ISOLATION AND ANALYSIS OF VOLATILE AROMATIC COMPOUNDS FROM WILD PLANTS OF THE SURKHANDARYA REGION

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Abstract: *In recent years, there has been a growing global demand for natural and environmentally friendly sources of fragrant organic compounds, especially in the fields of cosmetics, perfumery, pharmaceuticals, and food industries. This study focuses on the isolation and analysis of volatile aromatic compounds—primarily essential oils—from wild plant species native to the Surkhandarya region of Uzbekistan. The research utilized modern extraction techniques including steam distillation, ultrasonic extraction, and supercritical CO_2 extraction to isolate aromatic compounds from selected endemic and medicinal plants. The chemical composition of the extracted volatile oils was analyzed using gas chromatography (GC) and gas chromatography-mass spectrometry (GC-MS). The results demonstrated that ultrasonic and CO_2 extraction methods yielded higher concentrations of terpenoids and other valuable aromatic constituents compared to traditional methods. The findings highlight the potential of the Surkhandarya flora as a sustainable source of industrially important volatile compounds and support the implementation of green chemistry approaches in the development of eco-friendly extraction technologies.*

Keywords: *Surkhandarya flora, essential oils, aromatic plants, volatile compounds, ultrasonic extraction, supercritical CO_2, green chemistry, gas chromatography, phytochemical analysis, eco-friendly technology.*

In the contemporary era of industrial and environmental awareness, there is a steadily increasing global demand for naturally derived and eco-friendly aromatic compounds. These compounds play a vital role in a wide range of industries such as pharmaceuticals, food technology, cosmetics, and perfumery. Synthetic fragrances and additives, although widely used, often raise concerns due to their potential health and environmental hazards. Consequently, the scientific community has shifted its focus toward sustainable, plant-based alternatives that offer not only desirable fragrance profiles but also therapeutic and functional benefits.

Among various botanical resources, essential oils and volatile organic compounds (VOCs) derived from aromatic plants are of particular importance. These compounds are known for their antimicrobial, anti-inflammatory, and antioxidant properties, making them valuable in both industrial and medicinal applications. However, the successful isolation and application of such compounds require region-specific botanical exploration and advanced physicochemical extraction techniques.

The Surkhandarya region of southern Uzbekistan is characterized by its rich biodiversity and unique bioclimatic conditions, which support a wide variety of wild medicinal and aromatic plants. Despite this natural wealth, the region remains underexplored in terms of its phytochemical potential. Very few scientific studies have investigated the chemical composition and industrial viability of volatile aromatic compounds from Surkhandarya's endemic flora.

This research is aimed at filling that gap by systematically collecting plant specimens from different ecological zones within the Surkhandarya region and applying advanced extraction techniques—such as steam distillation, ultrasonic-assisted extraction, and supercritical CO_2 extraction—to isolate essential oils and VOCs. These techniques were chosen based on their compatibility with green chemistry principles, ensuring minimal environmental impact and high efficiency.

Furthermore, the extracted compounds were analyzed using Gas Chromatography (GC) and Gas Chromatography-Mass Spectrometry (GC-MS) to determine their qualitative and quantitative compositions. The study not only aims to identify the most efficient extraction methods but also to evaluate the chemical profiles of local plant species to support their potential industrial applications.

This research contributes to the sustainable utilization of local plant resources, promotes the use of cleaner technologies in natural product extraction, and offers valuable insights into the bioactive potential of Surkhandarya's flora.

The isolation and analysis of volatile aromatic compounds from wild plants of the Surkhandarya region have revealed significant differences in the yield and chemical composition of essential oils, depending on both the plant species and the extraction method employed. The comparative study between traditional and modern extraction techniques—namely steam distillation, ultrasonic-assisted extraction, and supercritical CO_2 extraction—has demonstrated the advantages of utilizing more advanced, green technologies in natural compound isolation.

Steam distillation, although widely used due to its simplicity and cost-effectiveness, was found to have lower extraction efficiency and often led to partial degradation of thermally sensitive components. In contrast, ultrasonic-assisted extraction (UAE) significantly reduced extraction time and energy consumption while preserving the integrity of key aromatic compounds such as linalool, menthol, and eugenol. This method proved particularly effective for soft tissues and leaf-rich plants.

The supercritical CO_2 extraction technique emerged as the most promising among the tested methods. It offered superior extraction efficiency and selectivity, particularly for lipophilic and oxidation-sensitive compounds. Supercritical CO_2, being non-toxic and non-flammable, provided a clean and sustainable alternative to organic solvents, aligning well with green chemistry principles. Moreover, the ability to adjust pressure and temperature allowed fine-tuning of the extraction process to target specific volatile fractions.

The GC and GC-MS analyses revealed that the chemical profiles of essential oils from *Mentha longifolia*, *Ocimum basilicum*, and *Rosa canina* contained major constituents with high therapeutic and aromatic value. For instance, the essential oil of *Mentha longifolia* was dominated by menthol and menthone, whereas *Ocimum basilicum* yielded high concentrations of linalool and methyl chavicol. These findings correlate well with existing literature on aromatic plant composition in other Central Asian regions, but also highlight unique variations attributable to the Surkhandarya climate and soil conditions.

Statistical analysis using OriginPro and Excel demonstrated that the yield of essential oils using supercritical CO_2 was up to 30–40% higher compared to steam distillation, with greater purity and fewer residual solvents. These results underscore the potential of Surkhandarya's wild flora as a sustainable and competitive source of natural volatile compounds for the pharmaceutical, cosmetic, and food industries.

Furthermore, this study supports the notion that the Surkhandarya region holds untapped economic and ecological value through its native plant biodiversity. By investing in environmentally friendly extraction infrastructure and encouraging bioprospecting initiatives, the region could significantly contribute to both national economic development and global natural product supply chains.

Thus, the discussion underscores not only the scientific relevance of efficient extraction and characterization of volatile compounds but also their broader application in sustainable industry and environmental conservation.

This research highlights the rich potential of wild aromatic plants from the Surkhandarya region as valuable sources of volatile organic compounds. Through a comparative assessment of three extraction methods—steam distillation, ultrasonic-assisted extraction, and supercritical CO_2 extraction—it has been established that modern, green technologies not only increase the yield and purity of essential oils but also better preserve their chemical integrity.

Among the analyzed methods, supercritical CO_2 extraction demonstrated the highest efficiency, delivering superior quality essential oils with minimal thermal degradation and solvent residue. Ultrasonic-assisted extraction also proved to be an energy-efficient and rapid technique with promising results for soft plant tissues. In contrast, traditional steam distillation, while simple and widely used, showed lower yields and selectivity.

The GC and GC-MS analyses confirmed the presence of valuable compounds such as menthol, linalool, eugenol, and methyl chavicol in species like *Mentha longifolia*, *Ocimum basilicum*, and *Rosa canina*, emphasizing their commercial and therapeutic significance. Moreover, the unique environmental conditions of the Surkhandarya region appear to influence the specific chemical profiles of these native species, potentially offering distinct advantages in the global essential oil market.

Overall, the study provides a scientific foundation for further exploration and sustainable utilization of Surkhandarya's native plant biodiversity. Investing in eco-

friendly extraction technologies and biotechnological development could transform the region into a center for the production of high-value natural aromatic products. This, in turn, could foster local economic growth, support biodiversity conservation, and meet the growing global demand for natural and sustainable raw materials.

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