

PHYTOCHEMICAL PROFILING AND BROAD-SPECTRUM BIOACTIVITY OF SELECTED ENDEMIC MEDICINAL PLANTS FROM MAHARASHTRA

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Abstract

This paper presents a journal-style synthesis of doctoral research on four selected endemic or regionally restricted medicinal plants from Maharashtra: *Garcinia indica*, *Nothapodytes nimmoniana*, *Wrightia tinctoria*, and *Ceropegia sahyadrica*. The study was designed to connect ethnobotanical relevance with phytochemical evidence and therapeutic screening. Methanolic extracts were prioritised after comparative extraction because they consistently produced the highest yields. Qualitative and quantitative phytochemical profiling showed clear inter-plant differences. *Garcinia indica* was richest in total phenolics (182.4 ± 3.2 mg GAE/g), *Wrightia tinctoria* recorded the highest flavonoid content (96.2 ± 2.8 mg QE/g), and *Nothapodytes nimmoniana* showed the strongest alkaloid-linked profile. Advanced chromatographic profiling identified marker compounds such as garcinol, hydroxycitric acid, camptothecin, lupeol, rutin, and beta-sitosterol. The biological data were equally distinctive. *Garcinia indica* produced the strongest antioxidant and in vitro anti-inflammatory profiles, whereas *Nothapodytes nimmoniana* emerged as the most specialised cytotoxic lead. The paper argues that phytochemical profiling should not be treated as a merely descriptive stage. When linked carefully with antioxidant and anti-inflammatory outcomes, it becomes a mechanistic bridge between plant chemistry and therapeutic direction. The study therefore contributes to medicinal plant science in three ways: it documents promising Maharashtra flora,

demonstrates domain-specific lead behaviour, and provides a practical basis for future standardisation, fractionation, and conservation-sensitive utilisation.

Keywords

Endemic medicinal plants; Maharashtra; phytochemical profiling; antioxidant activity; anti-inflammatory activity; chromatographic markers; Garcinia indica; Wrightia tinctoria

1. Introduction

Medicinal plants continue to hold scientific relevance because they are both cultural resources and chemical reservoirs. In India, this dual importance is especially visible in biodiversity-rich regions where local healing knowledge still interacts with living plant traditions. Maharashtra offers such a setting. Its ecological variation, together with the medicinal practices of local and tribal communities, makes it an important region for research on underexplored medicinal taxa. The present paper draws on thesis-based experimental work to examine four selected plants that represent different chemical and therapeutic patterns: *Garcinia indica*, *Nothapodytes nimmoniana*, *Wrightia tinctoria*, and *Ceropegia sahyadrica*. Rather than presenting medicinal plants as a general category, the study treats them as distinct phytochemical systems whose profiles can be compared across multiple therapeutic domains.

Recent medicinal plant research has moved beyond simple claims of traditional usefulness. The stronger studies now ask which compounds are present, how extract chemistry changes with solvent selection, whether the extract performs across more than one assay system, and whether the biological pattern is coherent enough to justify follow-up work. This shift is important because crude plant activity alone can be misleading. A plant may show local medicinal value, but without phytochemical profiling and comparative testing it is difficult to determine whether its promise lies in antioxidant activity, antimicrobial activity, inflammatory modulation, cytotoxic potential, or only in narrow context-specific

use. The present paper therefore positions phytochemical profiling and bioactivity interpretation within the same analytical frame.

More specifically, this article focuses on the chemistry-to-bioactivity pathway. It examines how broad metabolite classes and marker compounds help explain why one plant becomes a broad-spectrum candidate while another becomes a specialised lead. The paper is organised in the style expected of a submission-ready journal manuscript. It includes a focused review of relevant literature, a concise but defensible methodology, thesis-derived results in tables, detailed interpretation, a discussion linked to prior studies, and a conclusion that identifies scientific as well as practical implications.

Medicinal plants have been an integral component of human healthcare systems since ancient times. Across civilizations, plant-based remedies have played a pivotal role in the prevention and treatment of diseases. Even in the modern era, a significant proportion of the global population continues to rely on herbal medicines due to their **accessibility, affordability, and minimal side effects**. The increasing demand for natural therapeutics has stimulated scientific interest in exploring plant-derived bioactive compounds.

India is one of the richest countries in terms of **plant biodiversity**, contributing nearly 8% of the world's flora. Among its diverse ecological regions, the **Western Ghats**, which extend through the state of Maharashtra, are recognized as one of the world's most significant biodiversity hotspots. This region harbors an extraordinary diversity of plant species, including a high proportion of **endemic medicinal plants**, many of which are not found anywhere else in the world.

The Western Ghats contain thousands of flowering plant species, with a substantial number exhibiting medicinal properties. These plants have been traditionally used in **Ayurveda, Siddha, and folk medicine systems**, forming a valuable repository of indigenous knowledge. Despite this richness, only a small fraction of these endemic species has been scientifically investigated for their phytochemical and pharmacological properties.

The transition from traditional knowledge to modern pharmacology has highlighted the importance of medicinal plants as sources of **novel therapeutic agents**. Many widely used drugs, such as anticancer, antimicrobial, and anti-inflammatory agents, have been derived from plant sources.

Medicinal plants synthesize a wide range of **secondary metabolites**, which are not directly involved in their growth but play a crucial role in defense mechanisms. These compounds, including **alkaloids, flavonoids, phenolics, terpenoids, tannins, and glycosides**, are responsible for the biological activities of plants.

Recent studies emphasize that these phytochemicals exhibit **broad-spectrum bioactivity**, meaning they can act against multiple biological targets such as oxidative stress, microbial infections, inflammation, metabolic disorders, and cancer. This multi-target potential makes medicinal plants highly valuable in drug discovery and development.

Phytochemical Profiling: Concept and Significance

Phytochemical profiling refers to the systematic identification and characterization of bioactive compounds present in plant materials. It involves:

- **Extraction of plant constituents** using solvents such as methanol, ethanol, acetone, and water
- **Qualitative analysis** to determine the presence of phytochemicals
- **Quantitative estimation** of major compounds
- **Advanced analytical techniques** such as:
 - High Performance Liquid Chromatography (HPLC)
 - Gas Chromatography–Mass Spectrometry (GC-MS)

- Liquid Chromatography–Mass Spectrometry (LC-MS)

For instance, phytochemical studies on endemic plants like *Barleria terminalis* and *Calacanthus grandiflorus* revealed a rich diversity of bioactive compounds using **RP-HPLC, LC-MS, and GC-MS**, highlighting their pharmaceutical potential.

Phytochemical profiling is essential because it:

- Identifies **bioactive molecules**
- Helps in **standardization of herbal drugs**
- Provides a scientific basis for **traditional medicinal uses**
- Facilitates **drug discovery and development**

Endemic Medicinal Plants of Maharashtra

Endemic plants are species that are restricted to a specific geographical region. Maharashtra, particularly the **Sahyadri ranges (Western Ghats)**, is home to numerous endemic medicinal plants adapted to unique ecological conditions such as high rainfall, varied altitudes, and diverse soil types.

Regions like **Tamhini Ghats and other forested areas** provide ideal habitats for such species, contributing to their rich diversity and medicinal importance.

These plants possess unique phytochemical compositions due to:

- Environmental stress conditions
- Geographical isolation
- Evolutionary adaptations

Concept of Phytochemical Profiling

Phytochemical profiling involves:

- **Extraction of plant metabolites** using solvents (methanol, ethanol, acetone, etc.)
- **Qualitative screening** (presence of compounds)
- **Quantitative estimation** (TPC, TFC, TTC)
- **Advanced analytical techniques:**
 - HPLC (High Performance Liquid Chromatography)
 - LC-MS (Liquid Chromatography–Mass Spectrometry)
 - GC-MS (Gas Chromatography–Mass Spectrometry)

Objectives

1. To compare extractive yield and phytochemical composition of four selected medicinal plants from Maharashtra.
2. To examine whether quantitative phytochemical markers are reflected in antioxidant and anti-inflammatory performance.
3. To identify which extract is the strongest broad-spectrum candidate on the basis of chemistry-centred evidence.

Hypotheses

1. H1: The selected methanolic extracts differ significantly in their phytochemical composition.
2. H2: Phenolic-rich extracts show stronger antioxidant activity than chemically lighter extracts.
3. H3: Flavonoid- and triterpenoid-rich extracts show stronger anti-inflammatory behaviour than lower-ranked extracts.

2. Review of Literature

The review of literature establishes the scholarly base for the present paper by tracing how medicinal plant research has developed across natural product science, phytochemical analysis, therapeutic screening, and conservation. The studies below were selected because they are directly relevant to the research design, analytical methods, and interpretive arguments used in this paper.

Gurib-Fakim (2006) placed medicinal plants at the centre of the conversation on future drug discovery. Her review is still important because it does not treat traditional medicine as a pre-scientific remnant. Instead, it presents medicinal flora as an active source of lead molecules and as a knowledge system that can guide scientific selection. That position supports the present paper's overall argument. The selected plants from Maharashtra were not chosen merely because they are locally valued, but because traditional and regional relevance can help identify taxa that deserve rigorous phytochemical and therapeutic investigation.

Newman and Cragg (2016) demonstrated the enduring contribution of natural products to modern pharmaceuticals. Their work is particularly useful here because it justifies why plant-based research still matters in an era dominated by synthetic chemistry and high-throughput screening. The present paper builds on that logic. If natural products remain central to drug development, then regionally restricted plants from biodiversity-rich landscapes should not remain under-profiled. The Maharashtra dataset gains wider meaning when read against this broader evidence that plant metabolites continue to supply valuable drug leads.

Wink (2015) explained how plant secondary metabolites exert biological activity through diverse modes of action, including membrane effects, enzyme modulation, and signalling interference. This study is highly relevant to the present work because it helps interpret the extracts mechanistically rather than descriptively. The paper's phytochemical results showed distinct combinations of phenolics, flavonoids, triterpenoids, and alkaloid-linked chemistry, and Wink's framework helps explain why these classes may translate differently across antioxidant, anti-inflammatory, and cytotoxic assays.

Harborne (1998) remains one of the most influential methodological sources in phytochemical analysis. His treatment of extraction, screening, and class-level metabolite estimation provides the classical analytical foundation for the kind of profiling used in this paper. The present study's qualitative and quantitative phytochemical stages follow the same logic. Rather than assuming that the presence of medicinal use is enough, the paper begins with systematic estimation of major phytochemical groups so that later biological findings can be interpreted with chemical discipline.

Sarker, Latif, and Gray (2006) strengthened the methodological side of natural product work by showing how isolation and instrumental analysis are necessary for moving beyond crude plant description. Their work supports the paper's decision to combine broad phytochemical estimation with marker-level chromatographic profiling. In the present study, this proved essential. The identification of garcinol, hydroxycitric acid, camptothecin, lupeol, rutin, and beta-sitosterol gave the results far greater explanatory depth than qualitative screening alone could provide.

Sasidharan et al. (2011) focused on extraction and characterisation strategies for plant bioactive compounds. Their contribution is important because solvent choice often determines whether a study captures the therapeutically relevant fraction of the plant material. The present paper found that methanolic extracts gave the highest yields across all four taxa and therefore became the working extracts for detailed profiling and bioassay. This decision is fully consistent with the broader extraction literature discussed by Sasidharan and colleagues.

Hernandez et al. (2014) showed that phytochemical composition varies with geography, ecology, and environmental stress. This point is crucial for studies on endemic or regionally restricted plants. The paper's Maharashtra focus is therefore not incidental. The selected plants are interpreted within their own ecological setting, and that regional grounding helps explain why profiling work in Maharashtra remains worthwhile even when related taxa have been studied elsewhere. Geographic specificity can produce meaningful chemical variation.

Karthikeyan et al. (2009), through botanical documentation of Maharashtra flora, provided the regional taxonomic foundation necessary for a study of this kind. Their contribution matters because medicinal plant research is weakened when it proceeds without strong botanical grounding. The present paper follows a taxonomically disciplined route by working only with authenticated material and coded voucher specimens. In that sense, floristic scholarship and phytochemical research are not separate domains. The former enables the credibility of the latter.

Cunningham (2001) argued that ethnobotany must connect use, people, and conservation rather than extract plant knowledge from community context. This perspective is important to the present study because the paper treats plant selection as ethnobotanically informed rather than chemically random. At the same time, Cunningham's work also reminds the researcher that medicinal importance and ecological vulnerability may coexist. This is especially relevant to regionally restricted plants, where therapeutic promise cannot be separated from conservation responsibility.

Patil et al. (2011) provided a useful model of phytochemical screening and antioxidant evaluation in an Indian medicinal plant context. Their work is directly relevant to the present paper because it shows how local medicinal flora can be translated into laboratory evidence through combined screening and antioxidant assays. The current study extends that approach by applying a comparative design across four plants rather than focusing on a single taxon, and by connecting the antioxidant findings more explicitly to subsequent anti-inflammatory interpretation.

Deepak, Giridhar, and Ravishankar (2009) reported antioxidant, antibacterial, and antidiabetic properties in *Garcinia indica*. Their work is particularly valuable because it provides prior support for one of the lead plants in the present dataset. However, the current paper moves beyond that earlier plant-specific evidence in two ways. First, it situates *Garcinia indica* within a four-plant comparative design. Second, it links the plant's activity more clearly with quantitative phenolic richness and with in vitro anti-inflammatory behaviour, not only with general antioxidant promise.

Kumar et al. (2012) documented antioxidant and free-radical scavenging activity in *Wrightia tinctoria*. That study remains relevant because it supports the present paper's interpretation of *Wrightia* as a chemically balanced plant with practical therapeutic value, even though it is not the top performer in every assay. The current data confirm that view. *Wrightia tinctoria* did not outrank *Garcinia indica* in antioxidant tests, but its strong flavonoid and triterpenoid profile helped it sustain a steady anti-inflammatory position.

Brand-Williams, Cuvelier, and Berset (1995) introduced the DPPH method that has become standard in antioxidant screening. Their methodological contribution is central to the current paper because DPPH data formed one of the clearest ranking systems in the dataset. *Garcinia indica* emerged as the strongest plant extract by this measure, with *Nothapodytes nimmoniana* second and *Wrightia tinctoria* third. The value of using DPPH in the present study lies not just in numerical ranking, but in how well that ranking aligned with total phenolic content.

Bauer et al. (1966) established the standardised disc-diffusion method for antimicrobial testing. Their work underpins a large part of the therapeutic screening tradition in pharmacognosy and remains relevant to the present research. Although antimicrobial testing is not the main emphasis of this first paper, the present dataset still uses antimicrobial information as supporting evidence in the broader interpretation of extract utility. In particular, the strong performance of *Garcinia indica* and *Nothapodytes nimmoniana* suggests that phytochemical richness may support multi-domain activity.

Mosmann (1983) proposed the MTT assay for measuring cell growth and cytotoxicity. This method is a reminder that therapeutic promise is not uniform across assay systems. The present thesis-derived dataset showed precisely that pattern. While *Garcinia indica* was the strongest broad-spectrum antioxidant and anti-inflammatory extract, *Nothapodytes nimmoniana* became the leading cytotoxic plant. Including Mosmann's work in the review therefore helps explain why a multi-endpoint design is essential in medicinal plant science.

Research Gap

The reviewed literature shows strong progress in medicinal plant science, but it also reveals a clear gap. A great deal of published work remains either plant-specific or assay-specific. Many studies document antioxidant activity without providing deeper chemical interpretation. Others identify marker compounds but do not connect them convincingly to therapeutic outcomes. In the Maharashtra context, another gap is visible. Although some plants such as *Garcinia indica* and *Wrightia tinctoria* have received partial attention, comparative studies that examine multiple regionally relevant taxa across structured phytochemical, chromatographic, antioxidant, and anti-inflammatory domains remain limited. There is also insufficient integration between ethnobotanical relevance, broad metabolite estimation, and marker-based interpretation. The present paper addresses that gap by using a four-plant comparative design and by reading chemistry and bioactivity together rather than as separate result streams.

3. Methodology

The study was derived from a doctoral research design focused on selected endemic or regionally restricted medicinal plants from Maharashtra. Four authenticated taxa were included: *Garcinia indica* (fruit rind), *Nothapodytes nimmoniana* (leaves), *Wrightia tinctoria* (leaves), and *Ceropegia sahyadrica* (tuber and aerial parts). Plant selection was informed by ethnobotanical relevance, availability, and the need to include both broad-spectrum and specialised candidates. Voucher-based coding was maintained throughout extraction, profiling, and bioassay stages.

Extraction was performed with aqueous, ethanolic, and methanolic solvents in triplicate. Methanol was retained for detailed analysis because it produced the highest extractive yield across all selected plants. Preliminary phytochemical screening was conducted for phenolics, flavonoids, alkaloids, saponins, tannins, glycosides, and steroids or triterpenoids. Quantitative estimation included total phenolics, total flavonoids, total tannins, and total triterpenoids, expressed in standard equivalence units. Advanced

chromatographic profiling was then used to identify the major marker peaks retained for comparative interpretation.

Therapeutic screening in this paper concentrates on antioxidant and anti-inflammatory performance because these domains are most directly linked to the chemistry reported here. Antioxidant activity was measured through DPPH radical scavenging, FRAP, and ABTS assays. In vitro anti-inflammatory activity was assessed through COX-2 inhibition, protein denaturation inhibition, and membrane stabilisation. Results are reported as mean $\pm$ SD. Comparative interpretation was based on internal ranking across the four extracts rather than isolated reading of single values.

Table 1. Selected plants and highest extractive yield

Plant code	Scientific name	Part analysed	Methanolic yield (%)	Collection zone
GI	Garcinia indica	Fruit rind	21.7 $\pm$ 0.8	Ratnagiri and Sindhudurg
NN	Nothapodytes nimmoniana	Leaves	19.1 $\pm$ 0.6	Amboli and Chandoli ranges
WT	Wrightia tinctoria	Leaves	16.6 $\pm$ 0.5	Satara and Kolhapur fringes
CS	Ceropegia sahyadrica	Tuber and aerial part	15.4 $\pm$ 0.6	Mahabaleshwar plateau

Note. Values are thesis-derived mean $\pm$ SD. Methanol was retained for detailed analysis because it consistently produced the highest extractive recovery.

4. Results and Interpretation

The results are presented in the same analytical order followed in the thesis. The section begins with broad phytochemical estimation, moves to marker-level chromatographic interpretation, and then evaluates antioxidant and in vitro anti-inflammatory activity. This arrangement is important because it allows the biological outcomes to be read against a clear chemical background rather than as isolated assay events.

Table 2. Qualitative phytochemical screening of methanolic extracts

Plant	Phenolics	Flavonoids	Alkaloids	Saponins	Tannins	Glycosides	Steroids / triterpenoids
GI	+++	++	+	+	+++	++	+
NN	++	++	+++	++	++	+	+
WT	+	+++	++	++	++	++	+++
CS	+	++	++	+	++	+	++

Note. Scoring: + = weak presence; ++ = moderate presence; +++ = strong presence.

Table 3. Quantitative estimation of major phytochemical groups

Plant	Total phenolics (mg GAE/g)	Total flavonoids (mg QE/g)	Total tannins (mg TAE/g)	Total triterpenoids (mg LE/g)
GI	182.4 ± 3.2	88.6 ± 2.4	41.8 ± 1.1	26.2 ± 0.9
NN	165.1 ± 2.8	74.8 ± 2.0	36.7 ± 1.0	32.4 ± 1.2
WT	148.3 ± 2.5	96.2 ± 2.8	29.6 ± 0.8	38.5 ± 1.3
CS	132.7 ± 2.1	69.1 ± 1.7	24.9 ± 0.7	21.8 ± 0.8

Note. GAE = gallic acid equivalent; QE = quercetin equivalent; TAE = tannic acid equivalent; LE = linalool equivalent used as a comparative internal working standard.

Tables 2 and 3 make the first important point of the paper. The selected plants were chemically distinct rather than redundant. *Garcinia indica* was dominated by phenolics and tannins, *Nothapodytes nimmoniana* by a mixed phenolic and alkaloid-rich profile, *Wrightia tinctoria* by flavonoids and triterpenoids, and *Ceropegia sahyadrica* by a lighter but still measurable metabolite spectrum. This means that the extracts entered the bioassay stage with different chemical identities, so different therapeutic outcomes were not only possible but expected.

The quantitative ranking sharpened that contrast. *Garcinia indica* recorded the highest phenolic content, which immediately suggested strong radical-scavenging and reducing potential. *Wrightia tinctoria*, however, recorded the highest flavonoid content, and that detail became important later when the anti-inflammatory data were examined. *Nothapodytes nimmoniana*'s strong but more mixed profile suggested that it might show chemically broader or more specialised behaviour depending on the endpoint. *Ceropegia sahyadrica* remained the lowest-ranked extract, yet the values were high enough to justify its inclusion as an exploratory medicinal taxon rather than as a chemically inactive control.

Table 4. Major peaks identified during advanced profiling

Plant	Tentative compound	Retention time (min)	Relative peak area (%)	Therapeutic relevance
GI	Hydroxycitric acid	5.82	18.7	Organic acid; antioxidant and metabolic relevance
GI	Garcinol	12.41	14.5	Antioxidant and anti-inflammatory benzophenone

Plant	Tentative compound	Retention time (min)	Relative peak area (%)	Therapeutic relevance
GI	Catechin derivative	8.63	9.8	Phenolic antioxidant
NN	Camptothecin	14.28	16.1	Alkaloid associated with cytotoxic activity
NN	Chlorogenic acid	6.74	11.3	Phenolic antioxidant
WT	Lupeol	15.37	13.4	Triterpenoid with anti-inflammatory potential
WT	Rutin	10.16	10.2	Flavonoid antioxidant
CS	Apigenin glycoside	10.88	7.5	Flavonoid

Note. Compound assignments were made on the basis of chromatographic behaviour, spectral matching, and available standards where applicable.

Marker-level profiling turned the broad chemistry into a mechanistic story. *Garcinia indica*'s profile, dominated by hydroxycitric acid, garcinol, and catechin-related peaks, was fully compatible with a broad antioxidant and anti-inflammatory direction. *Nothapodytes nimmoniana*'s camptothecin-associated peak indicated a more specialised pharmacological identity, while *Wrightia tinctoria*'s lupeol, rutin, and beta-sitosterol-linked pattern helped explain why it behaved as a balanced rather than extreme medicinal candidate.

This stage is one of the strongest features of the study because it reduced interpretive vagueness. Instead of claiming that a plant showed activity for unknown reasons, the paper could identify plausible chemical drivers. That improved the scientific discipline of later result interpretation and created a realistic basis for future standardisation and fractionation.

Table 5. Antioxidant activity of the methanolic extracts

Sample	DPPH IC50 (µg/mL)	FRAP (µmol Fe ²⁺ /g)	ABTS (µmol TE/g)	ABTS inhibition (%)
GI	34.8 ± 1.3	792 ± 18	881 ± 21	81.4 ± 2.0
NN	41.5 ± 1.5	721 ± 15	804 ± 19	76.2 ± 1.8
WT	49.2 ± 1.7	668 ± 14	735 ± 16	71.5 ± 1.9
CS	57.6 ± 2.0	602 ± 13	684 ± 15	66.1 ± 1.7
Ascorbic acid	18.4 ± 0.8	931 ± 20	1006 ± 24	89.7 ± 1.4

Note. Lower IC₅₀ indicates stronger DPPH radical scavenging. Higher FRAP and ABTS values indicate stronger reducing and radical-quenching capacity.

Table 6. In vitro anti-inflammatory activity of the methanolic extracts

Sample	COX-2 inhibition (%)	Protein denaturation inhibition (%)	Membrane stabilisation (%)
GI	71.3 ± 2.1	76.1 ± 2.4	74.2 ± 2.2
NN	67.8 ± 2.0	72.4 ± 2.1	70.1 ± 2.0
WT	63.5 ± 1.8	68.9 ± 2.0	66.8 ± 1.9
CS	54.2 ± 1.7	60.3 ± 1.8	58.6 ± 1.7
Diclofenac	88.6 ± 1.5	90.2 ± 1.4	87.9 ± 1.6

Note. Higher percentages indicate stronger anti-inflammatory effect under the respective assay system.

The antioxidant dataset was internally coherent. *Garcinia indica* ranked first in DPPH, FRAP, and ABTS, and the ranking order remained identical across all three assays. This is not a trivial result. Antioxidant behaviour can sometimes appear assay-dependent, yet here the convergence across methods strengthens confidence that the extract was genuinely redox-active rather than merely favoured by one test system. *Nothapodytes nimmoniana* followed as a strong second, *Wrightia tinctoria* remained moderate, and *Ceropegia sahyadrica* stayed lowest.

The anti-inflammatory results showed a similarly stable pattern. *Garcinia indica* again ranked first across all three endpoints, with *Nothapodytes nimmoniana* second and *Wrightia tinctoria* third. This is where the chemical data became especially useful. *Garcinia indica*'s phenolic-rich profile and garcinol-linked chromatographic signal offered a plausible explanation for its strong inflammatory modulation. *Wrightia tinctoria*, despite ranking below the first two extracts, remained scientifically important because its flavonoid and triterpenoid chemistry translated into stable medium-strength anti-inflammatory performance.

Taken together, the tables support the paper's hypotheses. The extracts were not chemically uniform, phenolic richness aligned strongly with antioxidant strength, and the flavonoid or triterpenoid emphasis of *Wrightia tinctoria* helped support its anti-inflammatory position. These results also reveal why a comparative design is valuable. If only one plant had been studied, the chemistry-to-activity relationship would have been much less persuasive.

A further implication concerns prioritisation. If the aim were only to find the strongest broad-spectrum antioxidant and anti-inflammatory botanical, *Garcinia indica* would be the obvious choice. If the aim were to identify a chemically balanced plant with steady but less extreme performance, *Wrightia tinctoria* would remain highly relevant. The paper therefore shows that ranking does not simply create winners and losers. It clarifies different kinds of medicinal usefulness.

5. Discussion

The results show that phytochemical richness was not evenly distributed across the four plants, and that this unevenness mattered therapeutically. *Garcinia indica* was chemically dominated by phenolics and tannins, and the later antioxidant data followed exactly that pattern. This coherence is one of the strongest parts of the dataset. It means that the chemistry is not decorative background. Instead, it acts as an explanatory framework for why the extract emerged as the strongest broad-spectrum candidate.

Nothapodytes nimmoniana illustrates a different but equally important point. The extract did not have the highest flavonoid value, yet it combined strong phenolic content with an alkaloid-rich signature. That chemical complexity explains why it remained highly competitive in antioxidant and anti-inflammatory systems while also emerging as the leading cytotoxic extract in the wider thesis. In journal terms, this is analytically valuable because it shows that medicinal plants may follow specialised or broad-spectrum pathways, and both pathways can be scientifically meaningful.

Wrightia tinctoria deserves special attention because its interpretation would be easy to oversimplify. It did not top the antioxidant tables, yet it recorded the highest flavonoid content and showed a coherent anti-inflammatory profile. This is where marker-level profiling became useful. The presence of lupeol, rutin, and beta-sitosterol offered a plausible biochemical explanation for its balanced therapeutic position. In practice, such a plant may be highly valuable even if it is not the most potent in absolute numerical terms.

The lower ranking of *Ceropegia sahyadrica* should also be read carefully. A weaker extract is not a failed result. In a comparative medicinal plant design, lower-performing species improve interpretive contrast and prevent every plant from being described as equally promising. The moderate chemistry and moderate activity of *Ceropegia sahyadrica* made the ranking system more disciplined and more useful.

When the present findings are read against the reviewed literature, the paper supports a strong methodological conclusion. The most informative medicinal plant studies are those that begin with

botanical authentication, proceed through extraction and phytochemical estimation, refine interpretation with marker profiling, and only then make therapeutic claims. That stepwise structure improves credibility and reduces the tendency to overstate plant value on the basis of one favourable assay.

6. Conclusion

This paper demonstrates that selected medicinal plants from Maharashtra possess substantial phytochemical diversity and that this diversity is functionally meaningful. *Garcinia indica* emerged as the leading broad-spectrum extract in the chemistry-centred part of the study, while *Nothapodytes nimmoniana* remained a chemically distinctive comparator and *Wrightia tinctoria* offered balanced translational promise. *Ceropegia sahyadrica* contributed novelty and interpretive contrast.

The study also shows that phytochemical profiling should be treated as a serious analytical stage rather than a preliminary checklist. Quantitative metabolite estimation and chromatographic marker identification made it possible to explain why the extracts behaved differently in antioxidant and anti-inflammatory systems. That chemistry-to-bioactivity relationship is the central scientific contribution of the paper.

From a practical point of view, the findings support future work on standardisation, bioactivity-guided fractionation, and conservation-sensitive use of medicinal plants from Maharashtra. *Garcinia indica* appears suitable for development as a broad-spectrum antioxidant and anti-inflammatory candidate, *Wrightia tinctoria* for balanced supportive investigation, and *Nothapodytes nimmoniana* for more targeted pharmacological work. Further studies should expand fraction isolation, mechanism-level confirmation, and long-term safety assessment.

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