**Review Article**

**Environmental and Geographical Influences on the Composition and Extraction of Calotropis procera Seed Oil: A Global Study**

**Abstract:**

Calotropis procera is a traditional plant renowned for its medicinal uses, including the oil extracted from its seeds, which has been used for centuries in various healing practices. In Hinduism, the plant holds cultural significance, particularly in its association with Lord Hanuman, symbolizing strength and embodying ancient Ayurvedic knowledge. Traditionally, oil extraction was performed using simple methods, but with modern advancements, new techniques have been developed to improve oil yield and quality. Calotropis procera thrives in regions with moderate climates and is found globally. Contemporary analysis has enabled a deeper understanding of the chemical and physical composition of its seed oil, revealing numerous potential uses for future research and applications. This study aims to gather and compare data from various geographical regions to analyze the differences in the chemical composition of the seed oil, enhancing our knowledge of the plant’s bioactive compounds and their applications in modern science.

**Keywords:** Calotropis procera, Extraction, Composition, Regions, Seed oil

**1. Introduction**

The study of Calotropis procera seed oil's chemical composition boasts significant potential, not only due to its richness in monoterpenes but also because of its diverse biochemical properties. Monoterpenes, which dominate approximately 60.4% of the oil, are well-regarded for their roles in plant defence mechanisms and therapeutic potential. However, beyond these prevalent compounds, C. procera seed oil comprises 23.81% of other diverse chemical constituents [1]. This intriguing composition highlights its prominence as a source of plant-based oil with versatile applications [20]. As the oil’s chemical profile is subject to change due to environmental and geographical factors, the depth of understanding for each component's role and its potential application require thorough examination [16,17].

The chemical architecture of C. procera seed oil is intricately tied to its geographic origins. Influenced by environmental variables such as climate, soil type, and humidity, variations in its biochemical profile are inevitable, creating a rich tapestry of research opportunities. Such variability is pivotal, as it underscores the essence of conducting regional-specific studies, providing nuanced insights into how shifting environmental factors influence the oil's chemical and functional properties [2]. These examinations not only have scientific relevance but also practical implications for industries ranging from pharmaceuticals to agriculture, where the oil’s varying chemical composition can be strategically leveraged [18,19].

This paper investigates the biochemical properties and extraction methods of C. procera seed oil, examining the impact of geographical diversity and environmental factors on its chemical composition. By employing both traditional and modern extraction techniques, such as Gas Chromatography-Mass Spectrometry and Soxhlet extraction, we aim to delve into the comprehensive profiling of the seed oil constituents [2,3,8]. Comparative analyses of samples collected from diverse regions offer enlightening insights into how location-specific environments dictate the oil's chemical profile. This research not only enhances our scientific understanding but also supports the development of more informed cultivation and application strategies, thereby maximizing C. procera seed oil's potential as a resource with vast economic and therapeutic applications [3,4].

**2. Chemical Composition of C. Procera Seed Oil**

The biochemical properties of C. procera seed oil serve as a vital point of examination within the realm of plant-based oils. Primarily composed of monoterpenes, which constitute a substantial 60.4% of the oil, C. procera seed oil demonstrates a robust chemical profile (Monoterpenes (60.4% of the oil) were the most common component, followed by other compounds (23.81%)). This high concentration of monoterpenes positions the oil as particularly significant in biochemical applications, due to their known roles in plant defense mechanisms and potential therapeutic benefits. Additionally, other compounds account for 23.81% of the oil’s composition, indicating a diverse array of chemical components that may contribute uniquely to the oil’s overall characteristics [8,9,11].

The variation in the chemical composition of C. procera seed oil is also markedly influenced by geographical and environmental factors. Such variations are an inherent aspect of natural products, as the profiles of essential oils can significantly differ based on the location and season of harvest. This dynamic quality underscores the importance of considering regional and temporal factors when analyzing the biochemical properties of the oil. For instance, environmental conditions such as temperature, soil type, and humidity can affect the biosynthetic pathways in plants, leading to alterations in the concentration and types of chemical constituents within the oil [3,12,13].

Understanding the chemical composition of C. procera seed oil has broad implications for its utilization and potential applications. The predominance of monoterpenes, supplemented by other compounds, suggests a multifaceted chemical profile that can be leveraged in fields such as medicine, cosmetics, and agriculture. Given its variability due to environmental factors, there is a necessity for further research to fully elucidate the biochemical properties across different regions, which will enhance both the scientific understanding and the practical application of this oil. Such investigative efforts can bridge existing knowledge gaps, contributing to a more comprehensive picture of C. procera seed oil’s potential benefits and uses.

The chemical composition of C. procera seed oil is a topic of significant interest due to its potential applications in various industries. The oil is predominantly composed of monoterpenes, which make up a notable 60.4% of its chemical makeup, highlighting their significance in its composition. These compounds are followed by other constituents that form. 23.81% of the oil's profile [5]. This distinct chemical configuration positions C. procera seed oil as a unique resource with promising biochemical properties. Monoterpenes, in particular, are known for their applications in plant defense mechanisms and therapeutic benefits, suggesting that the oil may have a wide range of uses. Moreover, the presence of a diverse array of compounds may enhance the oil's effectiveness in different applications, further underscoring the importance of understanding its complete chemical profile.

In addition to its intrinsic biochemical properties, the composition of C. procera seed oil is subject to variation due to geographical and environmental influences. Such variability is a found characteristic of natural products, necessitating a comprehensive analysis that considers diverse environmental conditions such as climate, soil type, and moisture levels. These external factors can affect the biosynthetic pathways of plants, leading to changes in the concentration and types of chemical constituents found within the oil [3,7]. This dynamic nature of C. procera seed oil underscores the necessity for region-specific studies, which can offer insights into how environmental conditions influence its chemical and functional properties. The following table 1 explains the oil composition of C. procera.

**Table 1: Chemical composition of C. procera** **oil**

|  |  |  |
| --- | --- | --- |
| **Sr. No.** | **Component** | **%** |
| 1 | **Fatty Acids** | |
| a) Palmitic acid | 10-15 |
| b) Oleic acid | 15-20 |
| c) Linoleic acid | 23-30 |
| d) Stearic acid | 4-6 |
| e) Arachidic acid | 2-3 |
| 2 | **Sterols** | |
| a) β-Sitosterol | 50-60 |
| b) Stigmasterol | 20-30 |
| c) Campesterol | 10-15 |
| 3 | **Other Compounds** | |
| a) Triterpenes | 1-2 |
| b) Phospholipids | < 1 |

A deeper understanding of these variations in chemical composition has significant implications for the potential utilization of C. procera seed oil. As the oil's properties fluctuate with environmental factors, there exists an opportunity to explore its diverse applications across different fields, from agriculture to medicine. For instance, the high concentration of monoterpenes, in combination with other compounds, may present unique benefits that could be specifically leveraged for environmental conditions or geographic regions. Therefore, advancing research on C. procera seed oil's biochemical properties across various locales is crucial to maximize its potential benefits and practical applications. This pursuit not only promotes scientific advancement but also fosters practical solutions in sectors that can benefit from the unique properties of this versatile oil [13,14].

**3. Extraction Methods for C. Procera Seed Oil**

The extraction of C. procera seed oil involves various methods that are both traditional and modern, each with distinct advantages in terms of efficiency and chemical integrity preservation. Among these, Gas Chromatography-Mass Spectrometry (GC-MS) stands out as a critical analytical tool for identifying and separating the constituents of the oil. C. procera constituents were separated and identified through GC-MS analysis [5]. Such advanced analytical techniques allow for a more nuanced understanding of the oil's chemical composition, enabling more precise identification of compounds like monoterpenes, which are significant for their potential therapeutic benefits. The reliability of GC-MS analysis underlines the importance of using sophisticated technology to ensure the comprehensive profiling of seed oil constituents, which is pivotal for subsequent applications in pharmaceuticals and cosmetics [15]. In addition to advanced techniques, traditional methods remain relevant in the extraction of C. procera seed oil, providing a basis for understanding the fundamental processes involved. The Soxhlet extraction method, notably, continues to be a popular choice due to its effectiveness in extracting diverse organic compounds. This method ensures thorough extraction by employing heat and a solvent, facilitating the dissolution and retrieval of desired constituents. Such time-tested procedures complement modern analysis methods, providing a comprehensive approach to maintaining the chemical integrity of the oil while optimizing yield efficiency [3,4].

Both traditional and advanced methods play integral roles in the study and application of C. procera seed oil, highlighting their combined impact on understanding its chemical properties. By integrating these methods, researchers can achieve detailed insights into the oil's composition, adapting processes to suit varied research and commercial objectives. This combination facilitates a robust framework for identifying potential variables affecting oil quality, which is essential for developing industrial applications and enhancing the nutritional and antioxidant profile of the oil. As studies continue to evolve, maintaining a balance between traditional practices and modern analytical techniques will remain crucial for advancing our understanding of C. procera seed oil's diverse properties. The following table 2 explained the different methods used for extraction of oil from seeds.

**Table 2: Different methods used for Oil Extraction**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Sr. No.** | **Extraction Method** | **Yield (%)** | | **Effect on Composition** | | --- | |
| 1 | Mechanical Pressing | 15-25 | Lower concentration of unsaturated fatty acids |
| 2 | Solvent Extraction | 25-35 | Preserves a higher amount of fatty acids and sterols |
| 3 | Cold Pressing | 10-20 | Solvent residue, environmental concerns |
| 4 | Supercritical CO₂ Extraction | 20-30 | Preserves volatile compounds, higher quality oil |
| 5 | Ultrasound-Assisted Extraction | |  |  | | --- | --- | |  | 22-28 | | Increases extraction of polyunsaturated fatty acids |
| 6 | Microwave-Assisted Extraction | 25-32 | May alter fatty acid profile, higher yield of sterols |
| 7 | Enzymatic Extraction | 20-28 | Enhanced extraction of specific lipids |
| 8 | Aqueous Extraction | 10-18 | Preserves water-soluble compounds |

**4. Impact of Geographical Diversity on Oil Composition**

The variability in the chemical composition of C. procera seed oil is significantly influenced by geographical and environmental factors. This section presents a comparative analysis of samples collected from diverse regions to understand how these factors contribute to the differing chemical properties of the oil. The chemical makeup of essential oils from the same species can vary depending on when and where they were harvested [3]. This highlights the importance of considering both temporal and spatial variations when analyzing the biochemical properties of C. procera seed oil. Different regions might impose varying climatic conditions and soil types, which could potentially alter the concentration and presence of specific compounds such as monoterpenes and other essential constituents of the oil.

In the study, particular attention is given to the collection and authentication of C. procera samples from specific regions, ensuring the reliability of the resulting data. Fruits of C. procera and T. terrestris were collected from local area of Solapur district, Maharashtra, India. This meticulous process underscores the scientific rigor required for ensuring that variations in chemical composition are accurately attributed to environmental factors rather than sampling errors. By examining samples from well-documented origins, researchers can more precisely identify how the local environmental conditions impact the biochemical characteristics of the seed oil, hence providing a comprehensive understanding of geographical influence. Moreover, the comparative analysis of C. procera seed oil from different locations serves as a crucial step in assessing its potential uses and applications, guided by the oil's unique chemical profile from each region [1]. By understanding the environmental dependencies of the oil's composition, this analysis not only paves the way for optimized agricultural practices tailored to specific locations but also guides further research into improving the oil's nutritional and pharmaceutical applications. The variations in monoterpenes and other essential components due to geographical diversity can result in oils with distinct properties and potential health benefits. Thus, this study contributes valuable insights that could refine both the cultivation and application strategies for C. procera seed oil, aligning them with the geographical specificities observed in regional samples [6,8].

**5. Factors Influencing the Nutritional and Antioxidant Profile**

The exploration of C. procera seed oil's biochemical properties reveals that its chemical composition is highly susceptible to variations due to geographical and environmental influences. Understanding these biochemical properties is crucial, as they determine the oil's nutritional and antioxidant capabilities. In particular, the presence of certain compounds such as monoterpenes significantly impacts the oil's effectiveness. Research underscores that the chemical makeup of essential oils from the same species is not static [5]. This variability highlights the necessity for region-specific studies to discern the precise biochemical profile of C. procera seed oil.

Regional differences in the chemical composition of C. procera seed oil are pronounced, with notable gaps in the research from specific areas. For instance, there is a paucity of data from northern Nigeria, which poses challenges in fully comprehending the oil's diverse chemical spectrum across different landscapes. These gaps impede our ability to generate a holistic understanding of C. procera seed oil's potential benefits and qualities. Acknowledging such regional variations is essential for crafting more effective extraction and utilization strategies that can maximize the oil's nutritional and antioxidant properties. Consequently, integrating region-specific data could enhance agricultural practices by tailoring them to suit the environmental conditions of each location, thereby optimizing the quality of the seed oil produced. An investigation into the environmental determinants of C. procera seed oil's composition underscores the profound influence of factors such as climate and soil on its nutritional value. The interaction between these environmental conditions and the oil's chemical composition is complex, suggesting that specific patterns can be identified and leveraged to improve agricultural methodologies. Understanding this dynamic relationship not only aids in enhancing the nutritional profile of C. procera seed oil but also contributes to broader agricultural and scientific endeavours by offering insights into how external factors can be managed to optimize oil quality. As research progresses, the insights garnered can inform sustainable agricultural practices and bolster the nutritional understanding of this versatile oil, thereby fostering its application in diverse fields [9,13]

**6. Conclusion**

The investigation into the chemical composition and biochemical properties of Calotropis procera seed oil highlights its rich monoterpene content and diverse compound profile, underscoring its potential significance in numerous applications such as medicine, cosmetics, and agriculture. This oil's robust chemical profile is primarily characterized by its high concentration of monoterpenes, amounting to 60.4% of its composition, alongside a variety of other compounds. These components collectively contribute to the oil's functional properties, including possible therapeutic benefits and defensive roles in plant biology. Understanding this chemical composition paves the way for leveraging these benefits effectively, particularly given the oil's propensity to variation due to environmental factors. The geographical and environmental influences on C. procera seed oil's composition further emphasize the dynamic nature of natural products. Variability in the chemical makeup of the oil based on regional climatic conditions and soil types suggests that its application and utility can be optimized through region-specific studies. These variations necessitate a deeper examination of how harvesting conditions affect the oil's biochemical profile. By doing so, researchers can tailor agricultural practices and extraction techniques to maximize the unique properties of the oil from different regions, ensuring that its potential is fully realized. This adaptability also highlights the need for ongoing research to close existing knowledge gaps, such as those identified in under-represented areas like northern Nigeria, to gain a comprehensive understanding of the oil's global potential.

Considering extraction methods, both modern and traditional techniques are integral to the study of C. procera seed oil, providing a balanced approach to understanding and utilizing its chemical properties. Advanced analytical techniques such as Gas Chromatography-Mass Spectrometry (GC-MS) have elucidated the oil's specific constituents, while traditional methods like Soxhlet extraction remain valuable for their efficiency and reliability in extracting diverse compounds. Together, these methodologies facilitate a nuanced understanding of the oil's biochemical attributes and ensure that its chemical integrity is preserved throughout the extraction process. As the field continues to evolve, maintaining a synergy between innovative research and established practices will be crucial for harnessing the full potential of C. procera seed oil in various industrial and scientific contexts.

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