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Bibliometric analysis of Indonesian herbal plant gambir (Uncaria gambir Roxb.)

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Abstract This bibliometric study investigates the evolution of research on Gambir (*Uncaria gambir* Roxb.), an herbal plant native to Indonesia, from 1894 to 2024. Using data from 288 documents sourced from the Scopus database, the study explores publication trends, contributions by researchers and institutions, and patterns of international collaboration. The findings indicate a notable rise in publications, particularly after 2005, with a sharp increase during 2020-2024. Indonesia leads the research efforts with over 160 publications, followed by Japan and Malaysia. Andalas University stands out as a key research hub, contributing around 60 publications. An analysis of subject areas reveals that the majority of research is concentrated in Pharmacology, Toxicology, and Pharmacy (15.2%), with Medicine (12.1%) and Biochemistry, Genetics, and Molecular Biology (10.2%) following. Journal articles make up the bulk of the publications (75%), highlighting the significance of peer-reviewed studies. Co-occurrence analysis identifies four primary research clusters, focusing on antioxidant properties, in vivo studies, antibacterial activity, and drug development. The pattern of international collaboration shows strong partnerships between Indonesia and other Asian nations, particularly Japan and Malaysia. The research emphasizes Gambir's bioactive properties, its potential in medical and pharmaceutical applications, and innovations in nanotechnology and materials science. In summary, this analysis highlights Gambir's broad potential in various scientific and medical areas, as well as the critical role of international cooperation in advancing the understanding of this plant.

Keywords: gambir, trends, VOSViewer

1. Introduction

Gambir (*Uncaria gambir Roxb*) is a significant herbal plant that flourishes in Southeast Asia, particularly in Indonesia. It has been well-known in traditional communities for centuries and applied in medicinal and non-medicinal contexts. Traditionally, gambir is used to treat various conditions such as diarrhea, wounds, and inflammation, and it also serves as a raw material in industries like leather tanning and natural dye production (Rahmadiawan et al*.,* 2023; Jeong & Hwang, 2024). According to Amin et al. (2021), gambir has been utilized in traditional medicine to address issues such as diarrhea, indigestion, and as a wound astringent. Moreover, Anggraini et al. (2011) reported that gambir extracts from several regions in West Sumatra demonstrated significant antioxidant activity, which was linked to its catechin content.

The primary active compound in gambir is catechin, known for its powerful antioxidant, anti-inflammatory, and antibacterial properties. Research has shown that catechin can inhibit the growth of pathogenic bacteria and prevent cellular oxidation, making it a promising candidate for modern drug development (Labbani et al*.,* 2023). Alongside catechin, gambir contains other bioactive compounds like flavonoids, tannins, and alkaloids, all of which have potential applications in the pharmaceutical, cosmetic, and nutritional sectors (Rahmadiawan et al*.,* 2023). Ferdinal et al. (2019) successfully isolated and characterized catechin from gambir, demonstrating strong antioxidant activity with an IC50 value of 3.8 µg/mL. Furthermore, Rauf et al.(2019), in their comprehensive review of quercetin—another compound found in gambir—highlighted its anticancer potential, offering new insights into gambir's therapeutic prospects.

The Indonesian herbal plant Gambir (*Uncaria gambir* Roxb.) demonstrates significant bioactive properties and diverse applications, particularly in agriculture and medicine. This analysis emphasizes its genetic diversity, pharmacological benefits, and innovative uses, showcasing its relevance in both traditional and contemporary settings. Research has uncovered notable genetic variability among four Gambir genotypes in West Sumatra, using Specific Sequence-Related Amplified Polymorphism (SRAP) markers. The Mancik genotype was found to have the highest catechin concentration, highlighting its potential for selective cultivation and conservation (Wardi et al*.,* 2024). Gambir extracts, particularly the ethyl acetate fraction, have proven effective in treating hyperlipidemia, with stable film-coated tablets developed to enhance catechin delivery and protection (Ynarto et al*.,* 2024). Additionally, purified Gambir extracts showed substantial antioxidant properties, improving kidney function in diabetic rats (Rachmaini et al*.,* 2024). In agriculture, Gambir processing waste has been studied as a botanical

insecticide, demonstrating promise in sustainable pest control through nanotechnology—aligning with the growing demand for environmentally friendly agricultural practices. Despite the focus on Gambir's numerous benefits, challenges remain in standardizing its use and ensuring sustainable harvesting practices to preserve ecological balance (Hamid et al., 2024). Increasing global interest in herbs and natural products, particularly Gambir (Uncaria gambir), is attributed to its diverse health benefits and potential as a safer alternative to synthetic chemicals. Research in various fields highlights Gambir's bioactive compounds, which exhibit significant therapeutic properties. For example, gambir extract has shown effectiveness as an antioxidant with the ability to reduce malondialdehyde (MDA) levels and increase superoxide dismutase (SOD) in type 2 diabetic patients (Pane et al., 2018). In addition, scientific studies have also revealed the anti-inflammatory effects of Gambir, where the extract is able to reduce inflammatory markers such as TNF-alpha and improve gastric mucosal integrity in a gastritis model (Oswari et al., 2019). The richness of bioactive compounds, especially flavonoids identified through advanced techniques, further strengthens Gambir's potential as a herbal ingredient with multiple health benefits (Ismail et al., 2021).

According to bibliometric data from the Scopus database, there has been a notable rise in publications on Gambir since the early 1900s. This not only reflects growing interest in the plant but also highlights increased international collaboration among researchers. Indonesia, as Gambir's native country, leads in publication volume, followed by Japan, Malaysia, and South Korea, indicating strong research partnerships (Jeong & Hwang, 2024). In a comprehensive review, Syahputra et al. (2020) underscored the rising global interest in *Uncaria gambir* Roxb., particularly in its phytochemical and pharmacological properties. Elfahmi et al. (2022) further noted that Gambir is among the most extensively studied Indonesian medicinal plants in the context of rational drug development from traditional herbal medicine.

Bibliometric analysis plays a crucial role in this context by identifying research trends, international collaborations, and key topics discussed in the literature. This approach provides insight into the dynamics of Gambir research, spotlighting the most productive authors and institutions, as well as the most explored research areas (Jeong & Hwang, 2024). Donthu et al. (2021) highlighted that bibliometric analysis offers a comprehensive overview of a research field, aiding in the identification of knowledge gaps and collaboration opportunities. Zupic and Čater (2015) added that bibliometric methods reveal the intellectual structure of a field, helping researchers trace the evolution of concepts and theories over time. Consequently, bibliometric analysis not only offers a snapshot of the current research landscape but also guides future research directions, supporting both researchers and policymakers in formulating effective strategies for the further exploration and application of Gambir.

This analysis also offers valuable insights into the evolution of Gambir research and how new knowledge about the plant has been generated and integrated across various disciplines. Over the past decade, there has been a shift from basic research focused on isolating and characterizing Gambir's chemical compounds to more applied studies investigating the clinical and industrial uses of these compounds . For example, Rahmawati et al. (2021) highlighted Gambir extract's potential as a natural hand sanitizer, demonstrating significant antibacterial activity against common pathogens. Husni et al.(2020) further advanced this research by developing nanoparticles from Gambir extract for hypercholesterolemia treatment, showcasing how modern science blends traditional knowledge with advanced technology to create new therapeutic solutions.

Nevertheless, despite the extensive research conducted, several aspects of Gambir still need further exploration. These include studies on its potential in combination therapies for chronic diseases, the development of more efficient and environmentally sustainable processing methods, and a deeper investigation into the molecular mechanisms of its bioactive compounds. This study aims to provide a foundation for future research while enhancing our understanding of the diverse benefits and potential applications of the Gambir plant (Rahmadiawan et al., 2023).

2. Materials and Methods

A bibliometric analysis was conducted to identify publications related to Gambir from 1894 to 2024. The search queries used included the keywords "Gambir" and "*Uncaria gambir* Roxb." Data was sourced from Scopus, a premier platform for patent and scientific searches. To clean and transform the search result data, OpenRefine software was utilized. For data analysis and visualization, VOSviewer software (version 1.6.6) was employed to create network, overlay, and density visualizations. Additional details about the bibliometric analysis methods are provided in Figure 1.

The VOSviewer application is employed for this bibliometric analysis to map research trends related to Gambir. VOSviewer is a tool designed for creating and visualizing bibliographic networks and is particularly effective for both small and large datasets. It offers detailed data maps and various analytical insights (Shah et al., 2019).

3. Results and Discussion

3.1. Documents by subject area

Figure 2 shows the percentage of publications by subject area.

The distribution of research documents on Gambir reveals considerable diversity in subject areas, underscoring the plant's multidisciplinary study. Pharmacology, Toxicology, and Pharmacy are the leading fields, comprising 15.2% of the research, highlighting a significant focus on Gambir's medical and pharmacological potential. Research in this area primarily

explores the pharmacological properties of active compounds such as catechins, known for their antioxidant, anti-inflammatory, and antimicrobial effects. Investigations have also examined Gambir's antibacterial activity against pathogens like Staphylococcus aureus and Escherichia coli. An emerging area in pharmaceuticals is the development of nanoparticles to enhance drug delivery efficiency. Additionally, Gambir's antioxidant potential is being explored for treating degenerative diseases such as Alzheimer's and Parkinson's. The research also includes toxicological and safety assessments, along with pharmacokinetic and pharmacodynamic studies, to ensure the safety and efficacy of Gambir in medical applications.

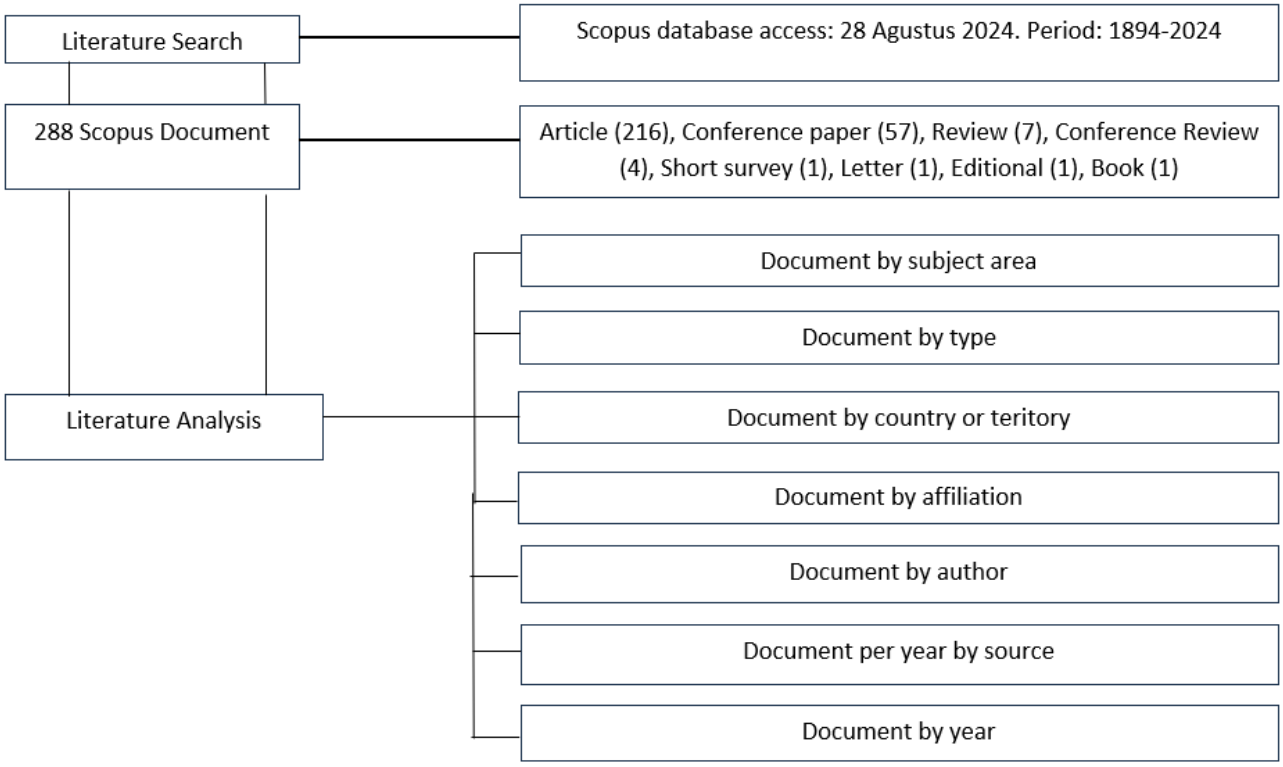

Figure 1 Data Collection Flow uncover publication trends across various dimensions, including subject area, publication type, country or territory, affiliation, author, source, and year.

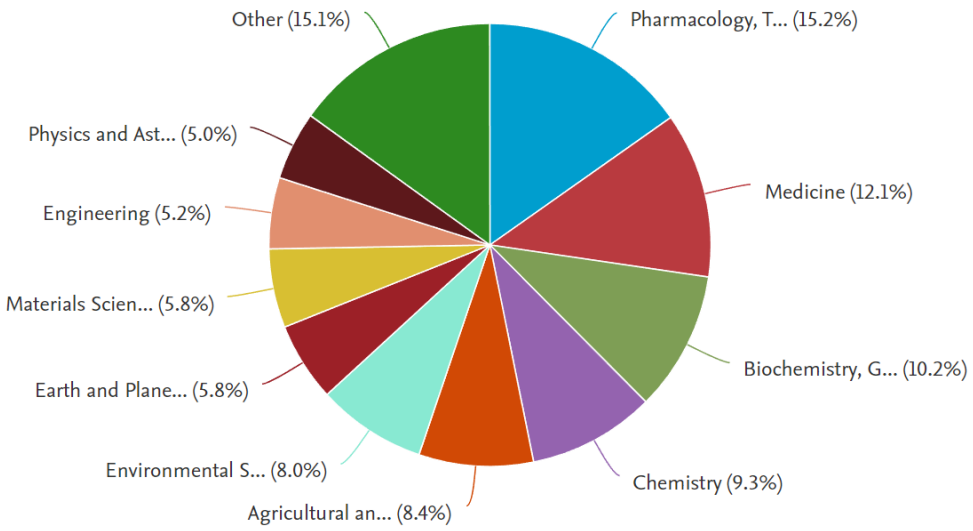

Figure 2 Percentage of publications by subject área. *Source:* Scopus database.

The distribution of research on Gambir highlights its broad and interdisciplinary nature. Following Pharmacology, Toxicology, and Pharmacy, Medicine (12.1%) and Biochemistry, Genetics, and Molecular Biology (10.2%) are prominent, underscoring Gambir's relevance in clinical and molecular research. Chemistry (9.3%) and Agricultural and Biological Sciences

(8.4%) are also significant, focusing on chemical analysis and agronomic aspects. Environmental Sciences (8.0%) and Earth and Planetary Sciences (5.8%) reflect interest in the ecological and geographical impacts of Gambir, while Materials Science (5.8%), Engineering (5.2%), and Physics and Astronomy (5.0%) explore its applications in technology and materials development. The "Other" category (15.1%) indicates a wide range of research extending beyond the primary disciplines.

This distribution illustrates Gambir's extensive potential, from traditional medical uses to modern technological and industrial applications. The multidisciplinary research not only investigates Gambir's bioactive properties for medical use but also focuses on its safety, new drug delivery technologies, and diverse scientific applications. This broad approach highlights the importance of interdisciplinary research in advancing innovations in medicine, pharmaceuticals, and various industries.

3.2. Documents by type

Figure 3 reveals the distribution of document types used in research on Gambir.

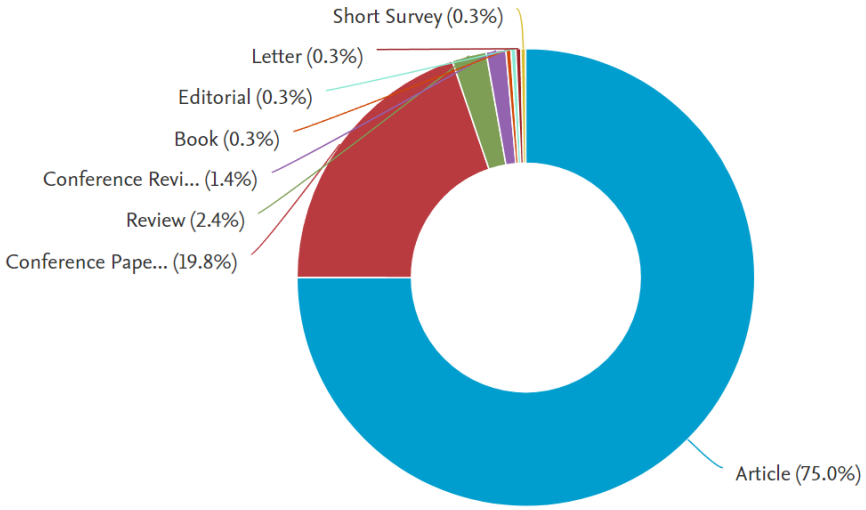

Figure 3 Percentage of publications by type. *Source:* Scopus database.

The distribution of document types in research on Gambir (*Uncaria gambir* Roxb.) reveals a clear predominance of journal articles, which constitute 75% of the total publications. This highlights the significance of original, peer-reviewed research in advancing scientific knowledge about Gambir. Conference papers follow, making up 19.8% of the documents, underscoring the crucial role of academic conferences in sharing preliminary research findings. Reviews account for 2.4% of the publications, offering a valuable synthesis of existing research and identifying current trends. Conference review papers contribute 1.4%, reflecting the importance of critically evaluating findings presented at conferences. Books, editorials, letters, and short surveys each represent only 0.3% of the literature, indicating their minor but varied contributions to the overall research landscape. This distribution emphasizes a strong emphasis on empirical and experimental research, with conferences playing a significant role in the early dissemination of results. While journal articles and conference papers are the primary sources of information, the presence of diverse document types highlights the multifaceted approach to disseminating knowledge about Gambir, supporting a well-rounded understanding of the plant within the scientific community.

3.3. Publication trends documents by country or territory

Figure 4 illustrates publication trends by country or region.

Research on Gambir (*Uncaria gambir* Roxb.) exhibits a notable global distribution, with Indonesia being the leading contributor. As the plant's country of origin, Indonesia tops the list with over 160 research documents, primarily from institutions such as Andalas University and the University of Indonesia. This dominance is highlighted by studies such as Amin et al., (2021), which reviews the traditional and pharmacological uses of Gambir, and Ferdinal et al., (2019), which focuses on the isolation and characterization of catechins and their antioxidant activities.

Japan follows as the second-largest contributor, reflecting its interest in Gambir's potential applications in material technology, pharmaceuticals, and cosmetics. Malaysia, with its similar ecosystem to Indonesia, contributes over 20 documents, indicating active research efforts. Other Asian countries like Thailand, China, and South Korea each contribute around 10-15 documents, showing significant regional interest in herbal research. Though smaller in number, research contributions from Taiwan and the United States suggest growing international interest, particularly in the pharmacological potential of Gambir. Germany and India, with about 5 papers each, further extend the global research network. This distribution underscores a strong regional focus on Southeast and East Asia while highlighting Gambir's global potential across various scientific and industrial fields, capturing the attention of the international research community.

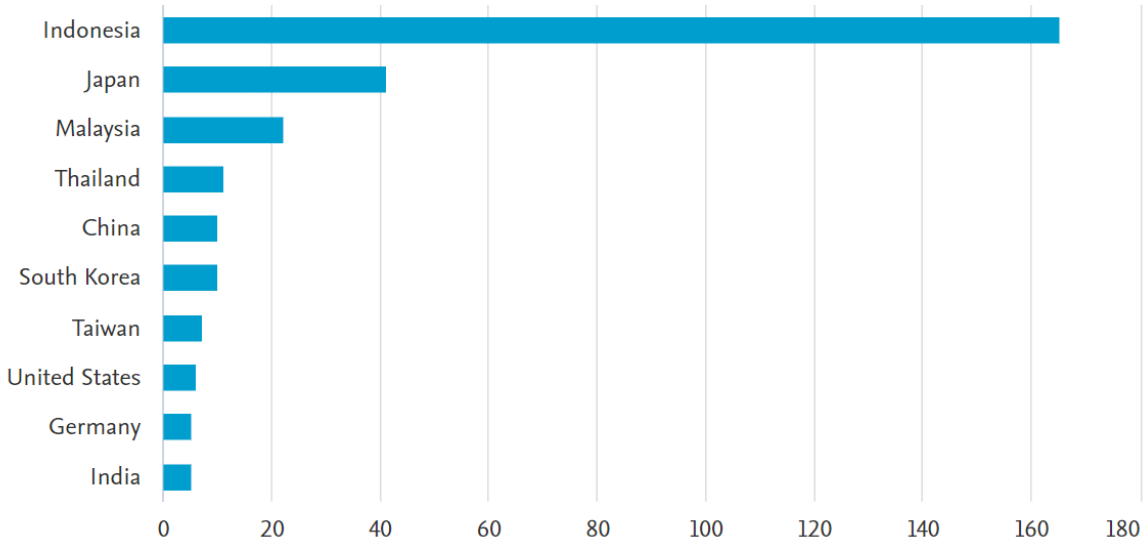

Figure 4 Percentage of publications by country or territory. *Source:* Scopus database.

3.4. Publication trends documents by affiliation

Figure 5 highlights the contributions of research institutions.

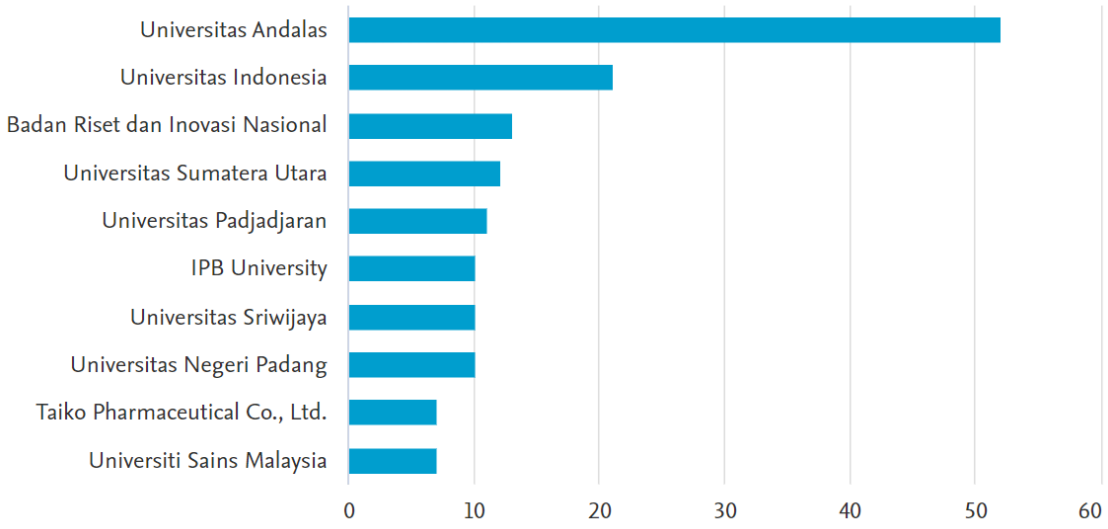

Figure 5 Percentage of publications by affiliate. *Source:* Scopus database.

The bibliometric analysis of research on Gambir (*Uncaria gambir* Roxb.) reveals a significant distribution of contributions from various Indonesian and international institutions. Andalas University stands out as the primary research center with approximately 60 publications, underscoring its leadership in Gambir research. Notable studies from this institution include the work by Yeni et al., (2019) from the Padang Industrial Research and Standardization Center, which explored the repeated extraction process of raw Gambir, and a study by Rahmawati et al., (2021) that examined the antibacterial properties of Gambir extract and its potential as a natural hand sanitizer.

Following Andalas University, the University of Indonesia contributes around 20 documents, while the National Research and Innovation Agency (BRIN) has 10 publications, indicating government backing for research on herbal plants with health and economic benefits. Other institutions such as the University of North Sumatra, Padjadjaran University, IPB University, Sriwijaya University, and Padang State University each contributed 8-10 documents, reflecting the geographical diversity and range of research focuses.

The involvement of Taiko Pharmaceutical Co., Ltd. and Universiti Sains Malaysia highlights interest from industry and international collaboration. Research from Andalas University encompasses a broad spectrum of topics, including antihypertensive and antidiabetic studies, antioxidant activity, applications in both traditional and modern medicine, green

synthesis of materials, isolation of bioactive compounds, agricultural uses, environmental impacts, and food technology applications. This diversity showcases the multifaceted potential of Gambir and emphasizes the importance of collaboration among institutions to advance research on Indonesian herbal plants.

3.5. Publication by author

Figure 6 shows the percentage of publications by author.

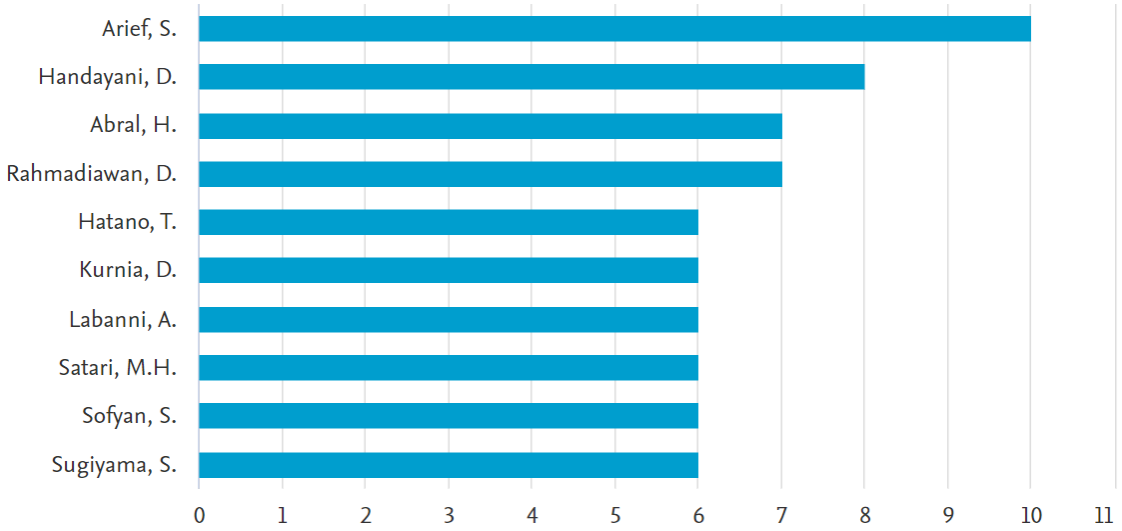

Figure 6 Percentage of publications by author. *Source:* Scopus database.

The bibliometric analysis of publications on Gambir (*Uncaria gambir* Roxb.) highlights significant contributions from several key researchers. Leading the way is Arief, S., with 11 publications focused on the synthesis of silver nanoparticles using Gambir extract as a reductant. His work explores the physical and antibacterial properties of the synthesized materials and their applications in bone implants, emphasizing a green chemistry approach that integrates herbal plant exploration with modern technology. A notable example of his contributions is the study by Arief et al., (2020), which investigates the green synthesis of silver nanoparticles from Gambir extract and their antibacterial properties. A subsequent study by Handayani *et al.,* (2023) further expands on the green synthesis of nanoparticles derived from Gambir extract and their potential antibacterial applications.

Handayani, D. ranks second with 8 publications, while Rahmadiawan, D., and Hatano, T. each have 7 contributions. Kurnia, D., Labanai, A., Sofyan, S., and Sugiyama, S. have also made significant contributions with 5-6 papers. This publication pattern suggests strong collaboration among researchers, with a small group driving the majority of the literature on Gambir. The concentration of publications among these key researchers indicates a focused collaborative network, which has the potential to shape future research directions in this field. Recognizing the contributions of these leading researchers is crucial for identifying potential collaborations and relevant literature in Gambir studies.

3.6. Publication trends documents by source

Figure 7 displays publications by source.

The bibliometric analysis of publications related to Gambir from 2019 to 2024 reveals a diverse distribution of research across various journals and conference proceedings. The five primary sources include Biodiversitas**,** IOP Conference Series: Materials Science and Engineering**,** AIP Conference Proceedings**,** Journal of Physics Conference Series**,** and IOP Conference Series: Earth and Environmental Science. This variety underscores the multidisciplinary nature of Gambir research, as noted by Syahputra et al., (2020) in their comprehensive review of the plant's traditional uses, chemical constituents, pharmacological activities, and quality control.

The Biodiversitas journal exhibited a stable publication trend, with a slight increase in 2023, reflecting ongoing interest in the biodiversity aspects of Gambir. The IOP Conference Series: Materials Science and Engineering experienced a significant spike in 2021 with 12 publications, although this was followed by a sharp decline, indicating a temporary surge in interest regarding the material applications of Gambir. Conversely, the AIP Conference Proceedings saw an uptick in 2023, suggesting renewed engagement from the physics or engineering community. The Journal of Physics Conference Series displayed limited activity, with few publications in 2019-2020, while the IOP Conference Series: Earth and Environmental Science had sporadic publications in 2021 and 2024, indicating a lack of consistent interest in the environmental aspects of Gambir. Overall, 2021

marked a peak in publication activity, particularly in materials science. However, the subsequent downward trend may indicate a shift in research focus or a more specialized.

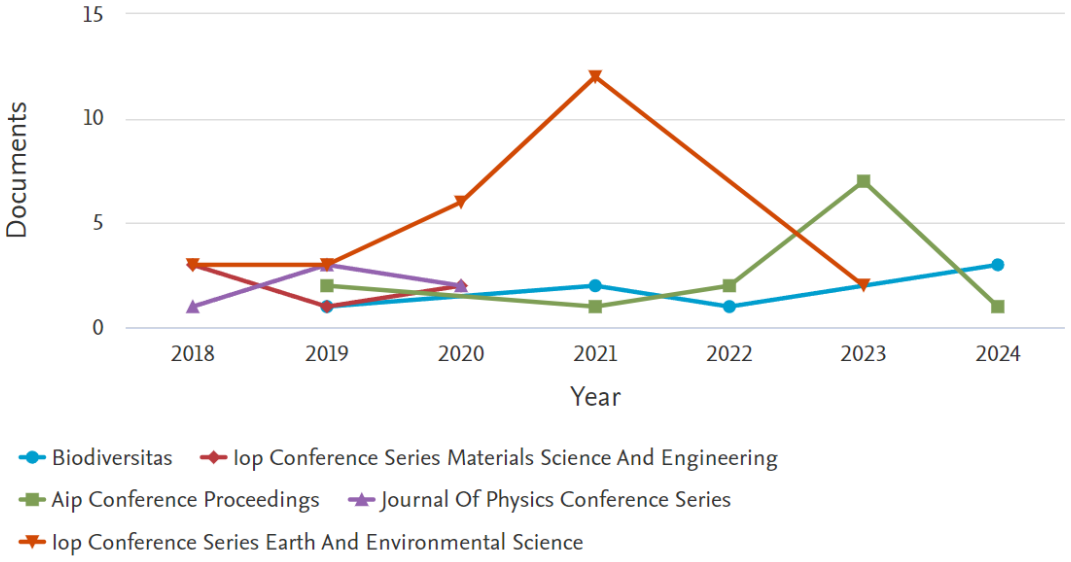

Figure 7 Publication by source. *Source:* Scopus database.

3.7. Publication by year

Figure 8 shows the trend of publications per year.

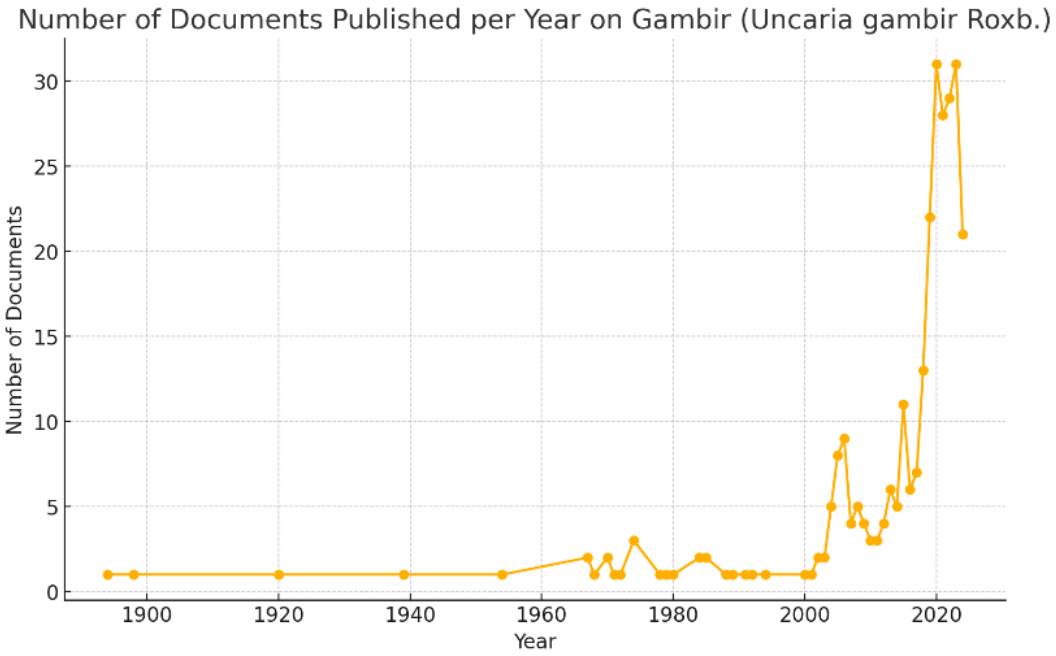

Figure 8 Publication by years. *Source:* Scopus database.

The bibliometric analysis of publications related to Gambir illustrates a significant evolution of research interest from 1894 to 2024. The annual publication graph reveals four main phases:Early Period (1894-1990s)**:** Characterized by minimal publication activity, indicating limited research interest.Gradual Increase (1990s to early 2000s)**:** A slow uptick in publications begins, marking the initial growing attention towards Gambir.Significant Growth (2005-2019)**:** A clear upward trend is observed, peaking around 2014-2015, likely reflecting a broader global interest in herbal medicine.Dramatic Spike (2020-2024)**:** The most substantial increase in publications occurs during this period, suggesting that Gambir has become a major focus of contemporary research. This surge aligns with heightened interest in the antioxidant and pharmacological properties of Gambir, as noted by Amir et al., (2012). The recent spike also reflects advancements in formulation technologies, such as the study by Husni et al., (2020) on the nanoparticle formulation of Gambir extract as an antihypercholesterolemic agent.

3.8. Analysis of inter-state relations

Figure 9 shows an analysis of the relationship between countries in Gambir research.

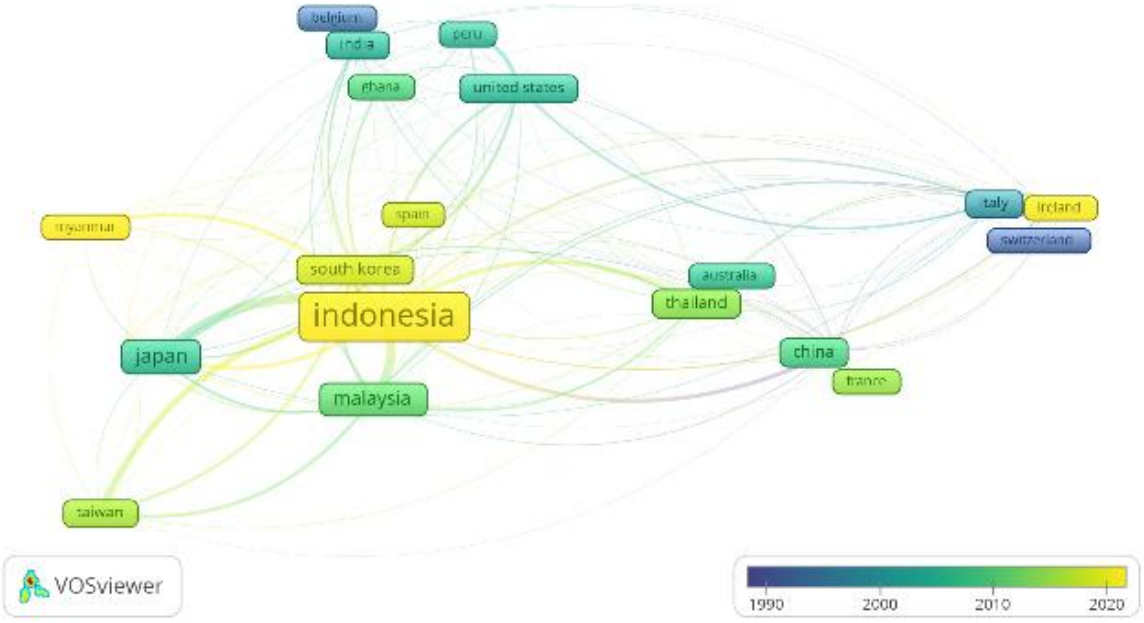

Figure 9 Collaboration between countries.

Research on Gambir reveals a notable pattern of international collaboration, with Indonesia emerging as a key hub. As the plant's country of origin, Indonesia serves as the largest and most interconnected node in the global research network. This collaborative spirit is exemplified by studies like those conducted by Anggraini et al., (2011), which investigated the antioxidant activity and catechin content in four types of Gambir extracts from West Sumatra. Additionally, Rauf et al., (2019) explored the anticancer potential of quercetin, a compound found in Gambir, highlighting the global interest in the plant's bioactive components.

Indonesia's collaboration is particularly strong with Asian nations, including Malaysia, Japan, Thailand, Taiwan, and South Korea, reflecting regional interests in herbal research. Japan and Malaysia are Indonesia's primary partners; Japan contributes to advancements in technology and pharmaceuticals, while Malaysia shares a similar ecosystem, enhancing joint research efforts. The development of these collaborations is illustrated by the color of the nodes in research networks, indicating recent partnerships with countries like Myanmar and Japan (2015-2020), and longer-standing collaborations with Italy, Switzerland, and the United States (2000-2010). The partnership between Indonesia and Japan has proven particularly fruitful, yielding numerous publications on topics such as nanotechnology, green chemistry, pharmacology, and socio-economic evaluations.

Examples of collaborative research include studies on Gambir nanoparticles for medical applications, the development of transdermal delivery systems for Gambir catechins, and the synthesis of silver nanoparticles from Gambir extracts. These efforts involve various Indonesian institutions, including the University of Indonesia and the University of Borneo Tarakan, along with Japanese counterparts. Key research focuses on the development and application of Gambir-derived nanoparticles as anticancer agents and stabilizers in chemical reactions, alongside pharmacological effects and chemopreventive potential.

Furthermore, the socio-economic aspects of Gambir cultivation are considered, showcasing a holistic approach to research. In conclusion, Indonesia leads global research on Gambir, supported by a robust collaborative network in Asia and increasing international interest. This underscores the significant potential of Gambir across various scientific applications and highlights the importance of international collaboration in advancing knowledge about this herbal plant.

3.9. Co-occurrence analysis in research

Figure 10 displays the co-occurrence analysis of research on Gambir (*Uncaria gambir* Roxb.). This visualization reveals the relationship between various concepts and topics that appear in the scientific literature.

Co-occurrence analysis of research on Gambir (*Uncaria gambir* Roxb.) reveals a fascinating pattern in the scientific literature, characterized by four main clusters and 680 links connecting various concepts. Central nodes include "Uncaria gambir Roxb." and "Gambir extract," which are closely associated with themes such as plant extracts, antioxidants, and antibacterial activity. This bibliometric analysis method, as outlined by Donthu et al. (2021), facilitates a deeper understanding

of trends and relationships within Gambir's research. Additionally, the approach discussed by Zupic and Čater (2015) provides insights into the intellectual structure and evolution of the field. The identified clusters are as follows: Antioxidant and Phytochemical Cluster: Focuses on the antioxidant properties and chemical constituents of Gambir. Nonhuman and Animal Experiments Cluster: Highlights the prevalence of in vivo studies using animal models.Tannins and Antibacterial Activity Cluster: Investigates the antibacterial properties of tannins present in *Gambir.Medical* and Pharmaceutical Research Cluster: Dominates the analysis with a strong emphasis on drug development and pharmacological testing.

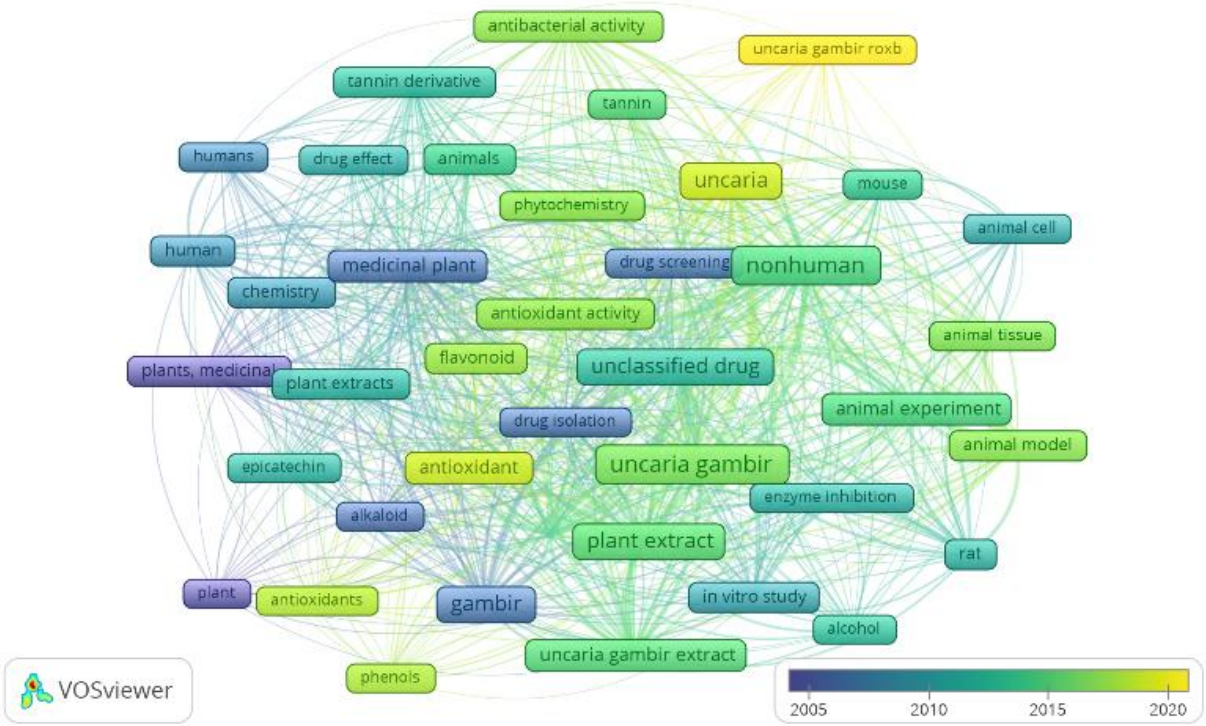

Figure 10 Co-occurrence of documents.

Temporal trends in the research are evident from the color of the nodes, indicating a shift from earlier focuses such as "chemistry" and "antioxidants" to more recent themes like "enzyme inhibition" and "alcohol." The thickness of the connecting lines underscores the close relationship between Gambir's chemical components and their pharmacological applications. The prevalence of drug-related terms like "unclassified drug" and "drug screening" highlights the significant focus on the medical potential of Gambir. In conclusion, this analysis demonstrates a multidisciplinary approach to Gambir research, primarily centered on its bioactive properties. The evolution of the research focus—from basic characterization of chemical components to specific applications in drug development and clinical trials—reflects Gambir's broad potential in various scientific and medical fields. This suggests promising directions for future research endeavors

5. Conclusions

The bibliometric analysis of research on Gambir (*Uncaria gambir* Roxb.) indicates a significant increase in scientific interest over the past few decades, particularly since 2005. Indonesia has established itself as a key center for Gambir research, with Andalas University leading in the number of publications. Strong international collaborations, especially with countries like Japan and Malaysia, further underscore the global interest in this plant. Research on Gambir spans multiple disciplines, primarily focusing on pharmacology, toxicology, and pharmacy, highlighting its broad potential in medical and pharmacological applications.

Co-occurrence analysis identified four main research clusters: antioxidants and phytochemistry, animal experiments, antibacterial activity, and drug development and pharmacological testing. Temporal trends indicate an evolution from basic characterization of chemical components to more specific applications in drug development and clinical trials. While journal articles dominate the literature, the diversity of document types reflects a broad dissemination of knowledge.In conclusion, Gambir has garnered global attention as a promising source for new drug development and industrial applications, with Indonesia playing a crucial role in advancing this research. The multidisciplinary approach and robust international collaborations pave the way for further innovations in the utilization of Gambir for various scientific and practical purposes.

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Ethical Considerations

Not applicable.

Conflict of Interest

The authors declare no conflicts of interest.

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