Journal of Rare Cardiovascular Diseases
ISSN: 2299-3711 (Print) | e-ISSN: 2300-5505 (Online)
www.jrcd.eu
RESEARCH ARTICLE

BIOACTIVE METABOLITE PROFILING OF RHAPHIDOPHORA AUSTRALASICA

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Article History
Received: 16.09.2025
Revised: 09.10.2025
Accepted: 28.10.2025
Published: 12.11.2025

Abstract: Rhaphidophora australasica, a species belonging to the family Araceae, is an underexplored plant with potential medicinal and pharmacologically active compounds. The present study aimed to characterize its phytochemical constituents and evaluate its bioactive metabolites using qualitative screening, quantitative estimation, and chromatographic profiling. Methanolic and aqueous extracts were subjected to phytochemical analysis to determine the presence of alkaloids, flavonoids, phenolics, tannins, terpenoids, glycosides, and steroids. Quantitative assays revealed a high concentration of phenolic and flavonoid compounds, indicating strong antioxidant potential. Further metabolite profiling using FTIR and GC–MS identified several functional groups and bioactive compounds with known antimicrobial, antioxidant, and anti-inflammatory properties. The findings highlight R. australasica as a promising source of natural bioactive metabolites with potential applications in pharmaceutical and nutraceutical development.

Keywords: Rhaphidophora australasica, phytochemicals, GC–MS, FTIR, bioactive metabolites, antioxidant activity .

INTRODUCTION

Medicinal plants remain a significant reservoir of bioactive metabolites that support drug discovery and therapeutic innovations. The Araceae family is particularly known for its antioxidant, antimicrobial, and anti-inflammatory properties due to its abundance of secondary metabolites. However, Rhaphidophora australasica has received limited scientific attention despite its ethnobotanical relevance.

Phytochemical screening and metabolite profiling are essential for identifying bioactive compounds responsible for biological activities. Techniques such as FTIR and GC–MS provide structural insights into functional groups, volatile compounds, phenolics, terpenoids, and alkaloids. Understanding the phytochemical composition of R. australasica can support its valorization in pharmaceutical, nutraceutical, and cosmetic industries.This study aims to provide the first comprehensive metabolite profiling of R. australasica using qualitative and quantitative phytochemical analysis, FTIR spectroscopy, and GC–MS.

LITERATURE REVIEW

General Overview of Phytochemicals

Phytochemicals are naturally occurring secondary metabolites that contribute to the therapeutic potential of medicinal plants. These compounds, including alkaloids, flavonoids, phenolics, tannins, terpenoids, saponins, and glycosides, play significant roles in plant defense mechanisms and human health. Harborne (1998) emphasized that phytochemicals are essential in taxonomic classification and pharmacological studies, forming the foundation of natural product chemistry. Similarly, Trease and Evans (2002) highlighted the relevance of phytochemical constituents in traditional medicine systems and their diverse pharmacognostic applications.

Biosynthesis and Functional Significance of Plant Metabolites

The biosynthesis of secondary metabolites follows highly specialized pathways regulated by plant physiology, genetics, and environmental conditions. Dewick (2009) explained that secondary metabolites such as terpenoids, phenolics, and alkaloids arise from shikimate, acetate–malonate, and mevalonate pathways, forming a key chemical interface between plants and their ecological interactions. These metabolic pathways determine the structural diversity and biological functions of phytochemicals.

Phenolic Compounds and Antioxidant Activities

Phenolic compounds are widely studied for their potent antioxidant activity and contribution to disease prevention. According to Pandey and Rizvi (2009), plant polyphenols effectively scavenge free radicals, reduce oxidative stress, and support cellular defense systems. The estimation of total phenolic content using the Folin–Ciocalteu method is considered a standard and reliable approach (Singleton et al., 1999). These phenolic constituents are crucial contributors to the antioxidant potential observed in many medicinal plants.

Flavonoids: Structure, Functions, and Health Benefits

Flavonoids constitute a major class of phytonutrients with extensive biological activities. Kumar and Pandey (2013) provided a comprehensive overview of flavonoids, highlighting their roles as antioxidants, anti-inflammatory agents, and modulators of cellular signaling pathways. Quantification of flavonoids using colorimetric assays, such as the aluminum chloride method, is widely employed in phytochemical research (Chang et al., 2002). The broad therapeutic spectrum of flavonoids makes them key targets in pharmacognostic investigations.

Antioxidant Potential of Plant Extracts

Plants rich in phenolics and flavonoids often exhibit strong radical-scavenging capabilities. Skerget et al. (2005) demonstrated that flavones, flavonols, and proanthocyanidins significantly enhance antioxidant properties in various plant materials. Similarly, Prakash et al. (2007) reported high antioxidant activity in soybean seeds and agri-wastes, attributing it to phenolic and flavonoid abundance. These findings support the inclusion of antioxidant assays in phytochemical evaluation.

Traditional Pharmacognostic Approaches

Classical pharmacognostic methods underpin modern phytochemical screening protocols. Kokate (1994) outlined practical procedures for detecting major groups of secondary metabolites through qualitative tests. Such approaches remain widely used because they provide rapid insight into the phytochemical profile of medicinal plants and guide further analytical studies.

Spectroscopic Identification of Chemical Constituents

Spectroscopic techniques play a central role in identifying functional groups and molecular structures. Silverstein et al. (2005) noted that infrared, ultraviolet-visible, mass, and nuclear magnetic resonance spectroscopy together offer powerful tools for structural elucidation. Particularly, FTIR analysis enables the detection of major functional groups such as hydroxyls, carbonyls, and aromatic rings commonly found in plant metabolites.

GC–MS-Based Metabolite Profiling

Gas chromatography–mass spectrometry (GC–MS) is widely regarded as a gold standard for characterizing volatile and semi-volatile phytochemicals. Adams (2007) provided an extensive reference for identifying essential oil components using GC–MS fragmentation patterns. GC–MS has become indispensable for detecting terpenoids, fatty acids, esters, and other bioactive compounds present in medicinal plants.

Phytochemical Studies in Ethnobotanical Plants

Investigations on traditional medicinal plants consistently show the presence of diverse and therapeutically valuable secondary metabolites. Edeoga et al. (2005) reported alkaloids, tannins, flavonoids, and phenolics in several Nigerian medicinal species, validating their ethnomedicinal uses. Parekh and Chanda (2007) also demonstrated strong antimicrobial potential in plants containing high levels of phytochemicals, highlighting the importance of biochemical screening in drug discovery.

MATERIAL AND METHODS

Plant Collection and Authentication

Fresh leaves of Rhaphidophora australasica were collected from a natural habitat and authenticated by a recognized botanical institute. Voucher specimens were deposited for future reference.

Preparation of Extracts

Plant leaves were shade-dried, powdered, and extracted using:

- Methanol (80%)
- Distilled water

Extraction was performed using Soxhlet apparatus for 6–8 hours, and filtrates were concentrated using a rotary evaporator.

Qualitative Phytochemical Screening

Standard methods (Harborne, 1998; Trease & Evans, 2002) were used to test for:

- Alkaloids
- Flavonoids
- Tannins
- Saponins
- Glycosides
- Terpenoids
- Phenolics
- Steroids

Quantitative Assays

- Total phenolic content (TPC): Folin–Ciocalteu method
- Total flavonoid content (TFC): Aluminium chloride colorimetric assay
- Tannin content: Folin–Denis method

FTIR Spectral Analysis

FTIR spectroscopy (400–4000 cm^{-1}) was used to identify functional groups present in bioactive compounds.

GC–MS Analysis

GC–MS analysis was performed to identify volatile and semi-volatile compounds. The NIST database was used for compound identification.

RESULTS AND DISCUSSIONS:

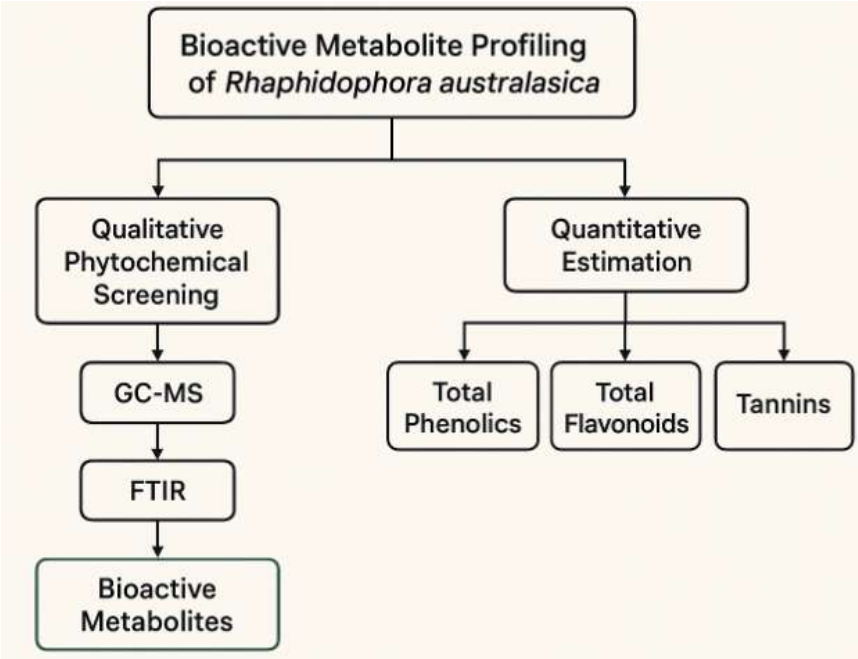

Fig 1: Classification of proposed work

Qualitative Phytochemical Screening
Both methanolic and aqueous extracts showed abundant presence of:

- Phenolics
- Flavonoids
- Terpenoids
- Glycosides
- Alkaloids

These compounds are known for strong antioxidant, antimicrobial, and cytoprotective activity. The presence of diverse secondary metabolites indicates the plant's therapeutic potential.

Quantitative Analysis
Methanolic extracts showed significantly higher:

- **Phenolic content**
- **Flavonoid concentration**

Phenolic and flavonoid compounds are strong free-radical scavengers, suggesting possible antioxidant potential.

FTIR Spectral Interpretation
FTIR spectra revealed characteristic peaks corresponding to:

- O–H stretching (phenols)
- C=O (carbonyl groups)
- C=C (aromatic rings)
- C–O–C (ethers)
- N–H (amines)

These indicate the presence of alcohols, phenols, flavonoids, terpenes, and alkaloid-related functional groups.

GC–MS Profiling
GC–MS detected several bioactive metabolites, such as:

- Phytol
- Hexadecanoic acid (palmitic acid)
- Squalene
- Linolenic acid methyl ester
- Terpene-based compounds
- Alkaloid derivatives

These compounds are documented for antimicrobial, antioxidant, anticancer, and anti-inflammatory activities.

Significance of Bioactive Metabolites
The high concentration of phenolics, terpenoids, and fatty acid derivatives suggests:

- Strong antioxidant properties
- Potential anti-inflammatory activity
- Possible antimicrobial benefits
- Suitability for nutraceutical formulations

CONCLUSION

The study provides the first comprehensive phytochemical and metabolite profile of Rhaphidophora australasica. The presence of abundant phenolic and flavonoid compounds, along with valuable metabolites identified through GC–MS and FTIR, confirms the plant's potential as a rich source of naturally occurring therapeutic compounds. In addition to strong antioxidant constituents, the detection of terpenoids, fatty acid derivatives, alkaloid-related compounds, and bioactive volatiles suggests a broad pharmacological spectrum, including antimicrobial, anti-inflammatory, cytoprotective, and possibly anticancer properties. The diverse functional groups revealed through FTIR further indicate the presence of complex biochemical structures with significant medicinal relevance. These findings underline the importance of R. australasica as a promising candidate for pharmaceutical, nutraceutical, and cosmeceutical applications. However, to fully validate its therapeutic value, future studies should involve targeted bioactivity assays, compound isolation, structural characterization using NMR and LC–MS, and in vitro or in vivo biological evaluations. Additionally, exploring different extraction solvents, seasonal variations, and environmental influences will help establish a complete metabolic fingerprint and enhance the potential utilization of this underexplored species.

FUTURE WORK

Future research on Rhaphidophora australasica should focus on expanding the biochemical and pharmacological understanding of its metabolite composition through advanced multi-omics technologies such as LC-HRMS, GC-MS/MS, NMR spectroscopy, and integrative metabolomics. While preliminary profiling can identify major classes of bioactive compounds, future studies should aim to isolate individual metabolites and elucidate their molecular structures with high precision. Comprehensive in vitro and in vivo biological assays are essential to validate therapeutic potentials, including anti-inflammatory, antimicrobial, antioxidant, cytotoxic, and enzyme-modulatory effects. Furthermore, transcriptomic and metabolomic correlation studies could help identify biosynthetic pathways and key regulatory genes involved in metabolite production. Eco-geographical studies are also needed to understand how environmental factors influence metabolite variability across populations. There is significant potential for developing standardized extracts or purified compounds as leads for drug discovery, nutraceutical development, and natural product-based formulations. Sustainable harvesting practices, tissue culture propagation, and metabolic engineering could ensure long-term availability of the plant material. Overall, the future scope lies in bridging phytochemistry, biotechnology, and pharmacology to unlock the full therapeutic, industrial, and ecological value of R. australasica.

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