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Pharmacological Activity of Basil (*Ocimum basilicum*) – A Review

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ABSTRACT
Basil (Ocimum basilicum L.), one of the most commonly used fragrant herbs, has many bioactive ingredients and is used to flavor and scent food. Both when the leaves are fresh and when they are dried, many civilizations use them in their cuisine. O. basilicum is well known for its therapeutic and preservation qualities. The current study investigated the toxicity of basil at three different growth stages (GS), specifically GS-1 (58 days of development), GS-2 (69 days of growth), and GS-3 (93 days of growth), using the brine shrimp assay. The results demonstrated that cytotoxicity was influenced by both extract concentration and GS. Basil water extracts showed no observable toxicity at concentrations between 10 and 1000 µg/mL. At 8.9%, the death rate observed was lowest for GS-2, extracts of basil. The mortality rates at GS-1, GS-2, and GS-3 were found to be 26.7 ± 3.34%, 8.91 ± 0.10%, and 16.7 ± 0.34%, respectively, at 1000 µg/mL. Among the solvents used to extract the powdered basil, GS-2, the least toxicologically dangerous one was n-hexane, dichloromethane, ethanol, and water. Plant secondary metabolites, including total phenolic acid, flavonoids, and tannin content, were most abundant in ethanol extracts. Ethanol extracts also showed the highest level of antioxidant activity in FRAP, H2O2, and DPPH tests. By using LC-ESI-MS/MS analysis, it was demonstrated that basil ethanol extracts could potentially be a source of well-known therapeutic and health-promoting compounds like liquiritigenin, umbelliferone, ellagic acid, and catechin. The results suggest that the culinary plant basil may be a potential source of bioactive compounds with a variety of therapeutic and health-promoting properties.
Key Words –*Brine shrimp, liquiritigenin, catechin, FRAP, mass spectrometry, Chemical Assay, polyphenol*

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INTRODUCTION

Plant-derived bioactive compounds are well recognised for their wide range of uses as active components in many medicinal products [1]. There is sufficient evidence to support the use of medicinal herbs in place of conventional and/or synthetic antimicrobials in the future. Similarly, there is need to investigate the possibility of using more natural components in food processing and preservation, given the data supporting the harmful health consequences of artificial food additives and their careless use in the food industrial business. Limiting the use of artificial food additives and investigating safer natural alternatives is recommended in light of mounting data about the potential health effects associated with their careless application [2, 3]. In recent times, polyphenols have garnered significant interest as potentially beneficial dietary additives that might enhance food quality and lower the risk of many illnesses such as cancer, inflammation, and oxidative stress [4]. Sweet basil, or *Ocimum basilicum* L., is a well-known culinary herb category in the Lamiaceae family that is grown all over the world today, but it is native to India and other Asian nations like Nepal, Bhutan, and Pakistan [5]. For a long time, people have utilized basil leaves as a traditional home remedy for a several illnesses. These comprise bronchitis, cancer, tremors, diarrhoea, mental illnesses, inflammation, biliousness, and teeth decay [6]. Pharmacological evidence—such as features such as anticancer, radical scavenging, anti-infective, antipain, and immunomodulatory effects—strongly supports the traditional assertions [7]. These bioactivities are caused by flavonoids, rosmarinic acid, phenolic acids, aromatic compounds, and essential oils from O. basilicum, such as eugenol, chavicol, linalool, and α-terpineol [8,9]. Strong antibacterial and antioxidant effects against both Gram-positive and Gram-negative bacteria are demonstrated by *O. basilicum* leaf extracts in ethanol and water [10]. Recent

studies have demonstrated that *O. basilicum* leaf extracts possess anti-inflammatory, neuroprotective, immunoprotective, antidiabetic, cardioprotective, antistress, and antitussive properties [11,12,13,14,]. It has also been found that *O. basilicum* leaves exhibit radioprotective and antimelanoma properties when it comes to metastatic melanoma cell lines [16]. The two most prevalent flavonoids found in sweet basil, quercetin and rutin, have been shown to have anti-inflammatory and cytoprotective properties against a variety of malignancies [17, 18]. Some common culinary uses for *O. basilicum* include seasoning soups, spinach, tomato-based dishes, cream cheese, sandwiches, pasta, dips, and a variety of squashes [19]. Moreover, the herb extends the shelf life of perishables high in nutrients [20]. Ascorbic acid and potassium sorbate-made breads have lower antioxidant activity than breads made with *O. basilicum* extracts, according to a recent discovery [10]. Although the phytochemical composition of *Oryza basilicum*, a widely used culinary herb, has been thoroughly studied, there is still a suggestion that the biological potential and chemical composition of the plant's different anatomical fractions should be associated with distinct geographical locations due to their variability. Basil's aromatic profile, which is determined by the quality of its essential oil, is greatly influenced by the plant's vegetative stage [19]. In Italy, it's said that the best basil leaves for pesto are small, immature ones that reach a height of 10–12 cm [19, 21]. Studies reveal that basil plants that are growing in favorable phases contain higher levels of methyleugenol, which is dangerous because it resembles the structure of carcinogens like safrole and estragole [22, 23, 24, 25, 26]. Thus, the current study set out to determine the relationship between different stages of development and toxicological reactions for *O. basilicum* leaf extracts grown in Southern Punjab, Pakistan's temperate climate. We looked more closely at the phytochemical content and antioxidant properties of the GS that exhibited the least amount of toxicity or non-toxic reaction.
Evaluation of Phytochemicals Qualitatively the *O. basilicum* leaf extracts were subjected to a screening process for phenols, alkaloids, tannins, flavonoids, steroids, terpenoids, and saponins using the Kokate et al. [27] method, which is summarized in Table 1.

Table 1. Chemical Constituents of *O. basilicum* leaf extracts.

Test	Observation	Chemical Constituents
Wagner's Test	Cream, reddish brown precipitate	Alkaloids
Ferric Chloride Test	Dark brown or blackish red color	Flavonoids
Folin–Ciocalteu reagent Test	Gray or black color	Phenols
Froth Test	Copious lather formation	Saponins
Salkowki's Test	Brown ring formation	Steroids
Ferric Chloride Test	Greenish brown, blue green or blue-black color	Tannins
Salkowki's Test	Red brownish precipitate	Terpenoids

Basil occurrence, cultivation, classification and variation in species
Growing in tropical and sub-tropical climates, basil (*Ocimum basilicum* L.) is a significant crop for essential oils, a culinary herb, and a member of the Lamiaceae family. Its essential oil is used in dental and oral health products, as well as in the food and fragrance industries [25]. *O basilicum* is a member of the class Magnoliopsida, phylum Magnoliopsida, kingdom Plantae, family Lamiacaea, order Lamiales, and genus Ocimum. In lab experiments, its germination rate ranges from 95% to 98%, whereas in field settings, it is closer to 10% to 15% [26]. The main stem, nodes, internodes, dominant growing point, future stem development, and leaves make up a basil plant's anatomy. Basil may be utilized for dried leaves, flowers, essential oil, and as an attractive plant in all of its components [27, 28]. Sweet basil, purple basil, lemon basil, cinnamon basil, anise basil, fine leaf basil, and bush basil are the most significant types of the plant. Aphids, leafhoppers, and whiteflies are the three principal pests associated with basil. Leaf spot, Botrytis, and Fusarium are the three main diseases that affect basil plants. Basil is susceptible to drought stress; previous research has shown a significant decline in the production of fresh and dry matter, essential oil content, and chemical components including proline, protein, and carbs [29, 30]. According to research by Kalamartzis et al. [31], basil cultivars in semi-arid areas should have greater water usage efficiency so they can conserve more water. The dry stem products are typically harvested at 1.2–2 t/ha (fresh weight 8–10)[32]. Fusarium wilt (*Fusarium oxysporum* f. sp. basilicum), leaf spot (*Pseudomonas cichorii*), gray mold (Botrytis cinerea), damping off or root rot (*Rhizoctonia solani*; Pythium spp.), and downy mildew (*Peronospora belbahrii*) are the most common diseases that affect basil. Field conditions can affect the output and quality of essential oils produced by basil plants [35–40]. The two primary phenolic compounds in basil are phenolic acids and flavonol-glycosides [41, 42]. Stearic acid, Oleic acid, Palmitic acid, Linoleic acid, Myristic acid, α-Linolenic acid, Carpic acid, Lauric acid, and Arachidonic acid are the primary fatty acid compositions of basil species. Increased levels of temperature

and light have an impact on antioxidant capacity [43]. The caffeic, vanillic, rosmarinic, quercetin, rutin, apigenin, chlorogenic, and p-hydroxybenzoic acids are the most significant antioxidant chemicals found in basil [44]. α-Pinene, β-Pinene, Methyl chavicol, 1,8 cineole, Llinalool, Ocimene, Borneol, Geraneol, B-Caryphyllone, n-Cinnamate, and Eugenol are the essential oils of basil [45].

Medicinal uses and potential HEALTH benefits in traditional medicine

Basil is utilized in both religious orthodox Christian ceremonies and traditional medicine in India. It is also revered as the goddess Tulsi in several regions of Asia [52]. This plant's traditional uses include its use as a flavoring ingredient in culinary goods, as well as in dental and oral hygiene products and perfumes [53]. Iran is a country where this herb is widely grown and utilized as a vegetable as well as a medicinal medicine[54]. Its seeds are used as a nutritional fiber component in Asian drinks and sweets in traditional medicine [55]. Infections of the skin, worms, diarrhea, cough, and headaches are also treated with it [56]. Additionally, it is a component of Mediterranean diets, particularly those in Southern Europe, such as Greek and Italian cuisines [57]. Traditional Chinese medicine has utilized basil polysaccharides to treat cancer [58] and continues to employ them in daily life [59].

Medicinal uses and potential health benefits in modern medicine industry

In addition to controlling and lowering blood glucose, it has been used to treat a variety of illnesses, including anxiety, pyrexia, infections, stomach aches, coughs, headaches, and constipation. Previous research has also shown that it has anti-spasmodic and anti-diabetic properties, as well as anti-bacterial, anti-fungal, and anti-oxidant properties [65, 66]. Eugenol's anti-fungal, nematocide, and antibacterial properties against food-borne pathogenic microorganisms are its most significant therapeutic qualities [67,68]. In diabetic rats, the ethanol extract from basil leaves can lower blood glucose and advanced glycation end products [69]. Basil leaves are used as an antispasmodic, carminative, and stomachic in traditional medicine [70]. Basil leaves contain molecules of essential oils that are composed of alkaloids, tannins, flavonoids, and saponins [71–76]. The antimicrobial, anti-inflammatory, and anti-oxidative qualities of basil essential oil are among its components [77–95]. Basil leaves have antispasmodic, diuretic, stomachic, and antipyretic properties [96, 97]. Numerous advantages of basil seed mucilage include its hydrophilicity, biocompatibility, low cost of manufacturing, suitable film formation, edibility, and viscoelastic qualities [98–102]. Basil polysaccharides are beneficial in the treatment of diabetes mellitus and have anti-tumor, anti-oxidant, and anti-aging properties. They also have antibacterial and anti-atherosclerotic properties [103]. BSG is a high molecular weight (2320 kDa) anionic polysaccharide that comes in two fractions: PER-BSG (6000 kDa) and SUPER-BSG (1045 kDa) [104].BSG is made up of a small fraction of protein (1.32% wt/wt), a minor fraction of highly branched arabino-galactan and glucan (2.31%), gluco-mannan (43%), (1-4)-linked xylan (24.3%), and a typical uronic acid content between 12.1 and 19.5% [105,106]. It has been used to alter the composition of processed bread, ice cream, and cheese [107–109]. Glucuronic acid, galacturonic acid, rhamnose, mannose, arabinose, galactose, and glucose make up the BSG. Because of its unpredictable coil conformation, BSG is prone to the SUPER-BSG faction due to its great chain flexibility [110–112].BSG is a hydrocolloid that has surface-active properties, thickening, stabilizing, fat-substituting, texurizer, and emulsifying properties [107,112,113]. Frozen food quality can be enhanced using BSG. The food business views it as a commercial hydrocolloid due to its unique behavior and ease of extraction [114]. Edible films may be produced by BSM, and thermostable, ultra-thin nanofibers can be produced using BSM and Polyvinyl alcohol for a variety of uses in the food industry. Studies on the cytotoxicity and cell adhesion of BSM hydrogel sponge revealed that the sponge was neither cytotoxic nor adherent [115,116]. When BSG is added, heat-induced egg albumin gels that are tougher may be produced for use in various food applications or to deliver active ingredients in functional meals [117].It can provide a new source of edible hydrocolloids for the food industry [118,119]. Making edible films with basil seed gum has a lot of potential for a variety of culinary uses [115]. Basil seeds contain gum in acceptable amounts and with acceptable functional qualities [120]. The freeze-dried basil seed gum exhibited the highest level of hardness and consistency; an increase in temperature had a negative impact on the basil gum solution's color changes [121]. Basil seed gum can be used as a textural and rheological modifier in the formulation of foods subjected to heat and freezing temperatures because of its remarkable resistance to freeze-thaw treatment and its increased textural qualities after freezing [122].

CONCLUSION

Ocimum tenuiflorum L., *Ocimum sanctum* L., *Ocimum americanum* L., *Ocimum basilicum* L., *Ocimum hispidulum Schum*, and *Ocimum ratissimum* L. are the most significant members of the Ocimum genus. Eugenol, methyl chavicol, methyl cinnamate, linalool, and bergamotene are the main volatile ingredients in basil. Additionally, Indian, Chinese, Italian, and Persian cuisines are linked to basil. Basil plants are classified as having the following anatomical features: (a) main stem; (b) node; (c) internode; (d) dominant growing tip; (e) future stem development; and (f) leaves. The two primary phenolic compounds in basil are phenolic acids and flavonol-glycosides. Stearic acid, Oleic acid, Palmitic acid, Linoleic acid, Myristic acid, α-Linolenic acid, Carpic acid, Lauric acid, and Arachidonic acid are the primary fatty acid compositions of basil species. Increased temperatures and light levels affect an antioxidant's ability. The most significant antioxidants found in basil include p-hydroxybenzoic, quercetin, rutin, apigenin, vanillic, and rosmarinic acids. α-Pinene, β-Pinene, Methyl chavicol, 1,8 cineole, Llinalool, Ocimene, Borneol, Geraneol, B-Caryphyllone, n-Cinnamate, and Eugenol are the essential oils of basil. Terpenoids, chavicol, and eugenol are the three most significant essential oils found in basil. It is extensively grown and used as a vegetable and medicinal tincture in traditional herbal treatments. Basil's most significant pharmacological applications include its use as a prophylactic agent, in the treatment of cardiovascular disease, and its anti-cancer, radioprotective, anti-microbial, anti-inflammatory, immunomodulatory, anti-stress, anti-diabetic, anti-arthritic, and anti-oxidant properties. Often called basil seed gum, basil seed mucilage. Glucuronic acid, galacturonic acid, rhamnose, mannose, arabinose, galactose, and glucuronic acid make up the BSG. Because of its unpredictable coil conformation, BSG is prone to the SUPER-BSG faction due to its great chain flexibility. BSG is a surface-active, emulsifying, thickening, stabilizing, fat-substituting, texurizer, and hydrocolloid that can enhance the quality of frozen meals. The food business views it as a commercial hydrocolloid due to its unique behavior and ease of extraction. Based on the results, it is recommended that basil be used in the food and pharmaceutical industries.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

Authors Contribution

Mamta Nagar: Investigation, Writing - Original Draft preparation **Neha Dahiya:** Conceptualization, Validation, Supervision,**Ranjna Rani:** Writing - Review & Editing**, Ajay Berwal:** Writing - Review & Editing**, Deepa Sarkar:** Writing - Review & Editing **&Jagjiwan Singh:** Proofreading.

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