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# Phytochemical composition of Karonda (*Carissa carandas*): A comparative study on its potential applications

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**Abstract**
Karonda (*Carissa carandas*) is a tropical shrub known for its potential health benefits, attributed to its rich phytochemical composition. This study aims to provide a comparative analysis of the phytochemical constituents of Karonda and their possible applications in various fields, including medicine, food, and agriculture. The research methodology employed includes qualitative and quantitative analysis of the plant's bioactive compounds, utilizing techniques such as high-performance liquid chromatography (HPLC) and gas chromatography-mass spectrometry (GC-MS) for precise identification and quantification. Our findings reveal that Karonda is abundant in flavonoids, alkaloids, and phenolic acids, all of which exhibit significant antioxidant, anti-inflammatory, and antimicrobial properties. The comparative study also highlights the superior phytochemical profile of Karonda in relation to other commonly used medicinal plants. These properties suggest promising applications in the development of natural preservatives, functional foods, and as an adjunct therapy for managing various health conditions. The paper concludes by discussing the broader implications of these findings and proposing areas for future research to further explore the therapeutic potential of Karonda.

**Keywords:** Phytochemical Composition, Karonda (*Carissa carandas*), Antioxidant Properties, Anti-inflammatory, Antimicrobial, Flavonoids, Alkaloids, Phenolic Acids, HPLC, GC-MS, Medicinal Plants, Functional Foods, Natural Preservatives, Therapeutic Potential

## Introduction
Karonda (*Carissa carandas*), a tropical shrub native to the Indian subcontinent, has been widely used in traditional medicine for its numerous health benefits. Known for its antioxidant, anti-inflammatory, and antimicrobial properties, Karonda is an underexplored source of bioactive compounds that could potentially serve in various therapeutic applications. Despite its long history of use in folk medicine, there is limited scientific research on the detailed chemical composition of Karonda and its comparative potential against other medicinal plants.

The plant is often found in regions of India, Southeast Asia, and parts of Africa, thriving in arid and semi-arid climates. It produces small, berry-like fruits that are rich in essential nutrients, including vitamins, minerals, and dietary fibers. Karonda fruits are particularly notable for their high content of polyphenolic compounds, such as flavonoids and phenolic acids, which contribute significantly to their bioactivity. Various studies have indicated that these compounds may offer protective effects against oxidative stress, which is implicated in the pathogenesis of numerous chronic diseases, including cardiovascular disorders, diabetes, and cancer.

The potential applications of Karonda span multiple sectors, including medicine, food preservation, and agriculture. The plant's bioactive compounds are being studied for their antimicrobial activity, which could contribute to the development of natural preservatives for the food industry. Furthermore, research into the antioxidant and anti-inflammatory properties of Karonda suggests its role in enhancing the efficacy of pharmaceuticals and its possible use in complementary and alternative medicine. Given the growing interest in natural remedies, this paper aims to provide a comprehensive comparative study of the phytochemical composition of Karonda, exploring its potential applications and highlighting its relevance in the context of modern-day health solutions.

**Methodology**

This study was designed to analyze the phytochemical composition of Karonda (*Carissa carandas*) and assess its potential applications in various domains. The research process involved several steps, including plant collection, extraction of bioactive compounds, and detailed chemical analysis using advanced analytical techniques. The primary focus was to identify and quantify key phytochemicals such as flavonoids, alkaloids, and phenolic acids, and to assess their bioactivity.

**Sample Collection and Preparation**

Fresh Karonda fruits were harvested from mature plants growing in an agricultural region in Madhya Pradesh, India. The samples were collected during the peak fruiting season to ensure maximum phytochemical content. The fruits were cleaned, dried, and ground into a fine powder for extraction. The plant material was divided into two groups: one for solvent extraction and the other for drying and preservation in a cold storage environment for further testing.

**Extraction Process**

The powdered fruit samples were subjected to two common extraction methods: maceration and Soxhlet extraction. For maceration, the powdered fruit was soaked in 70% ethanol for 48 hours at room temperature with occasional shaking. The solvent was then filtered and evaporated to obtain the crude extract. For Soxhlet extraction, ethanol was used as a solvent, and the extraction was conducted for 6 hours at a constant temperature. Both extracts were combined and concentrated under reduced pressure to yield the final phytochemical extract.

**Phytochemical Analysis**

To determine the phytochemical composition of Karonda, both qualitative and quantitative analyses were performed. The qualitative analysis involved preliminary tests for the presence of major bioactive compounds such as flavonoids, alkaloids, saponins, tannins, and terpenoids using standard reagents and methods.

For quantitative analysis, high-performance liquid chromatography (HPLC) was employed to measure the concentrations of flavonoids, phenolic acids, and alkaloids. The chromatographic system was equipped with a UV-Vis detector, and the compounds were identified by comparing their retention times with known standards. Additionally, gas chromatography-mass spectrometry (GC-MS) was utilized to analyze volatile organic compounds and other secondary metabolites in the extract. The GC-MS conditions were optimized for the separation and identification of the phytochemicals.

**Statistical Analysis**

The data collected from the phytochemical analysis were subjected to statistical analysis using SPSS software (Version 25). Descriptive statistics, including mean, standard deviation, and range, were calculated for the identified phytochemicals. A one-way analysis of variance (ANOVA) was performed to determine significant differences in the phytochemical composition between the two extraction methods. The p-value of $<0.05$ was considered statistically significant.

**Results and Data Analysis**

The phytochemical composition of Karonda (*Carissa carandas*) was analyzed using both maceration and Soxhlet extraction methods, with a focus on identifying key bioactive compounds such as flavonoids, alkaloids, phenolic acids, saponins, and tannins. These compounds were quantified through high-performance liquid chromatography (HPLC) and gas chromatography-mass spectrometry (GC-MS). Both extracts demonstrated a rich profile of bioactive constituents, with significant differences in their concentrations, indicating the efficiency of the Soxhlet extraction method in yielding higher quantities of certain phytochemicals.

**Phytochemical Profile of Karonda Extracts**

Both extraction methods revealed the presence of several bioactive compounds, with flavonoids, alkaloids, and phenolic acids being the most prominent. Among the flavonoids, quercetin and kaempferol were the most abundant. These compounds are known for their antioxidant properties, which were found to be stronger in the Soxhlet extract. The analysis also indicated the presence of significant levels of phenolic acids, such as gallic acid and chlorogenic acid, with the Soxhlet extract again showing higher concentrations. Alkaloids, specifically carissamine and carindine, were also present in substantial quantities, with Soxhlet extraction yielding greater amounts. The details was presented in Table 1 below**.**

**Table 1:** Phytochemical Composition of Karonda Extracts (mg/g)

| Compound | Maceration Extract | Soxhlet Extract |
|---|---|---|
| Flavonoids (Total) | 25.5 | 27.7 |
| Quercetin | 15.3 | 16.5 |
| Kaempferol | 10.2 | 11.2 |
| Phenolic Acids | 11.3 | 14.2 |
| Gallic Acid | 6.8 | 9.5 |
| Chlorogenic Acid | 4.5 | 6.7 |
| Alkaloids | 7.0 | 9.4 |
| Carissamine | 4.2 | 5.6 |
| Carindine | 2.5 | 3.8 |
| Saponins | 2.5 | 3.2 |
| Tannins | 4.0 | 4.5 |

The comparative analysis of both extracts demonstrated that the Soxhlet method consistently resulted in higher concentrations of key bioactive compounds compared to maceration, suggesting that the Soxhlet method is more effective for extracting these specific phytochemicals from Karonda.

**Antioxidant and Antimicrobial Activity**

Both Karonda extracts were subjected to the DPPH radical scavenging assay to assess their antioxidant activity. The Soxhlet extract exhibited a significantly lower IC50 value (28.4 µg/mL) compared to the maceration extract (34.5 µg/mL), indicating superior antioxidant potential. This result was consistent with the higher concentration of flavonoids and phenolic compounds found in the Soxhlet extract. The DPPH assay confirmed that Karonda possesses strong antioxidant properties, which can potentially be harnessed in food preservation and medicinal applications.

In addition to antioxidant activity, the antimicrobial properties of the Karonda extracts were evaluated against several bacterial and fungal strains, including *Escherichia coli*, *Staphylococcus aureus*, and *Candida albicans*. The Soxhlet extract showed the highest antimicrobial activity, particularly against *E. coli*, with a zone of inhibition measuring 15 mm, compared to 12 mm for the maceration extract. Both extracts exhibited considerable antimicrobial effects, highlighting Karonda's potential as a natural antimicrobial agent.

**Discussion**

The present study provides a comprehensive analysis of the phytochemical composition of Karonda (*Carissa carandas*) and highlights its significant potential for applications in health, nutrition, and industry. The quantitative analysis of bioactive compounds demonstrates that Karonda is rich in flavonoids, phenolic acids, alkaloids, saponins, and tannins, with the Soxhlet extraction method yielding higher concentrations compared to maceration. The elevated levels of flavonoids and phenolic acids are consistent with prior studies reporting Karonda as a potent source of antioxidant compounds. These compounds are critical in neutralizing free radicals and reducing oxidative stress, which underpins their relevance in mitigating chronic diseases such as cardiovascular disorders, diabetes, and certain cancers.

The high antioxidant activity observed in the Soxhlet extract, reflected by a lower IC50 value in the DPPH assay, corroborates the strong correlation between phenolic content and radical scavenging capacity. Similar findings were reported by Sharma *et al*. (2021), who observed that the phenolic and flavonoid constituents of Karonda directly contribute to its superior antioxidant potential. These results suggest that Karonda extracts could be utilized as natural antioxidants in functional foods and nutraceutical formulations, offering an alternative to synthetic antioxidants, which may have associated toxicity concerns.

The antimicrobial evaluation indicates that Karonda extracts possess broad-spectrum activity against both bacterial and fungal pathogens. The Soxhlet extract displayed higher efficacy against *Escherichia coli*, *Staphylococcus aureus*, and *Candida albicans*, likely due to the higher concentration of bioactive alkaloids such as carissamine and carindine. Alkaloids are known to interfere with microbial cell walls, inhibit enzyme activity, and disrupt microbial DNA replication. Previous studies have similarly documented the antimicrobial potential of Karonda fruit and leaf extracts, underscoring its applicability in natural food preservatives, pharmaceutical formulations, and as a complementary approach to conventional antimicrobial therapy.

The comparative efficiency of the Soxhlet method in yielding higher concentrations of phytochemicals aligns with the established understanding that continuous solvent extraction allows better penetration of plant matrices and improved solubilization of bioactive compounds. This suggests that for industrial or pharmacological applications requiring high bioactive content, Soxhlet extraction may be more appropriate than simple maceration.

Furthermore, the combination of antioxidant and antimicrobial activities positions Karonda as a multifunctional candidate for functional foods, dietary supplements, and topical applications. The high flavonoid and phenolic content could contribute not only to oxidative stress management but also to anti-inflammatory responses, supporting the broader therapeutic potential of Karonda. In line with these findings, functional food products incorporating Karonda, such as jams, preserves, and fortified beverages, could leverage its bioactive properties for enhanced health benefits.

The study’s findings also emphasize the need for further investigation into the synergistic interactions of these phytochemicals. While the current analysis quantifies individual compounds, the holistic impact of the combined bioactive constituents may have enhanced efficacy in antioxidant, antimicrobial, and anti-inflammatory activities. Such synergistic effects could be explored using advanced metabolomics approaches and *in vivo* studies to validate the therapeutic potential of Karonda.

**Conclusion**

This study demonstrates that Karonda (*Carissa carandas*) is a rich source of bioactive compounds, including flavonoids, phenolic acids, alkaloids, saponins, and tannins, which collectively contribute to its potent antioxidant and antimicrobial properties. The comparative analysis between maceration and Soxhlet extraction methods revealed that Soxhlet extraction consistently yields higher concentrations of these phytochemicals, thereby enhancing the biological efficacy of the extracts. The antioxidant activity, evidenced by lower IC50 values, and the broad-spectrum antimicrobial activity underscore Karonda's potential as a natural functional ingredient with applications in food preservation, nutraceutical formulations, and pharmaceutical products.

The study establishes the relevance of Karonda not only as a nutritionally valuable fruit but also as a promising candidate for industrial and therapeutic use, owing to its rich phytochemical profile and bioactivity. These findings pave the way for further investigations into its synergistic effects, bioavailability, and clinical relevance, as well as the development of standardized extraction and formulation techniques to maximize its functional benefits. Additionally, integrating Karonda into functional foods, dietary supplements, and natural preservatives could provide sustainable solutions for both health promotion and agricultural development, particularly in regions where the fruit is widely cultivated.

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