Nusantara Scientific Medical Research Journal (NSMRJ)
Volume 03, No. 02, August 2025, Page 46-51
E-ISSN 2985 – 3508 (Online Media)
https://nusantarascientificjournal.com/index.php/nsmrj/index
https://doi.org/10.58549/nsmrj.v3i01.132

Isolation and Analytical Characterization of Flavonoids from Indonesian Medicinal Plants: A Comprehensive Literature Review

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Abstract

Indonesia is recognized as one of the world's megabiodiversity countries, possessing a vast range of medicinal plants that serve as rich sources of secondary metabolites, particularly flavonoids. These compounds are widely reported to exhibit significant pharmacological activities, including antioxidant, antidiabetic, and antibacterial effects, thereby encouraging continuous research on their isolation and identification. This study aims to systematically review the isolation and identification methods of flavonoid compounds derived from Indonesian medicinal plants, as well as to determine the most frequently reported flavonoid types and their pharmacological relevance. A literature review approach was applied by searching three scientific databases: Google Scholar, ScienceDirect, and ProQuest. Keywords used included "isolation and flavonoids" (Indonesian) and "isolation and flavonoid compounds" (English). Articles were selected based on inclusion criteria comprising publication period (2019–2024), journal accreditation, and full-text accessibility. From an initial pool of 13,400 records, only 10 articles met all eligibility criteria. The reviewed studies reported various isolation techniques, including maceration using ethanol or methanol, fractionation with ethyl acetate or water, and compound identification through Thin Layer Chromatography (TLC), UV–Vis spectrophotometry, and Nuclear Magnetic Resonance (NMR). The major flavonoids identified were quercetin, flavanone, and flavonol-3-O-galactose. Overall, Indonesian medicinal plants demonstrate strong potential as natural sources of flavonoids, with isolation and identification methods proving effective in detecting compounds with significant biological activity, particularly antioxidants.

Keywords: flavonoids; isolation; medicinal plants; Indonesia

Abstrak

Indonesia dikenal sebagai salah satu negara megabiodiversitas di dunia yang memiliki kekayaan tanaman obat yang sangat beragam dan berpotensi sebagai sumber metabolit sekunder, khususnya flavonoid. Senyawa ini dilaporkan memiliki aktivitas farmakologis yang penting, antara lain sebagai antioksidan, antidiabetik, dan antibakteri, sehingga penelitian mengenai isolasi dan identifikasinya terus berkembang. Penelitian ini bertujuan untuk menelaah secara sistematis metode isolasi dan identifikasi senyawa flavonoid yang berasal dari tanaman obat Indonesia, serta menentukan jenis flavonoid yang paling sering dilaporkan beserta relevansi farmakologinya. Pendekatan yang digunakan adalah studi tinjauan pustaka dengan penelusuran artikel melalui tiga basis data, yaitu Google Scholar, ScienceDirect, dan ProQuest. Kata kunci yang digunakan meliputi "isolation and flavonoids" dalam bahasa Indonesia dan "isolation and flavonoid compounds" dalam bahasa Inggris. Artikel dipilih berdasarkan kriteria inklusi yang mencakup periode publikasi (2019–2024), akreditasi jurnal, serta ketersediaan teks lengkap. Dari total 13.400 artikel yang teridentifikasi, hanya 10 artikel yang memenuhi seluruh kriteria. Hasil telaah menunjukkan bahwa teknik isolasi yang umum digunakan meliputi maserasi dengan etanol atau metanol, fraksinasi menggunakan etil asetat atau air, serta identifikasi senyawa melalui Kromatografi Lapis Tipis (KLT), spektrofotometri UV–Vis, dan Nuclear Magnetic Resonance (NMR). Flavonoid utama yang berhasil diidentifikasi adalah kuersetin, flavanon, dan flavonol-3-O-galaktosa. Secara keseluruhan, tanaman obat Indonesia menunjukkan potensi yang sangat besar sebagai sumber flavonoid, dengan metode isolasi dan identifikasi yang terbukti efektif dalam mendeteksi senyawa dengan aktivitas biologis signifikan, terutama sebagai antioksidan.

Kata kunci: *lavonoids; isolation; medicinal plants; Indonesia*

Received: 30 July 2025 *Revised: 28 August 2025* *Accepted: 04 September 2025* *Publish: 05 September 2025*

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INTRODUCTION

Indonesia is internationally recognized as one of the world's megabiodiversity countries, harboring an extraordinary richness of medicinal plant species that have long been utilized in traditional and modern healthcare systems. Many of these plants are known to biosynthesize secondary metabolites, particularly flavonoids, which represent one of the most important classes of plant-derived bioactive compounds. Flavonoids have been extensively reported to exhibit a wide spectrum of pharmacological activities, including antioxidant, antibacterial, antidiabetic, anticancer, and antiviral effects, thereby positioning them as promising candidates for pharmaceutical and nutraceutical development[19]. Consequently, scientific interest in the isolation and structural characterization of flavonoids from Indonesian medicinal plants has increased markedly over the past decade[3].

From an analytical perspective, flavonoid isolation typically involves extraction with polar solvents such as ethanol or methanol, followed by liquid–liquid fractionation using ethyl acetate or water. Subsequent purification and identification are generally achieved through chromatographic and spectroscopic techniques, including Thin Layer Chromatography (TLC), gravity column chromatography, preparative TLC, High Performance Liquid Chromatography (HPLC), and Vacuum Liquid Chromatography (VLC)[16]. These methods enable not only the separation of complex plant matrices but also the reliable identification of flavonoid structures.

Several studies have demonstrated the effectiveness of these analytical strategies. Ridwanuloh and Syarif (2019), for instance, isolated flavonoids from the stems of Physalis angulata using phytochemical screening, TLC with n-hexane–ethyl acetate (7:3) as the eluent, column chromatography, and UV–Vis spectrophotometric analysis. Their results revealed the presence of flavanone, indicated by a characteristic blue spot on TLC with an Rf value of approximately 0.8. Similarly, Suhendi and Sjahid (2011) investigated the leaves of Eugenia uniflora (Dewandaru) using a combination of chloroform extraction, 70% ethanol maceration, ethyl acetate–water fractionation, and preparative TLC. Through diagnostic assays employing sodium hydroxide, sodium acetate, aluminum chloride, and two-dimensional analysis, they successfully identified 5,7,3′,4′-tetrahydroxy flavonol (quercetin) as the major flavonoid constituent.

Despite the growing number of individual studies, a comprehensive synthesis that integrates isolation methods, analytical approaches, and flavonoid profiles from Indonesian medicinal plants remains limited. Therefore, this review aims to systematically compile and critically evaluate published studies on the isolation and identification of flavonoid

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compounds from Indonesian medicinal plants, as well as to identify the most frequently reported flavonoid types and to discuss their potential pharmacological relevance.

METHODOLOGY

Study Design

This study was conducted using a literature review design to systematically compile and analyze published research on the isolation and identification of flavonoid compounds from Indonesian medicinal plants.

Data Sources and Search Strategy

A comprehensive literature search was performed using three major scientific databases: Google Scholar, ScienceDirect, and ProQuest. Searches were carried out for articles published between 2019 and 2024. To capture both national and international publications, two sets of keywords were applied: "isolation and flavonoids" (for Indonesian-language articles) and "isolation and flavonoid compounds" (for English-language articles).

Eligibility Criteria

To ensure the relevance and scientific quality of the reviewed studies, a set of inclusion and exclusion criteria was applied during the article selection process. Articles were included if they were published between 2019 and 2024, focused on the isolation and/or identification of flavonoid compounds, were published in nationally or internationally accredited journals (ISSN, ISBN, or DOI), and were available in full-text format.

Conversely, studies were excluded if they employed qualitative research designs, were published as conference proceedings, were inaccessible or not available in full-text form, or represented duplicate publications.

The article selection process was conducted in several stages. Initially, a total of 13,400 records were identified from the database searches. Titles and keywords were then screened for relevance, resulting in 522 potentially eligible articles. After applying the inclusion and exclusion criteria, the number of relevant articles was reduced to 103. Subsequently, full-text assessment and rigorous evaluation were performed, leading to the final selection of 10 articles as primary sources for synthesis.

These selected studies formed the core dataset for the present review and served as the basis for the analysis and discussion of flavonoid isolation and identification from Indonesian medicinal plants.

Results and Discussion

As summarized in Table 1, numerous studies have successfully isolated flavonoids from Indonesian medicinal plants, particularly from species that are traditionally used in local medicine. The data in Table 1 demonstrate that most studies employed polar solvent extraction, followed by chromatographic purification and spectroscopic identification,

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confirming the widespread applicability of these techniques in flavonoid research.

Tabel 1. Summary of Studies on the Isolation and Identification of Flavonoids from Indonesian Medicinal Plants

No.	Study (Author, Year)	Plant Source	Methodology	Main Findings	Database
1	Suhendi, Sjahid & Hanwar (2025)[17]	*Eugenia uniflora* (leaves)	Soxhlet extraction with chloroform, 70% ethanol maceration, ethyl acetate fractionation, preparative TLC, UV–Vis, diagnostic reagents	Suspected flavonol quercetin (5,7,3′,4′-tetrahydroxy flavonol)	Google Scholar
2	Munawir, Harmoni & Maharani (2025)[12]	*Moringa oleifera* (leaves)	70% ethanol maceration, TLC, UV–Vis spectrophotometry	Quercetin detected (Rf 7.7); total flavonoids ≈ 0.99%	Google Scholar
3	Jubahar, Ramadhani & Rahmadani (2024)[7]	*Sida rhombifolia* (herb)	Extraction, isolation, UV and IR characterization	Flavonol-3-O-galactose detected; yield ≈ 0.17%	Google Scholar
4	Ridwanuloh & Syarif (2019)[14]	*Physalis angulata* (stem)	Phytochemical screening, TLC, column chromatography, UV–Vis	Flavanone detected (Rf 0.8; blue band)	Google Scholar
5	Azzahra (2023)[4]	*Hibiscus sabdariffa* (petals)	Sonication extraction, isolation of flavonoid compounds	Flavonoids isolated (structure not fully characterized)	Google Scholar
6	Fadhila (2024)5	*Morus alba* (wood)	Maceration, liquid–liquid extraction, TLC, VLC, column chromatography, NMR	6.3 mg flavonoid derivative obtained	Google Scholar
7	Santoso, Andriani & Zulfikar (2023)[15]	*Eugenia uniflora* (fruit)	96% ethanol maceration, TLC, UV–Vis, DPPH assay	Flavonoid-positive extract; IC_{50} ≈ 53.44 ppm	Google Scholar
8	Arbiyani, Nasution & Sari (2023)[2]	*Eugenia uniflora*	Literature review, UV–Vis	Quercetin identified as the main flavonoid	Google Scholar
9	Fadhilah, Putri & Pratama (2024)[6]	*Artocarpus integer* (stem wood)	Extraction, KCV, preparative TLC, TLC, NMR	Artoindonesianin E-1-like flavonoid isolate	Google Scholar
10	Yuliani, Pramesti & Susanti (2024)[20]	*Syzygium cumini* (leaves)	Literature review (2012–2023) via database	Myricetin, kaempferol, and quercetin; antioxidant potential	Google Scholar

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Suhendi et al. (2025) isolated flavonoids from the leaves of Eugenia uniflora using a sequential process involving 70% ethanol maceration, ethyl acetate fractionation, preparative Thin Layer Chromatography (TLC), and compound identification by UV–Vis spectrophotometry and diagnostic reagents (Table 1, No. 1). The isolated compounds were strongly suspected to be quercetin or 5,7,3′,4′-tetrahydroxy flavonol. Similarly, Munawir et al. (2025) reported the successful isolation of flavonoids from Moringa oleifera leaves using 70% ethanol maceration followed by TLC and UV–Vis spectrophotometric analysis (Table 1, No. 2), which revealed quercetin as the dominant compound with a total flavonoid content of approximately 0.99%.

The diversity of flavonoid structures across different plant species is further illustrated in Table 1. Jubahar et al. (2024) isolated flavonol-3-O-galactose from Sida rhombifolia through extraction, isolation, and UV–IR characterization (Table 1, No. 3), while Ridwanuloh and Syarif (2019) identified flavanone from Physalis angulata stems using phytochemical screening, TLC, and column chromatography (Table 1, No. 4). Azzahra (2023) also detected flavonoids in Hibiscus sabdariffa petals using sonication-assisted extraction, although the structures were not fully elucidated (Table 1, No. 5).

More advanced analytical strategies were applied in several studies listed in Table 1. Fadhila (2024) employed maceration, liquid–liquid extraction, TLC, Vacuum Liquid Chromatography (VLC), column chromatography, and NMR spectroscopy to isolate 6.3 mg of flavonoid derivatives from Morus alba wood (Table 1, No. 6). Meanwhile, Santoso et al. (2023) demonstrated strong antioxidant activity of flavonoid-rich extracts from Eugenia uniflora fruit, reporting an IC_{50} value of 53.44 ppm using the DPPH assay (Table 1, No. 7).

Secondary evidence further reinforces quercetin as a dominant flavonoid. Arbiyani et al. (2023) concluded that quercetin is the primary flavonoid in Eugenia uniflora (Table 1, No. 8). In addition, Fadhilah et al. (2024) isolated compounds structurally similar to Artoindonesianin E-1 from Artocarpus integer stem wood using KCV, preparative TLC, and NMR (Table 1, No. 9). Finally, Yuliani et al. (2024) identified myricetin, kaempferol, and quercetin in Syzygium cumini leaves, all of which are associated with antioxidant potential (Table 1, No. 10).

The integrated findings presented in Table 1 reveal a clear methodological and biological pattern. First, polar solvent extraction, particularly using ethanol or methanol, consistently produced flavonoid-rich extracts. This supports the established principle that flavonoids, as polyphenolic compounds, are more efficiently extracted using polar solvents.

Second, fractionation and chromatographic purification (ethyl acetate partitioning, TLC, preparative TLC, VLC,

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and column chromatography) were essential in separating individual flavonoid constituents from complex plant matrices. Studies employing advanced separation and spectroscopic techniques such as NMR were able to confirm flavonoid structures with higher confidence, as observed in Morus alba and Artocarpus integer (Table 1, Nos. 6 and 9).

Third, the type of flavonoid isolated is closely linked to biological activity. Quercetin, the most frequently identified compound across studies (Table 1, Nos. 1, 2, 8, and 10), is well known for its strong antioxidant, anti-inflammatory, and antidiabetic properties. Similarly, flavanone and flavonol-3-O-galactose, identified in Physalis angulata and Sida rhombifolia respectively (Table 1, Nos. 3 and 4), are also reported to possess antioxidant and cytoprotective activities.

Notably, the antioxidant potential measured through the DPPH assay in Eugenia uniflora fruit (IC_{50} = 53.44 ppm; Table 1, No. 7) provides experimental evidence that links structural flavonoid profiles with functional bioactivity. This demonstrates that the choice of extraction and identification techniques not only determines analytical success but also influences the detection of pharmacologically relevant compounds.

Overall, the synthesis highlights a coherent relationship between isolation strategy → flavonoid structure → biological activity, confirming that Indonesian medicinal plants represent a valuable reservoir of bioactive flavonoids with significant therapeutic potential.

CONCLUSION

This literature review demonstrates that Indonesian medicinal plants represent a highly promising source of flavonoid compounds, as flavonoids were consistently detected in almost all plant species reviewed. The findings indicate that these compounds can be effectively isolated using polar solvent extraction, particularly ethanol or methanol, followed by fractionation and chromatographic separation, with reliable identification achieved through Thin Layer Chromatography (TLC), UV–Vis spectrophotometry, and Nuclear Magnetic Resonance (NMR). Among the isolated compounds, quercetin, flavanone, and flavonol-3-O-galactose were the most frequently reported, and all were associated with significant biological activities, especially antioxidant effects, underscoring the strong pharmacological potential of Indonesian medicinal plants as valuable sources of bioactive flavonoids for future pharmaceutical and nutraceutical development.

ACKNOWLEDGMENTS

The authors would like to express their sincere gratitude to Sari Mutiara University, Medan, Indonesia, for the institutional support and facilities provided during the preparation of this literature review.

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