT and SOD were found to increase and creatinine and urea level became normal whereas MDA level lessened[52].

7. CONCLUSION

The importance of medicinal plants has increased with the passage of time because synthetic medicines have a number of side effects besides many benefits they offer. These plants have recorded and known pharmacological applications which we have got in heritage. The present review is meant to describe the importance of *Ocimum basilicum* in the field of herbal medication. Phytochemical and pharmacological studies of the herb are given along with botanical characteristics. Various effects like immunomodulatory, hyperglcaemic, hypolipidemic, anti-inflammatory, hepatoprotective, antimutagenic, antimicrobial, antifungal, antioxidant, lipid peroxidation, insect repellency, antiviral, antierythmic, depigmenting, antitoxic and CNS activity analysis reports are mentioned. The wide range of study on this herbal plant shows that it is very beneficial for the improvement of current drugs and more work can be done to take advantage of the potential remedial qualities of it.

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