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Review Article

Biological properties of basil plant oil and its antimicrobial activity: A review

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Victor Bamidele SIMPSON[1]*, Ahmed Saliu YUSUF[2], Opeyemi Adebola ADELEYE[2] & Jadesola Oyinloluwa OLUSOLA[3]

[1]*Moist Forest Research Station, Forestry Research Institute of Nigeria, Benin, Edo State, Nigeria.*
[2]*Forestry Research Institute of Nigeria; Federal College of Forest Resources Management, Fugar, Edo State, Nigeria.*
[3]*Federal University of Technology Akure, Ondo State, Nigeria.*

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A B S T R A C T

Basil (*Ocimum basilicum* Lamiaceae and *Ocimum gratissimum* Lamiaceae), known for their culinary and aromatic qualities;are gaining recognition for their wide-ranging biological properties, especially their antimicrobial capabilities. This study critically reviewed the phytochemical profile of basil oils and their biological effects, with a particular focus on antimicrobial activity. Numerous studies indicate that basil essential oils are abundant in bioactive compounds, primarily eugenol, linalool, and various phenolic substances, which enhance their strong antimicrobial effectiveness against a diverse array of pathogenic micro-organisms. The review considers the potential uses of basil oils in food preservation, highlighting their antioxidant and antimicrobial properties, which can prolong shelf life and improve food safety. Additionally, the therapeutic potential of basil oils in both traditional and contemporary medicine is examined, including their roles in complementary health approaches and as natural alternatives to synthetic antimicrobials. Despite these encouraging findings, the review points out existing gaps in the research, such as the need for standardized extraction techniques, detailed toxicity evaluations by integrating the current literature and outlining future research avenues, this paper seeks to enhance the understanding of basil's biological properties and encourage its application in health, nutrition, and sustainable agricultural practices.

K E Y W O R D S : *Essential oils, Eugenol, Health benefits, Phytochemicals.*

INTRODUCTION

Throughout history, early civilizations employed herbal medicine as a complementary method for addressing various health issues (World Health Organization, 2023) *Ocimum basilicum L.*, commonly referred to as scent leaf, is a notable medicinal plant recognized for its potential as an alternative treatment for various health conditions and as a source for new pharmaceuticals. This perennial herb, known for its strong aromatic scent, belongs to the Lamiaceae family and is prevalent in regions across Africa, Asia, and South America (Tanko *et al.*, 2008; Akara *et al.*, 2021). The plant flourishes in warm environments and well-drained soil, which contributes to its popularity in Mediterranean and other international cuisines (Nehra *et al.*, 2019; Barut *et al.*, 2021)

Basil has upright branches that grow to a height of 0.3–1.3 m, with light green silky leaves. The leaves are 3–11 cm long and 1–6 cm in diameter and have many oil

*Corresponding author: delerotciv@gmail.com; +2348165329885

glands (Kathirvel & Ravi, 2012). Basil is an annual plant that is often used as a spice and in traditional medicine (Singletary, 2018). In addition, basil can be used as a source of essential oil, which is well known for its anti-biotic and anti-oxidative properties (Naji-Tabasi & Razavi, 2017). The essential oil in basil is extracted from seeds, stems, flowers, and leaves. The largest essential oil content is found in the leaves (Heri Septya Kusuma *et al.*, 2023)

Basil belongs to the genus *Ocimum*, which includes several species and varieties. The most common culinary variety is *Ocimum basilicum*, but other types, such as Thai basil (*Ocimum basilicum var. thyrsiflora*) and holy basil (*Ocimum sanctum*), are also significant in various culinary and medicinal applications (Singletary, 2018). The taxonomic hierarchy is as follows:

Kingdom: Plantae

Order: Lamiales

Family: Lamiaceae

Genus: Ocimum

Species: O. basilicum

Traditionally, basil has been used not only as a culinary herb but also in various medicinal practices. In many cultures, it is employed for its anti-inflammatory, antimicrobial, and antioxidant properties. In traditional medicine, basil is used to alleviate symptoms such as respiratory disorders, digestive issues, and stress-related conditions (Thakur, 2023). Scent leaf is utilized as a natural flavouring agent, condiment, or vegetable in dishes such as fish, meat, soups, and stews. Oils from plant extracts, commonly called essential oils, have been used as traditional medicine, fragrances, and seasoning. Various institutions have recognized that essential oils are safe to use as a mixture in the food industry, one of which is the US Food and Drug Administration (Cimino *et al.*, 2021), where essential oils are proven as natural preservatives to extend the shelf life of raw materials and food (Singh *et al.*, 2019). In addition, essential oils are also used as ingredients for pharmaceutical industry applications because they have anti-inflammatory, antimicrobial, antioxidant, and wound-healing properties (Jiang *et al.*, 2022). Essential oils can be obtained from plant parts such as flowers for cloves (Jiang *et al.*, 2022), bark for cinnamon (Nirmal *et al.*, 2023), roots for ginger, seeds for nutmeg, and leaves for eucalyptus (Jiang *et al.*, 2022).

The major aim of this review paper is to thoroughly examine and consolidate existing research on the biological properties of the basil plant, with a particular emphasis on the essential oils obtained from *Ocimum basilicum*. The review aims to assess and summarize the antimicrobial effectiveness of basil essential oils against a range of pathogenic micro-organisms, including both Gram-positive and Gram-negative bacteria, as well as fungal pathogens.

Production and Nutritional Composition of Basil oil

Extraction Methods for Basil Oil

The essential oil in basil is extracted from seeds, stems, flowers, and leaves. The largest essential oil content is found in the leaves. The leaf essential oil contains eugenol, ursolic acid, carvacrol, linalool, limatrol, caryophyllene, and methyl chavicol. *In vitro* investigations of these phytochemical constituents have shown that they are widely used as anticancer, anti-fungal, antimicrobial, antioxidant, and anti-inflammatory (Romano *et al.*, 2022).

Essential oils are often extracted by conventional distillation methods using water solvents or what is often called hydro distillation (HD). Though this method generally requires a long extraction time and a lot of energy as well. In addition, extraction using the HD method also obtains oil results that are not maximized. Ngamprasertsith *et al.* (2018) have analysed the extraction of lemon basil (*Ocimum citriodorum* Vis.) using hydro distillation and supercritical CO_2 methods. The results showed that the hydro distillation method produced $0.07\,\% \pm 0.01\,\%$ oil while the supercritical CO_2 method produced $1.21\,\% \pm 0.09\,\%$ oil. In recent years, new extraction methods based on green chemicals have been developed by utilizing microwaves.

Microwave extraction can increase the yield and quality of essential oils from plants and can reduce energy consumption (Yang *et al.*, 2022). Furthermore, microwave extraction is further developed into solvent-free extraction using microwaves, better known as solvent-free microwave extraction (SFME). This SFME method is a “greener” and more efficient method. This is because extraction with the SFME method only uses the vapour contained in the raw material itself without additional solvents (Wei *et al.*, 2022). SFME method has been used to extract several plants such as leaves of magnolia (*Oyama sieboldii*) (Yang *et al.*, 2022), patchouli leaves (Kusuma *et al.*, 2018), and *Centella asiatica* leaves (Idris *et al.*, 2020). SFME extraction method produces better essential oil quality and higher yield than the HD method (Wei *et al.*, 2023).

Prevalent techniques for basil oil extraction

1. Steam Distillation

Steam distillation remains the primary method for extracting essential oils from basil. In this process, steam

passes through the plant material, causing the essential oil to vaporized. The steam and vaporized oil mixture is then cooled, allowing the oil to condense and separate from the water due to its lower density. This method is favoured for its efficiency and ability to maintain the aromatic integrity of the oil (Souiy, 2023).

2. Solvent Extraction

Solvent extraction is another method employed to obtain essential oils, particularly when steam distillation may not be suitable. This technique involves using organic solvents, such as ethanol or hexane, to dissolve the essential oil from the basil leaves. After extraction, the solvent is evaporated, leaving behind a concentrated oil (Jiang *et al.,* 2021). While this method can yield higher quantities of oil, it may introduce solvent residues, which can compromise the purity of the final product (Mishra *et al.,* 2023).

3. Cold Pressing

Though more commonly used for citrus fruits, cold pressing can also be applied to basil. This method involves mechanically pressing the leaves to release essential oils without the use of heat ((Sangram Sanjay Wandhekar *et al.,* 2023). However, it is less common for basil compared to the other extraction methods.

Factors Influencing Oil Quality and Yield

Several factors influence the yield and quality of basil essential oil. The timing of harvest, environmental conditions, and the specific extraction method can all impact oil content and composition (Sushma Kholiya *et al.,* 2022). For instance, basil leaves harvested at their peak growth stage typically yield more essential oil with desirable chemical profiles (Singh *et al.,* 2010).

Health promoting benefits of basil essential oil

Blood Sugar Regulation: Research indicates that incorporating basil into your diet may assist in lowering elevated blood sugar levels and mitigating the long-term consequences associated with high blood sugar (Widjaja *et al.,* 2019).

Heart Disease Prevention*:* The eugenol found in basil can inhibit calcium channels, which may contribute to reduced blood pressure. Additionally, the essential oils in basil can help lower cholesterol and triglyceride levels. Basil is also a source of magnesium, which can enhance blood flow by promoting the relaxation of muscles and blood vessels (Irshad *et al.,* 2023).

Reduced Inflammation*:* Basil's essential oils, including eugenol, linalool, and citronellol, possess anti-inflammatory properties that can combat inflammation in the body. These effects may lower the risk of developing inflammatory conditions such as arthritis, heart disease, and gastrointestinal issues (Ugbogu *et al.,* 2021).

Protection Against Infections*:* Basil exhibits antibacterial properties, and its oils may be effective against bacteria responsible for respiratory, urinary, abdominal, or skin infections (Sienkiewicz *et al.,* 2013).

Improves Asthma Symptoms: Initial studies suggest that holy basil may alleviate airway swelling in individuals with asthma. However, some studies have relied on animal models, and clinical trials demonstrating improvement did not include a control group (Aminian *et al.,* 2022). More research is needed to confirm these effects.

Enhances Immune System Function: Traditionally, holy basil is believed to boost overall immunity when consumed on an empty stomach. A small study has supported this idea, showing improved immune markers, including increased T cell levels, which are crucial for fighting infections (Thakur, 2023).

Impact of Antimicrobial Properties

Antimicrobial Properties

Basil oil, derived from the leaves of *Ocimum basilicum*, possesses significant antimicrobial properties, making it a valuable asset in both culinary and medicinal applications. This essential oil is effective against a variety of pathogens, including bacteria, fungi, and viruses, due to its unique chemical composition.

- **Chemical Composition**: The antimicrobial efficacy of basil oil is primarily attributed to its rich composition of phytochemicals. This include:

- *Eugenol*: This phenolic compound is known for its strong antibacterial and anti-fungal properties (Ulanowska & Olas, 2021). Eugenol disrupts the cell membranes of pathogens, leading to cell lysis.

- *Linalool*: Another major component, linalool has been shown to exhibit antimicrobial effects by interfering with the metabolism of micro- organisms (Mączka *et al.,* 2022)

- *Citronellol*: This compound contributes to the oil's overall antimicrobial activity and has been effective against several bacterial strains (Mangalagiri *et al.,* 2021).

- **Bacterial Inhibition**: Basil oil has demonstrated effectiveness against various bacterial pathogens, including:

- *Staphylococcus aureus*: This common bacterium is known for its role in skin infections and is often resistant to antibiotics. Studies have shown that basil oil can inhibit the growth of *S. aureus*, making it a potential alternative or complementary treatment for infections (Melo *et al.*, 2019)

- *Escherichia coli*: Basil oil has also been effective against pathogenic strains of *E. coli*, which can cause gastrointestinal issues. The oil's ability to disrupt bacterial cell membranes is a key factor in its effectiveness (Ilić *et al.*, 2021)

- **Anti-fungal Activity**: Basil oil exhibits significant anti-fungal properties, particularly against species such as:

- *Candida albicans*: Basil oil has shown effectiveness in inhibiting the growth of this yeast, which is a common cause of opportunistic infections. Its anti-fungal activity may offer a natural alternative to conventional anti-fungal treatments (Nazzaro *et al.*, 2017).

- *Aspergillus niger*: Studies have reported that basil oil can inhibit the growth of this mold, which is often responsible for food spoilage and can cause respiratory issues in immuno-compromised individuals (Abdi-Moghadam *et al.*, 2023).

- **Virucidal Effects**: Emerging research suggests that basil oil may possess virucidal properties as well. Some studies indicate that it can inhibit the replication of certain viruses, potentially offering protective effects against viral infections (Wani *et al.*, 2020). However, more research is necessary to fully understand its mechanisms in this area.

- **Mechanism of Action**: The antimicrobial action of basil oil is thought to occur through multiple mechanisms:

- *Membrane Disruption*: The oil's components can disrupt the integrity of microbial cell membranes, leading to cell death (Kairat Zhakipbekov *et al.*, 2024).

- *Inhibition of Enzyme Activity*: Basil oil may interfere with critical enzymes involved in microbial metabolism, thereby inhibiting growth and replication (Li *et al.*, 2022).

- **Applications of Basil Oil**: Given its antimicrobial properties, basil oil is being explored for various applications, including:

- *Natural Preservative*: Its ability to inhibit microbial growth makes it a candidate for use as a natural food preservative (Rattanachaikunsopon & Phumkhachorn, 2010).

- *Topical Treatments*: Basil oil can be formulated into creams or ointments for treating skin infections and wounds (Jayapal *et al.*, 2023)

Chimnoi *et al.* (2018) found that essential oil extracts from basil leaves, at concentrations between 0.015 and 8.00 mg/ml, rapidly inhibited the growth of *Escherichia coli* and *Salmonella typhimurium*. According to (Ugbogu *et al.*, 2021), the aqueous extract of basil plants effectively inhibited *Pseudomonas aeruginosa* and had a moderate effect on *Staphylococcus aureus*. Joshi (2013) employed the tube-dilution method to assess the antibacterial properties of basil essential oils and its primary compound, eugenol, which demonstrated strong antibacterial effects against *Klebsiella pneumoniae, Serratia marcescens, and E. coli*.

In a recent investigation, (Ugbogu *et al.*, 2021) examined the antibacterial properties of essential oil derived from basil leaves against a variety of bacterial species. Their findings demonstrated that the essential oil effectively inhibited the growth of *Staphylococcus aureus* at a concentration of 0.75 µg/ml. The minimal inhibitory concentrations (MICs) for other tested bacteria, including *Shigella flexneri*, *Salmonella enteritidis*, *Escherichia coli*, *Klebsiella* species, and *Proteus mirabilis*, ranged from 3 to 12 µg/ml. Notably, eugenol was identified as the primary active compound responsible for these antibacterial effects, highlighting the potential of basil oil for therapeutic use in the prevention and treatment of bacterial infections (Ugbogu *et al.*, 2021)

CONCLUSION AND RECOMMENDATIONS

In conclusion, the mechanisms through which these oils exert their effects reveal a complex interplay that disrupts microbial integrity and metabolic function, making them valuable natural antimicrobials.The potential applications of basil oils in food preservation and therapeutic practices underscore their importance in both culinary and medicinal contexts. Their antioxidant and antimicrobial qualities can not only enhance food safety but also serve as viable alternatives to synthetic antimicrobials, promoting health and well-being.

Additionally, despite the encouraging results, the review identifies several shortcomings in the current body of research. There is a notable need for standardized methods of extraction, comprehensive toxicity evaluations, and clinical trials to determine effective dosages and formulations. Addressing these gaps will be essential for advancing the application of basil oils in health, nutrition, and sustainable agriculture.

By fostering a deeper understanding of these properties and promoting further investigation, we can harness the full potential of basil as a natural resource in combating

antimicrobial resistance and enhancing food safety and human health.

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Authors' Contribution

SVB & OJO were responsible for managing the writing of the manuscript, providing material support, and drafting the initial version. YAS and AOA managed material support and reviewed the manuscript.

Ethical Statement

Not applicable

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