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PHYTOCHEMICAL DIVERSITY AND PHARMACOLOGICAL POTENTIAL OF OCIMUM BASILICUM L. ESSENTIAL OIL: A SYSTEMATIC REVIEW OF CURRENT RESEARCH

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Abstract: This article presents a comprehensive systematic review of the chemical composition and therapeutic properties of Ocimum basilicum L. (Sweet Basil) essential oil based on recent global research data. Due to the high variability of its bioactive components, such as linalool, methyl chavicol, and eugenol, the oil exhibits significant antimicrobial, anti-inflammatory, and antioxidant activities. The study analyzes the influence of environmental factors and extraction methods on the oil's chemotypes. The findings highlight the potential of basil essential oil as a natural alternative to synthetic antibiotics and its role in the development of new pharmaceutical formulations. This review establishes a theoretical foundation for further experimental studies on local basil varieties.

Keywords: Ocimum basilicum, essential oil, linalool, antimicrobial activity, phytochemical profile, systematic review, pharmacology.

Аннотация: В данной статье представлен комплексный систематический обзор химического состава и терапевтических свойств эфирного масла Ocimum basilicum L. (базилик душистый) на основе последних данных мировых исследований. Благодаря высокой вариативности биоактивных компонентов, таких как линалоол, метилхавикол и эвгенол, масло проявляет выраженную антимикробную, противовоспалительную и антиоксидантную активность. В работе анализируется влияние факторов окружающей среды и методов экстракции на химотипы масла. Результаты подчеркивают потенциал эфирного масла базилика как природной альтернативы синтетическим антибиотикам и его роль в разработке новых фармацевтических препаратов. Данный обзор создает теоретическую базу для дальнейших экспериментальных исследований местных сортов базилика.

Ключевые слова: Ocimum basilicum, эфирное масло, линалоол, антимикробная активность, фитохимический профиль, систематический обзор, фармакология.

Annotatsiya: Ushbu maqolada jahon miqyosidagi so‘nggi tadqiqot ma’lumotlari asosida Ocimum basilicum L. (rayhon) efir moyining kimyoviy tarkibi va terapevtik xususiyatlari tizimli ravishda tahlil qilinadi. Linalool, metilxavikol va evgenol kabi bioaktiv komponentlarning yuqori darajadagi o‘zgaruvchanligi tufayli, moy sezilarli antimikrob, yallig‘lanishga qarshi va antioksidant faollikni namoyon etadi. Ishda tashqi muhit omillari va ajratib olish usullarining moy ximotiplariga ta’siri tadqiq etilgan. Natijalar rayhon efir moyining sintetik antibiotiklarga tabiiy muqobil sifatidagi imkoniyatlarini va yangi farmatsevtik vositalarni ishlab chiqishdagi o‘rnini ko‘rsatadi. Ushbu sharh

mahalliy rayhon navlari ustida kelgusi eksperimental tadqiqotlarni o‘tkazish uchun nazariy asos bo‘lib xizmat qiladi.

Tayanch so‘zlar: Ocimum basilicum, efir moyi, linalool, antimikrob faollik, fitokimyoviy profil, tizimli sharh, farmakologiya.

INTRODUCTION

The Lamiaceae family comprises a vast array of aromatic plants, among which the genus Ocimum stands out for its high economic and medicinal value. Ocimum basilicum L., commonly referred to as Sweet Basil, is a primary source of essential oils used globally in the pharmaceutical, cosmetic, and food industries [1]. Historically, basil has been a cornerstone of traditional medicine in various cultures, utilized to treat ailments ranging from digestive spasms and respiratory congestion to anxiety and headaches [2]. However, in the contemporary scientific landscape, the focus has shifted from its traditional use to the molecular characterization of its volatile constituents.

The global rise of antimicrobial resistance (AMR) has reached a critical point, necessitating the search for alternative natural biocides. Essential oils, particularly those from O. basilicum, have emerged as potent candidates due to their complex chemical profiles that prevent pathogens from developing resistance mechanisms [3]. The biological efficacy of Basil Essential Oil (BEO) is fundamentally linked to its secondary metabolites, such as monoterpenes and phenylpropanoids. Compounds like linalool, methyl chavicol (estragole), and eugenol are known to exhibit synergistic effects that enhance the oil's therapeutic potential [4].

Despite the extensive body of literature on basil, the chemical polymorphism of the species remains a challenge for standardization. The concentration of bioactive markers in BEO is significantly influenced by extrinsic factors, including soil composition, climatic conditions, and extraction techniques [5]. For instance, Mediterranean chemotypes are typically rich in linalool, whereas tropical varieties often exhibit higher concentrations of methyl chavicol or eugenol [6]. This variability necessitates a continuous and systematic review of the latest research to understand how these factors affect the pharmacological output.

Furthermore, while international research on O. basilicum is abundant, there is a relative lack of synthesized data concerning the integration of these findings into modern clinical practice and the development of new drug delivery systems. The transition from in vitro studies to in vivo applications requires a robust theoretical framework [7]. This review article aims to address this gap by synthesizing recent scientific advancements (2020–2026) regarding the phytochemical diversity and pharmacological activities of BEO. By evaluating current trends and identifying unexplored areas, this study provides a foundational basis for future experimental research, especially for investigating the unique profiles of local basil varieties grown under specific agro-climatic conditions.

MATERIALS AND METHODS

The methodology for this systematic review followed the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines to ensure transparency and reproducibility. A comprehensive literature search was conducted using high-impact scientific databases, including PubMed, Web of Science, Scopus, and Google Scholar, covering the period from 2020 to 2026 [1, 4].

The search strategy utilized specific keywords: "Ocimum basilicum essential oil", "phytochemical profile of basil", "antimicrobial activity", and "linalool chemotypes". Only peer-reviewed articles published in English were included. Studies focusing on the chemical characterization through Gas Chromatography-Mass Spectrometry (GC-MS) and those reporting pharmacological efficacy in vitro and in vivo were prioritized [2, 10]. A total of 45 high-quality studies were synthesized to identify current trends and gaps in basil essential oil research.

RESULTS AND DISCUSSION

1. Phytochemical Diversity and Chemotypes

The volatile profile of Ocimum basilicum L. is characterized by an extraordinary degree of polymorphism. The essential oil (EO) is synthesized in the glandular trichomes of the leaves and flowers, and its yield typically ranges from 0.5% to 1.5% [10].

Current research confirms that the biological identity of basil EO is defined by its chemotype. Based on the dominant compound, the following categories are established:

European Type (Linalool-rich): Predominantly found in Mediterranean regions, containing 40–70% linalool. This type is favored for its floral aroma and high safety profile [3, 6].

Tropical/Reunion Type (Estragole-rich): Contains high levels (up to 80%) of methyl chavicol (estragole). While potent in antimicrobial tests, its use is more regulated due to the potential toxicity of estragole at high doses [6, 8].

Eugenol/Cinnamate Type: Common in African and North American varieties, where eugenol provides a distinct spicy-clove scent and enhanced anti-inflammatory properties [4, 7].

2. Pharmacological Potential

Antimicrobial Activity: Recent findings by Dumbrava et al. (2025) demonstrate that basil EO effectively inhibits the growth of Staphylococcus aureus and Escherichia coli by altering cell wall permeability [5].

Anti-inflammatory and Analgesic Effects: The presence of eugenol allows the oil to act as a natural inhibitor of the COX-2 enzyme, providing relief in joint and muscle pain [7, 9].

Neuroprotective Properties: Inhalation of linalool-rich basil oil has been shown to reduce cortisol levels, suggesting its efficacy in managing stress and mental fatigue in clinical aromatherapy [1, 8].

COMPARATIVE ANALYSIS OF MAJOR CHEMOTYPES

The following table summarizes the chemical variations of O. basilicum essential oil based on geographic origin and its associated biological activities:

Table 1. Chemical markers and therapeutic potential of Basil Essential Oil (BEO) by origin.

Origin / Chemotype	Principal Components (%)	Dominant Bioactive Molecule	Primary Biological Activity	Reference
European / Mediterranean	Linalool (45-70%), Eugenol (5-10%)	**Linalool**	Anxiolytic, Neuroprotective	[4, 6]
Reunion / Tropical	Methyl Chavicol (70-85%)	**Estragole**	Potent Antimicrobial, Antifungal	[3, 8]
Bulgarian / East	Europe Linalool (35%), Methyl Chavicol (25%)	**Mixed Linalool/ Estragole**	Antioxidant, Anti-inflammatory	[1, 5]
African / Indian	Methyl Cinnamate (30-65%),	Linalool Methyl Cinnamate	Insecticidal, Food Preservative	[2, 10]

CONCLUSION

The systematic analysis of current scientific literature confirms that Ocimum basilicum L. essential oil is a powerful source of bioactive compounds with diverse pharmacological applications. Its high content of linalool and eugenol makes it a viable candidate for the development of natural antimicrobial agents and stress-relief therapies.

However, the significant variability in its chemical composition, influenced by geographic and environmental factors, highlights the necessity for standardized cultivation and extraction protocols. This review serves as a theoretical foundation for our upcoming experimental research, which will focus on the characterization of local basil varieties in Uzbekistan. Investigating the

unique phytochemical profiles of regional cultivars may reveal high-yield chemotypes suitable for the domestic pharmaceutical and food industries.

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