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Bibliometric Analysis of Research on Genus *Etlingera*: Insights into its Biomedical Applications

(Analisis Bibliometrik Kajian ke atas Genus *Etlingera*: Pemahaman dalam Aplikasi Bioperubatannya)

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Abstract

The genus Etlingera belongs to the family Zingiberaceae (Ginger family), comprising more than 100 species, which possess a substantial medicinal value. Their role in drug discovery is significant due to their bioactive compounds, including antioxidants, anti-inflammatory, antimicrobials, and anticancer. Research on this genus is primarily limited to in vitro and in vivo studies. Thus, there is a significant gap in the research in pharmacology and drug development. This analysis aimed to explore the trends of worldwide publications on the genus Etlingera until 2023. Data collection was performed by a literature search of the word 'Etlingera' based on title, abstract, and keywords. We retrieved 329 articles from the Scopus database, which were limited to research articles published in English. We used Harzing's Publish and Perish software for citation metrics and analysis, and VOSviewer for data visualization. This data distribution in terms of the growth of publications, research areas, countries, organizations, top-cited articles, collaboration, and keywords were reported in this study. There was an increasing trend of publications on the genus Etlingera research after 2018, with Malaysia as the leading country. The top research area was 'Agricultural and Biological Sciences', and the most cited article was related to the methods of drying processes that best preserve or boost antioxidant levels. This bibliometric analysis highlights the pharmacological potential of the Etlingera plant, serving as a bridge between traditional and modern medicine. It also provides comprehensive data on the genus Etlingera research that may contribute valuable knowledge and suggest directions for future research.

Keywords: Etlingera, Zingiberaceae; Bibliometric; Harzing's Publish or Perish; VOSviewer

Abstrak

Genus Etlingera tergolong dalam famili Zingiberaceae (famili Ginger), yang terdiri daripada lebih 100 spesies yang mempunyai nilai perubatan yang penting. Peranannya dalam penemuan ubat adalah signifikan kerana sebatian bioaktif, termasuk antioksidan, anti-radang, antimikrobial, dan antikanser. Penyelidikan ke atas genus ini terutamanya terhad kepada kajian in vitro and in vivo. Oleh itu, terdapat jurang yang signifikan dalam penyelidikan farmakologi dan pembangunan ubat. Analisis ini bertujuan untuk meneroka corak penerbitan di seluruh dunia berkenaan dengan genus Etlingera sehingga tahun 2023. Pengumpulan data dilakukan melalui pencarian literatur perkataan 'Etlingera' berdasarkan tajuk, abstrak, dan kata kunci. Kami memperoleh 329 artikel dari pangkalan data Scopus yang diterhadkan kepada artikel penyelidikan yang diterbitkan dalam Bahasa Inggeris. Kami menggunakan perisian Harzing's Publish and Perish untuk metrik sitasi dan analisis, dan VOSviewer untuk visualisasi data. Taburan data ini daripada segi pertumbuhan penerbitan, bidang penyelidikan, negara, organisasi, artikel yang paling banyak disitasi, kolaborasi, dan kata kunci dilaporkan dalam kajian ini. Terdapat peningkatan penerbitan mengenai kajian genus Etlingera selepas tahun 2018, dengan Malaysia sebagai negara paling produktif. Bidang penyelidikan yang utama ialah 'Sains Pertanian dan Biologi', dan artikel yang paling banyak disitasi adalah berkait dengan metodologi proses-proses pengeringan yang paling baik mengekalkan atau meningkatkan tahap antioksidan. Analisis bibliometrik ini menonjolkan potensi farmakologi tumbuhan Etlingera, berfungsi sebagai penghubung antara perubatan tradisional dan moden. Ia juga menyediakan data yang komprehensif berkenaan kajian genus Etlingera yang boleh menyumbang pengetahuan yang bernilai dan mencadangkan arah tuju untuk penyelidikan masa depan.

Kata kunci: Etlingera; Zingiberaceae; Bibliometrik; Harzing's Publish or Perish; VOSviewer

INTRODUCTION

According to the World Health Organization (WHO), a significant portion of the global population continues to rely on medicinal plants as their primary source of treatment and healthcare (Yuan et al. 2016). One of the plants is classified under the genus *Etlingera*, which belongs to the family Zingiberaceae (Ginger family) and comprises about 150 species (POWO 2020). As the largest family within the order Zingiberales, Zingiberaceae consists of about 50 genera out of 1,600 species worldwide (Leong-Skornickova et al. 2019). The primary trait of Zingiberaceae is the distinct odor created by all parts of the plant, particularly the rhizome (Saensouk & Saensouk 2021). These plants are mainly grown in perhumid forests (Poulsen 2007), and are native to the Indo-Pacific region, including Malaysia, Indonesia, Thailand, Australia, and India (Ud-Daula & Basher 2019). They are characterized by their striking floral structures, big rhizomes, and strong stems. The flowers have red petal-like structures called labella that radiate outward while the flower tubes and ovaries are below ground.

Besides their economic value, the genus *Etlingera* is widely recognized for its significant medicinal properties with *E. elatior* having the maximum number of parts used for ethnomedicinal uses, followed by *E. fimbriobracteata* and *E. littoralis* (Koch et al. 2024). The *Etlingera* species, such as *E. brevilabrum, E. linguiformis, E. labellosa, E. littoralis, E. rubrolutea*, and *E. rubromarginata* exhibit pharmacological properties and substantial ethnobotanical importance. Most recently, the pharmacological activities that are attributed to this genus include antibacterial activities, anticancerous, anti-inflammatory, antioxidant, and antityrosinase activity (Koch et al. 2024). Previously, the plants have been used by indigenous communities to treat ailments ranging from skin conditions (Mahdavi 2014) to digestive disorders (Poulsen 2011). Additionally, some *Etlingera* species are utilized in spices, traditional cuisine, ornamentation, and landscape design (Sujarwo et al. 2015; Oktavia et al. 2019). These plants' leaves, stems, flowers, fruit, and rhizomes contain a high concentration of essential oil, making them highly scented (Ud-Daula & Basher 2019). Their flavor, medicinal properties, and culinary uses have attracted researchers to further explore their potential and medicinal values, which can be considered as potential pharmaceutical agents. To date, research on the genus *Etlingera* is primarily limited to *in vitro* and *in vivo* studies. There is a significant gap in the research in pharmacology and drug development.

Pharmacologically, *E. elatior* is a well-known and one of the most studied species due to its phytoconstituents that show a large number of biological activities, including antimicrobial, antioxidative, anti-inflammatory, nephroprotective, hepatoprotective, and anti-hyperglycaemic (Nor et al. 2020; Noordin et al. 2022; Fawzy & Putranti 2023; Koch et al. 2024). Nearly all parts of *E. elatior* contain certain percentages of beneficial phytochemicals, which can be utilized in different forms including fresh, extract, and essential oils (Ismail & Ridzuan 2023). The phytochemical analysis of this extract revealed the presence of secondary metabolites, including phenolic, flavonoid, coumarin, tannin, and quinone contents (Nor et al. 2019). Herbal formulations derived from this genus are often not standardized in terms of bioactive compound concentrations. Furthermore, the lack of standardized extracts makes it difficult to compare results across studies in the development of effective therapeutic agents. Extensive research is needed to determine optimal dosages and standardized formulations as information on these aspects is scarce. The *Etlingera* species have been used as food, condiment, ornament, and medicine (Chan et al. 2011; Yunus et al. 2022). Other species, such as *E. brevilabrumas* (Mahdavi 2014) and *E. fulgensare* (Chan et al. 2011) have been reported to have potential as cholesterol-lowering and antibacterial agents, respectively.

Despite their medicinal values, published data on this genus are limited. Furthermore, previous review articles on this genus mainly focused on certain species, such as *E. elatior* (Juwita et al. 2018; Ud-Daula & Basher 2019; Ismail & Ridzuan 2023; Fawzy & Putranti 2023), *E. coccinea* (Joseph & Godoong 2023), *E. Giseke* (Aromatic Ginger) (Koch et al. 2024) and *E. pavieana* (Naksang et al. 2020). Although most studies have been focused on those species, many lesser-known species remain unexplored for their potential pharmacological activities and phytochemical content. Thus, in this bibliometric analysis and visualization, we explored the global research trends in the genus *Etlingera*, including quantifying and mapping the scientific output, identifying influential research clusters and collaborations, and determining the emerging hotspots in the research on the genus *Etlingera*.

This review article aims to provide a comprehensive overview of the research landscape on the genus *Etlingera*. The Scopus database was used to retrieve the data on the growth of publications, citation metrics, top-research areas, country contribution, most active organizations, top-cited articles, relevant keywords, and collaboration between countries from 1993 to 2023. Despite

their use in traditional medicine, there is a lack of ethnopharmacological studies across the world. Data, knowledge, and their potential as medicinal plants could be lost without proper data documentation and systematic studies. Given the growing interest in the pharmacological potential of *Etlingera*, a comprehensive bibliometric analysis is needed to map ongoing research, identify key contributors, and identify current gaps in the scientific literature. Addressing these gaps would pave the way for its incorporation into the biomedical field, which is essential for advancing medical science and improving health outcomes across the world.

MATERIALS AND METHODS

Data Sources

Published papers about the genus *Etlingera* were retrieved online on the 18th of September 2024 from the Scopus database. Scopus was chosen because it is one of the largest indexing databases, a comprehensive, and thorough bibliographic data source that provides broader coverage (Pranckute 2021). Furthermore, Scopus is the largest indexing database, combining the characteristics of both PubMed and Web of Science. Data collection was performed using the following search: [TITLE-ABS-KEY ‘’(Etlingera)’’]. The search was limited to title, abstract, and keywords, which included papers that were published from 1993 to 2023.

Data Screening, Extraction and Analysis

We obtained a total of 413 publications. However, only original articles, which are the primary sources were included. Other document types, such as review articles, conference papers, or book chapters, which are typically secondary sources, were excluded from this study to maintain focus on primary research contributions. We restricted our search to those published in English. Thus, the total number of publications included in this study was 329. Figure 1 illustrates the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flowchart for the study selection process. For further analysis, data in .ris format were used to perform citation analysis using Harzing’s Publish and Perish software. Meanwhile, the selected articles were extracted into Comma-Separated Values (.csv) format, and exported into VOSviewer software (version 1.6.20) to visualize and create the bibliometric networks.

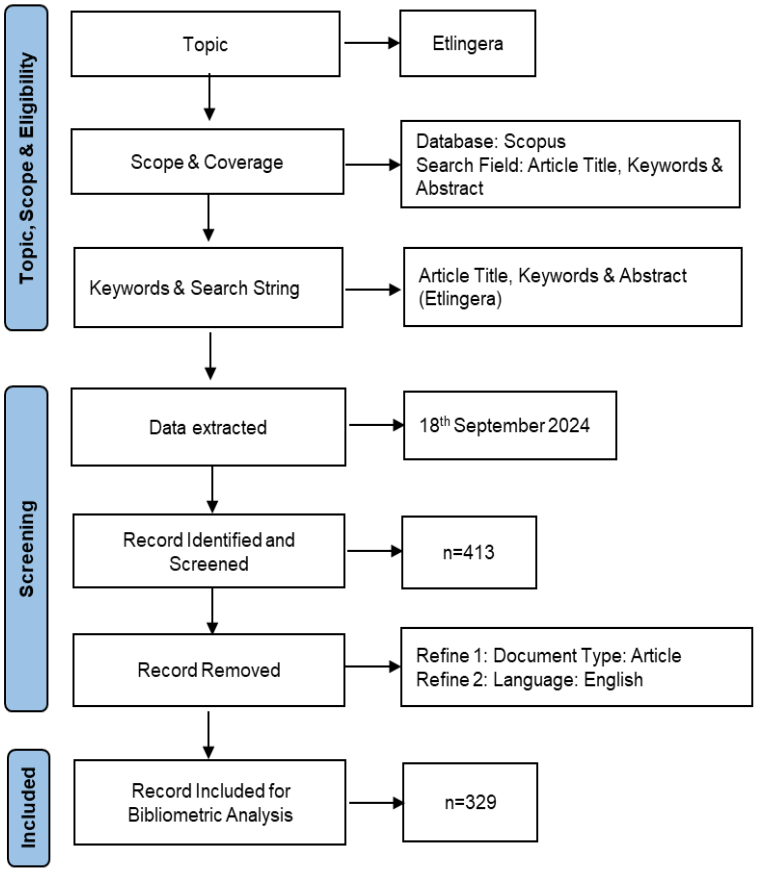

Figure 1 A flow chart depicting the process of selection of studies

The following aspects were analyzed, including research trends, growth of publications, citation metrics, the most active research areas, organizations, and countries, the top-cited articles, citations between countries, and co-occurrences and link strengths among authors' keywords and international collaborations between the countries.

RESULTS AND DISCUSSION

Publication Trends

The trends of publications related to the genus *Etlingera* from 1993 to 2023 are shown in Figure 2. The number of documents fluctuated since 1993 and increased gradually after 2018. The increasing number of published papers demonstrates the growing interest and relevance of *Etlingera* research. Furthermore, it indicates that this field of study is gaining traction in the scientific world, receiving increased attention from researchers, organizations, and many countries. In addition, there is more potential for citations and collaborations, which can increase the general visibility and impact of the research on *Etlingera*, resulting in more cross-disciplinary studies. The highest number of documents was in 2021 and 2022 (n=32) accounting for 9.73%, and no document on this topic was published in 1994 and 2002. The oldest paper was published in 1993 by Lechat-Vahirua et al. entitled 'Aromatic Plants of French Polynesia. I. Constituents of the Essential Oils of Rhizomes of Three Zingiberaceae: Zingiber zerumbet Smith, *Hedychium coronarium* J. Koenig and *Etlingera cevuga* Smith' (Lechat-Vahirua et al. 1993).

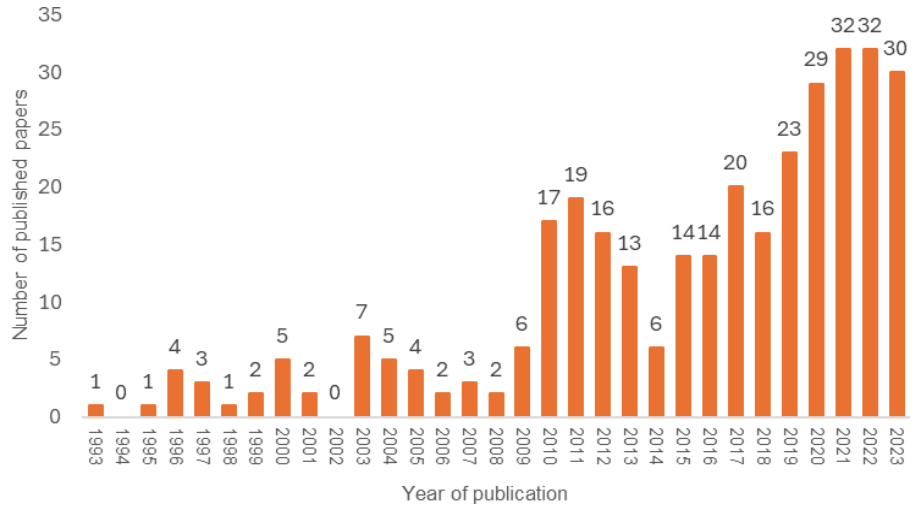

Figure 2 Number of publications on genus Etlingera throughout the years. Numbers above bars represent the total number of papers published in each year.

Table 1 represents the citation metrics of the total publications between 1993 and 2023. We discovered 329 documents published during this period, with a total of 5073 citations. The sample presents an average citation rate of 163.65 citations per year and 15.42 citations per paper. However, 33 documents, or 10.03%, have never been cited, and 187 documents, or 56.84%, have been cited one to ten times.

Table 1 Summary of citation metrics for publications on genus *Etlingera* from 1993 to 2023.

Metrics	Data
Publication years	1993-2023
Citation years	31 (1993-2024)
Papers	329
Citations	5073
Citations/year	163.65
Citations/paper	15.42
Citations/author	1267.69
Papers/author	96.75
h-index	33
g-index	61

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Table 2 summarizes the annual publications for the retrieved documents for the last ten years. The number of paper citations was the most in 2017 (n=294), with citations per paper (C/P) being 14.70 and citations per cited paper (C/CP) being 22.61. The highest h-index (10) was observed in 2019 while the highest g-index (17) was observed in 2017. The lowest citations of the paper were found in 2023, with citations per paper (C/P) and citations per cited paper (C/CP) values of 1.47 and 2.44, respectively.

Table 2 Annual publications for the retrieved documents on genus Etlingera over the last ten years.

Year	TP	NCP	TC	C/P	C/CP	h-index	g-index
2023	30	18	44	1.47	2.44	4	4
2022	32	28	135	4.22	4.82	5	9
2021	32	30	207	6.47	6.90	9	12
2020	29	28	205	7.07	7.32	9	12
2019	23	22	233	10.13	10.59	10	14
2018	16	14	100	6.25	7.14	7	9
2017	20	13	294	14.70	22.61	8	17
2016	14	9	189	13.50	21.00	7	13
2015	14	9	135	9.64	15.00	6	11
2014	6	6	68	11.33	11.33	5	6

Notes: TP = total number of publications; NCP = number of cited publications; TC = total citations; C/P = average citations per publication; C/CP = average citations per cited publication; h = h-index; and g = g-index.

Contribution by Research Areas

The 329 publications have been classified into research areas. The top ten research areas in terms of the number of publications are listed in Table 3. Based on the selected articles, the field of 'Agriculture and Biological Sciences' accounts for 184 publication records, making it the largest field of study for the genus *Etlingera* (55.92% of total documents). This is followed by 'Biochemistry, Genetics and Molecular Biology' (23.71%:78 documents), and Pharmacology, Toxicology and Pharmaceutics (21.28%:70 documents). Despite their well-known traditional medicinal uses, *Etlingera* plants remain underexplored in terms of their pharmacological potential. Investigating the bioactive compounds could lead to the drug discovery for various diseases. Moreover, the evaluation of their safety and toxicity is crucial to ensure they can be safely used for medicinal and pharmaceutical purposes. Given their medicinal properties, exploring the research areas of pharmacology, toxicology, and pharmaceutics holds immense potential for future scientific and medical advancements.

Table 3 Distribution of publications by research area on genus *Etlingera* studies.

Ranking	Items	Records (n)	Percentage (of 329)
1	Agricultural and Biological Sciences	184	55.92
2	Biochemistry, Genetics and Molecular Biology	78	23.71
3	Pharmacology, Toxicology and Pharmaceutics	70	21.28
4	Medicine	49	14.89
5	Chemistry	44	13.37
6	Environmental Science	23	6.99
7	Multidisciplinary	15	4.56
8	Immunology and Microbiology	14	4.25
9	Material Science	8	2.43
9	Social Science	8	2.43
10	Engineering	7	2.13

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CONTRIBUTION BY COUNTRIES

Fifty-four countries have published studies on the genus *Etlingera* since 1993. The number of papers by the top ten countries in this area of study is shown in Table 4. The countries in the Asian continent dominated the list whereby Malaysia was the leading publishing country with 103 publications, followed by Indonesia (79), Thailand (40), Australia (30), and Brazil (30). Using VOSviewer software (1.6.20), Figure 3 shows that Malaysia has published the most articles on the genus *Etlingera*.

Table 4 Distribution of publications on genus *Etlingera* by country

Ranking	Items	Records (n)	Percentage (of 329)
1	Malaysia	103	31.31
2	Indonesia	79	24.01

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3	Thailand	40	12.16
4	Australia	30	9.12
4	Brazil	30	9.12
5	Iran	16	4.86
5	United Kingdom	16	4.86
6	Philippines	13	3.95
7	United States	12	3.65
8	India	9	2.73
9	China	7	2.13
9	Japan	7	2.13
10	Denmark	6	1.82

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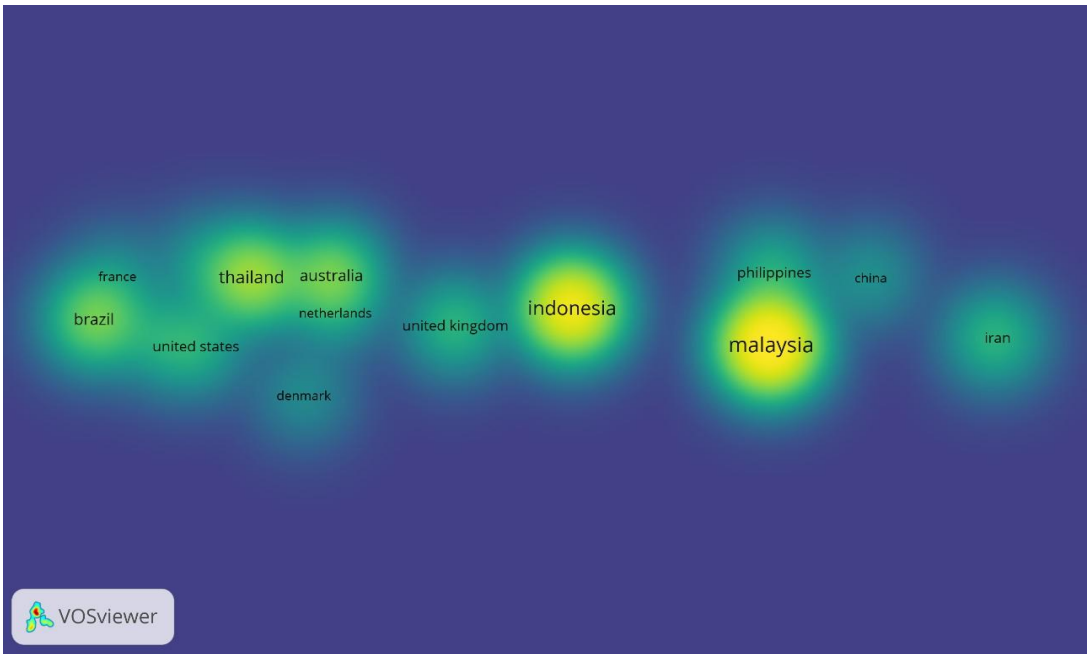

Figure 3 Density map of countries where the papers were published. Countries with a greater number of publications have brighter spots. Malaysia has published the most articles on the genus Etlingera.

Contribution by Organizations

A total of 160 organizations provided research studies on the genus *Etlingera*. Table 5 shows the top ten organizations that published genus *Etlingera*-related research from this total of 160. The top three were Universiti Putra Malaysia (31 documents), Universiti Kebangsaan Malaysia (21 documents), and Universitas Halu Oleo, Indonesia (15 documents). These organizations have published 15 or more articles in this area of research.

Table 5 Distribution of publications on genus Etlingera by organization.

Ranking	Items	Records (n)	Percentage (of 329)
1	Universiti Putra Malaysia	31	9.42
2	Universiti Kebangsaan Malaysia	21	6.38
3	Universitas Halu Oleo	15	4.56
4	Universitas Padjadjaran	12	3.65
5	The University of Queensland and Hakim Sabzevari University	11	3.34
6	Chiang Mai University, Burapha University, Monash Royal Botanic Garden Edinburgh University, and	9	2.73
7	Universidade Federal de Lavras, Universiti Malaysia Sabah, and Lembaga Ilmu Pengetahuan Indonesia	8	2.43
8	Universiti Sains Malaysia, IPB University, and Universitas Tadulako	7	2.13

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9	Universiti Teknologi MARA, Department of Agriculture and Food Western Australia, Universiti Malaysia Sarawak, Universidade Federal de Pernambuco, Universitas Sumatera Utara, Universitas Syiah Kuala, Universiti Tun Hussein Onn Malaysia, and Badan Riset dan Inovasi Nasional	6	1.82
10	Politeknik Bina Husada Kendari, Universidade Federal Rural de Pernambuco, Mahasarakham University, Cranfield University, Prince of Songkla, Universiti Malaya, Commonwealth Scientific and Industrial Research Organisation, Herbarium Bogoriense, Universitas Bengkulu, Universitas Riau, Central Mindanao University, Universiti Sultan Zainal Abidin, and Embrapa Agroindustria Tropical	5	1.52

Analysis of Articles' Citation

Among the 329 selected articles, 121 articles had been cited at least 10 times, and 7 had been cited more than 100 times. Table 6 shows the top ten most frequently cited publications in the genus *Etlingera* research. The most cited article was 'Effects of different drying methods on the antioxidant properties of leaves and tea of ginger species', which was cited 412 times (Chan et al. 2009). The article was published in 'Food Chemistry'. In that study, Chan et al. determined the effects of five different drying methods on the antioxidant properties of leaves of *Alpinia zerumbet*, *Etlingera elatior*, *Curcuma longa*, and *Kaempferia galanga*. This paper is highly cited because it contributes to determining which drying processes best preserve or boost antioxidant levels, which are necessary for both medicinal use and food processing. The findings of this work can be used as a baseline for future research on other medicinal plants that require phytochemical preservation throughout processing. Thus, this paper gives important information on how to preserve the health benefits of medicinal plants through proper drying procedures, having implications for both industrial applications and consumer health. Interestingly, the top three most cited articles were published in 'Food Chemistry'.

Table 6 Top ten most cited articles on genus *Etlingera* in the Scopus Database

Author	Title	Year	Source	Cited by
Chan et al. 2009	Effects of different drying methods on the antioxidant properties of leaves and tea of ginger species	2009	Food Chemistry	412
Chan et al. 2008	Antioxidant and tyrosinase inhibition properties of leaves and rhizomes of ginger species	2008	Food Chemistry	297
Andarwulan et al. 2010	Flavonoid content and antioxidant activity of vegetables from Indonesia	2010	Food Chemistry	246
Chan et al. 2007	Antioxidant and antibacterial activity of leaves of Etlingera species (Zingiberaceae) in Peninsular Malaysia	2007	Food Chemistry	243
Sulaiman et al. 2019	Effect of solvents in extracting polyphenols and antioxidants of selected raw vegetables	2011	Journal of Food Composition and Analysis	233
Crous et al. 2017	Fungal planet description sheets: 558-624	2017	Persoonia: Molecular Phylogeny and Evolution of Fungi	151
Wijekoon et al. 2011	Effect of extraction solvents on the phenolic compounds and antioxidant activities of bunga kantan (Etlingera elatior Jack.) inflorescence	2011	Journal of Food Composition and Analysis	146
Mohamad et al. 2005	Antioxidative constituents of Etlingera elatior	2005	Journal of Natural Products	89
Mackeen et al. 1997	Antimicrobial and cytotoxic properties of some Malaysian traditional vegetables (Ulam)	1997	International Journal of Pharmacognosy	89
Ghasemzadeh et al. 2015	Secondary metabolites constituents and antioxidant, anticancer and antibacterial activities of Etlingera elatior (Jack) R.M.Sm grown in different locations of Malaysia	2015	BMC Complementary and Alternative Medicine	84
Lachumy et al. 2010	Pharmacological activity, phytochemical analysis and toxicity of methanol extract of Etlingera elatior (torch ginger) flowers	2010	Asian Pacific Journal of Tropical Medicine	84

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Jackie et al. 2011	Antioxidant effects of Etlingera elatior flower extract against lead acetate - Induced perturbations in free radical scavenging enzymes and lipid peroxidation in rats	2011	BMC Research Notes	79
Ficker et al. 2003	Inhibition of human pathogenic fungi by members of Zingiberaceae used by the Kenyah (Indonesian Borneo)	2003	Journal of Ethnopharmacology	79

The second most cited article, 'Antioxidant and tyrosinase inhibition properties of leaves and rhizomes of ginger species' was published in 2008 and received 297 citations (Chan et al. 2008). The study demonstrated that leaves of *Etlingera* species have high total phenolic content (TPC) and ascorbic acid equivalent antioxidant capacity (AEAC). It also highlighted that some species displayed tyrosinase inhibition activity that can be utilized in cosmetic applications. Tyrosinase is an enzyme involved in melanin production, and its overactivity can lead to hyperpigmentation. Meanwhile, the third most cited article, which received 246 citations was published in 2010, entitled 'Flavonoid content and antioxidant activity of vegetables from Indonesia' (Andarwulan et al. 2010). The study identified and quantified flavonoid compounds of eleven leafy green vegetables, including *E. elatior*, from West Java, Indonesia, and screened them for antioxidant activity and total phenols. All the top-cited papers are highly valuable, particularly for researchers seeking to follow the outlined methodologies. In comparison to other authors, articles by Chan et al. contribute the largest number of citations.

Co-occurrence of Authors' Keywords

The co-occurrence of the keywords of the authors was conducted using the VOSviewer software (1.6.20) to determine the frequency of keywords, which will help researchers identify the most popular topics and trends in the genus *Etlingera* research. Of the 329 selected articles, there were 996 keywords provided by the authors. The minimum number of occurrences of a keyword was set as 4. A total of 26 keywords met the threshold, and the mapping is shown in Figure 4. A total of 9 keywords occurred more than 10 times in the titles, keywords, and abstracts of the 329 published papers. The results revealed that the top five authors' keywords were '*Etlingera*' (97 occurrences), 'Zingiberacea' (60 occurrences), 'antioxidant' (44 occurrences), 'essential oil' (25 occurrences), and 'torch ginger' (22 occurrences). These keywords were grouped into five clusters and nodes with the same color indicating a similar topic among the publications. The size of the circle nodes in the visualized map indicated the frequency of the analyzed items. *Etlingera* has the most links, with 21 links and 94 total link strength. The keyword '*Etlingera*' is connected to antioxidant, antimicrobial activity, and antiinflammatory, which indicates the pharmacological activities of *Etlingera*.

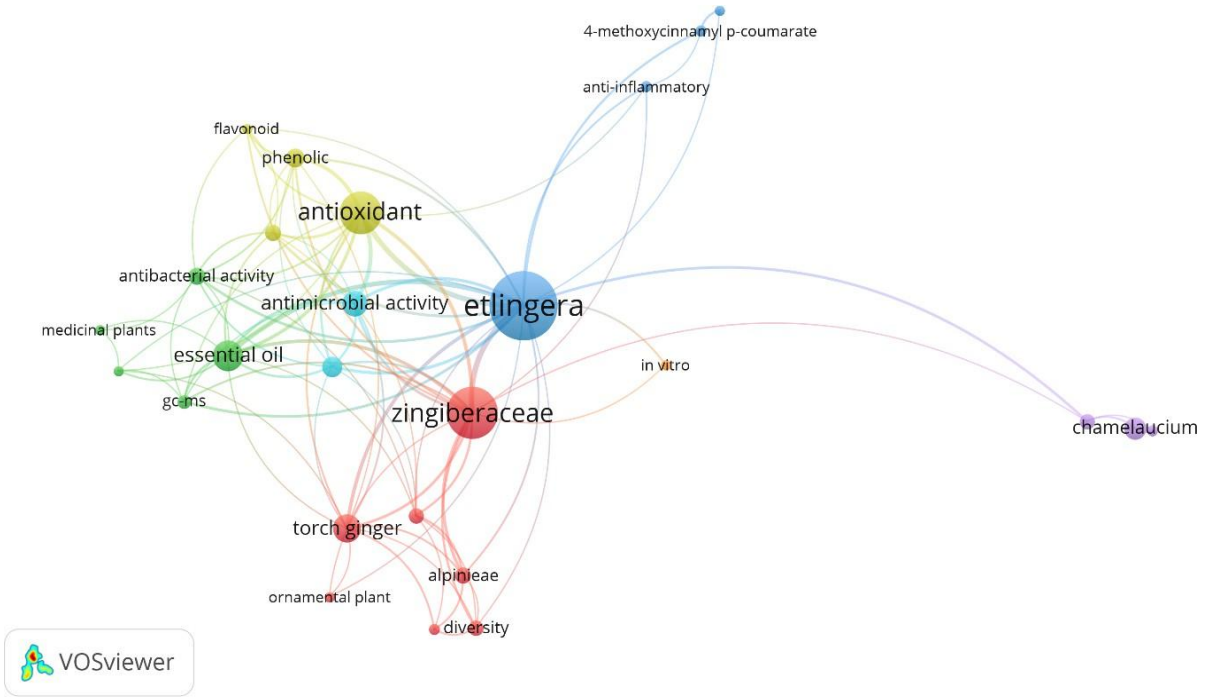

Figure 4 Network visualization map of co-occurrence analysis of authors' keywords in genus Etlingera research. Different clusters represent major research topics encountered in the retrieved documents. 'Etlingera' is the most frequently used term for the field of genus Etlingera.

Analysis of Collaboration between Countries

The collaborations of countries were visualized using co-authorship analysis. The diagram of interaction among the co-authorship from various countries was generated by VOSviewer (Figure 5). The minimum number of papers and the minimum number of citations for a country were set at 2 and 0. A total of 31 countries out of 56 countries met the threshold, resulting in four clusters or four node colors. The first cluster is in red and made up of Australia, Brazil, Czech Republic, Denmark, Ecuador, France, India, Japan, Netherlands, Nigeria, Norway, Poland, Spain, Thailand, the United States, and Vietnam. The second cluster is green and consists of China, Indonesia, Papua New Guinea, the Philippines, Saudi Arabia, Singapore, and the United Kingdom. Meanwhile, the third cluster is blue, including Iran, Iraq, Malaysia, South Korea, and Sudan. The fourth cluster is purple, consisting of Bangladesh, Brunei Darussalam, and Turkey. The strength of co-authorship is represented by the node size in the diagram, whereby the larger the node, the greater the co-authorship with other countries (Sajovic & Boh Podgornik 2022). Malaysia has the largest node, representing the most connections to other countries, with 13 links and a total link strength of 35.

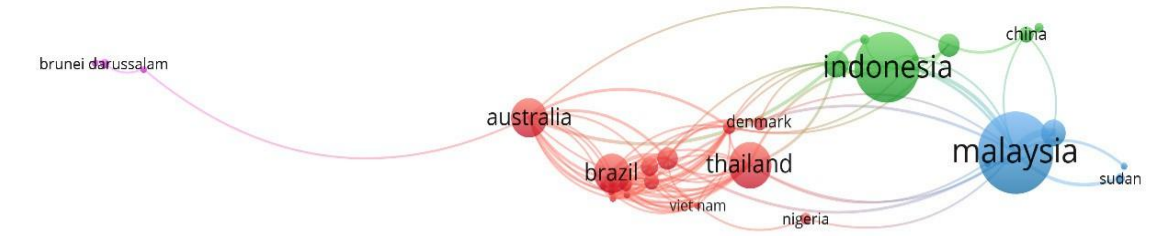

Figure 5 Network visualization map of international collaboration among countries in genus Etlingera research. The thickness of the connecting line between the two countries shows the strength of collaboration. Countries with a similar color form one cluster.

CONCLUSION

In conclusion, the genus *Etlingera* represents a fascinating group of plants with substantial medicinal, economic, and industrial significance. Interdisciplinary research integrating pharmacology, chemistry, ethnobotany, and molecular biology is necessary to explore further. This study discovered a fluctuating number of articles between 1993 and 2018. A gradual increase in the number of articles was observed after 2018. 'Agriculture and Biological Sciences' is the largest research area for the genus *Etlingera*. The data obtained identified Malaysia as the most productive country and Universiti Putra Malaysia as the most productive organization in researching the genus *Etlingera*. The topmost-cited article is 'Effects of different drying methods on the antioxidant properties of leaves and tea of ginger species' by Chan et al. (2009), which was cited 412 times. In addition, *'Etlingera'* is the most frequently used term for the field of genus *Etlingera*. Malaysia has the most connections to other countries, followed by Indonesia and Thailand. Through this data, we hope to contribute valuable knowledge to botany and the field of complementary medicine for the well-being of humankind. It also highlights the substantial pharmacological potential of the *Etlingera* plant, serving as a bridge between traditional and modern medicine, while also revealing a significant gap in research related to pharmacology and drug development. This will also encourage researchers to explore these remarkable plants, helping to consolidate current research trends and suggest directions for future research on genus *Etlingera*.

ACKNOWLEDGEMENT

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CONFLICT OF INTEREST

No conflict of interest in this work.

AUTHORS' CONTRIBUTIONS

All authors made substantial contributions to the conception and design, extraction, analysis and interpretation of data, drafting and revising the article, and agreed to submit it to the current journal.

REFERENCES

Andarwulan N, Batari R, Sandrasari DA, Bolling B. &, Wijaya H. 2010. Flavonoid content and antioxidant activity of vegetables from Indonesia. *Food Cchemistry*. 2010 Aug 15;121(4): 1231-5. doi:https://doi.org/10.1016/j.foodchem.2010.01.033.

Chan, E.W., Lim, Y.Y. &, Wong, S.K. 2011. Phytochemistry and pharmacological properties of Etlingera elatior: a review. *Pharmacognosy Journal*, 3(22):, 6-10.

Chan, E.W., Lim, Y.Y., Omar, M. 2007. Antioxidant and antibacterial activity of leaves of Etlingera species (Zingiberaceae) in Peninsular Malaysia. *Food chemistry*, 104(4):, 1586-93. doi:https://doi.org/10.1016/j.foodchem.2007.03.023.

Chan, E.W., Lim, Y.Y., Wong, L.F., Lianto, F.S., Wong, S.K., Lim, K.K., Joe, C.E., Lim, T.Y. 2008. Antioxidant and tyrosinase inhibition properties of leaves and rhizomes of ginger species. *Food Cchemistry*, 109(3):, 477-83. doi:https://doi.org/10.1016/j.foodchem.2008.02.016.

Chan, E.W., Lim, Y.Y., Wong, S.K., Lim, K.K., Tan, S.P., Lianto, F.S., Yong, M.Y. 2009. Effects of different drying methods on the antioxidant properties of leaves and tea of ginger species. *Food Cchemistry*, 113(1):, 166-72. doi:https://doi.org/10.1016/j.foodchem.2008.07.090.

Crous, P.W., Wingfield, M.J., Burgess, T.I., Hardy. G.S., Barber, P.A., Alvarado, P., Barnes, C.W., Buchanan, P.K., Heykoop, M., Moreno, G., Thangavel, R.. 2017. Fungal Planet description sheets: 558–624. *Persoonia: Molecular Phylogeny and Evolution of Fungi*, 38:, 240. doi:http://dx.doi.org/10.3767/003158514X682395.

Fawzy A, Putranti IO. 2023. The Potential Role of Kecombrang (Etlingera Elatior) Extract in Wound Management: A Review on its Anti-Oxidative, Anti-Inflammatory, Antimicrobial, and Anti-Melanogenesis Effects. *International Journal of Medical Science and Clinical Research Studies*, 3(10):, 2361-7. doi:https://doi.org/10.47191/ijmscrs/v3-i10-49.

Ficker, C. E., Smith, M. L., Susiarti, S., Leaman, D. J., Irawati, C., & Arnason, J. T. 2003. Inhibition of human pathogenic fungi by members of Zingiberaceae used by the Kenyah (Indonesian Borneo). *Journal of ethnopharmacology*, 85(2-3):, 289-293.

Ghasemzadeh, A., Jaafar, H. Z., Rahmat, A., & Ashkani, S. 2015. Secondary metabolites constituents and antioxidant, anticancer and antibacterial activities of Etlingera elatior (Jack) RM Sm grown in different locations of Malaysia. BMC complementary and alternative medicine, 15, 1-10.

Ismail, N.A., & Ridzuan, R. 2023. Medicinal potential and health benefits of torch ginger (Etlingera elatior). *Notulae Scientia Biologicae*, 15(4):, 11489-. doi: https://doi.org/10.55779/nsb15411489.

Jabbar, A., Hamzah, H., Windarsih, A., Pratiwi, S. U. T., & Rohman, A. 2024. LC-MS Analysis, Antioxidant and Anti-inflamatory Activity, Isolation of secondary Metabolite of Ethanol Extract Stem of Etlingera rubroloba AD Poulsen. *Case Studies in Chemical and Environmental Engineering*:, 100780.

Jackie, T., Haleagrahara, N., & Chakravarthi, S. 2011. Antioxidant effects of Etlingera elatior flower extract against lead acetate-induced perturbations in free radical scavenging enzymes and lipid peroxidation in rats. *BMC research notes*, 4:, 1-8.

Joseph, E., & Godoong, E. 2023. A Review of Etlingera coccinea (Blume) S. Sakai and Nagam (Zingiberaceae) on Achievement of Producing An an Essential Oil and Medicinal Properties in Sabah, East Malaysia. *Journal of Tropical Biology & Conservation (JTBC)*, 20:, 295-303. doi: https://doi.org/10.51200/jtbc.v20i.4668.

Juwita, T., Puspitasari, I.M., Levita, J. 2018. Torch ginger (Etlingera elatior): A review on its botanical aspects, phytoconstituents and pharmacological activities. *Pakistan Journal of Biological Sciences*, 21(4):, 151-65. doi:https://doi.org/10.3923/pjbs.2018.151.165.

Koch, D., Sarkar, A., Hajong, B., Singh, S. D., Gogoi, G., Kshattry, M., ... & Bharali, P. 2024. A scientific overview of the genus Etlingera Giseke (Aromatic Ginger): Botanical, traditional, phytochemical and pharmacological aspects. *South African Journal of Botany*, 167:, 130-144.

Lachumy, S. J. T., Sasidharan, S., Sumathy, V., & Zuraini, Z. 2010. Pharmacological activity, phytochemical analysis and toxicity of methanol extract of Etlingera elatior (torch ginger) flowers. *Asian Pacific Journal of Tropical Medicine*, 3(10):, 769-774.

Lechat-Vahirua, I., François, P., Menut, C., Lamaty, G. &, Bessiere, J.M. 1993. Aromatic plants of French Polynesia. I. Constituents of the essential oils of rhizomes of three Zingiberaceae: Zingiber zerumbet Smith, Hedychium coronarium Koenig and Etlingera cevuga Smith. *Journal of Essential Oil Research*, 5(1):, 55-9. doi:https://doi.org/10.1080/10412905.1993.9698170.

Leong-Skornickova, J., Dang, T. H., Binh, N. Q., Hlavata, K., Truong, L. H., Dat, N. Q., ... & Newman, M. 2019. The identity of Amomum trilobum and Amomum unifolium (Zingiberaceae: Alpinioideae), and description of four new related species from

Vietnam. *Phytotaxa*, 401(3):, 149-65. doi: https://doi.org/10.11646/phytotaxa.401.3.1.

Mackeen, M.M., Ali, A.M., El-Sharkawy, S.H., Manap, M.Y, Salleh KM, Lajis NH, Kawazu K. 1997. Antimicrobial and cytotoxic properties of some Malaysian traditional vegetables (ulam). *International Journal of Pharmacognosy*, 35(3):, 174-8. doi:https://doi.org/10.1076/phbi.35.3.174.13294.

Mahdavi, B. 2014. Chemical constituents of the aerial parts of Etlingera brevilabrum (Zingiberaceae). *Der Pharma Chemica*, 6(2):, 360-365.

Mohamad, H., Lajis, N.H., Abas, F., Ali, A.M., Sukari, M.A., Kikuzaki, H., Nakatani, N. 2005. Antioxidative Constituents of Etlingera elatior. *Journal of Natural Products*, 68(2):, 285-8. doi:https://doi.org/10.1021/np040098l.

Naksang, P., Tongchitpakdee, S., Thumanu, K., Oruna-Concha, M.J., Niranjan ,K., Rachtanapun, C. 2020. Assessment of antimicrobial activity, mode of action and volatile compounds of Etlingera pavieana essential oil. *Molecules*. 25(14):, 3245. doi:https://doi.org/10.3390/molecules25143245.

Noordin, L., Wan Ahmad, W. A. N., Muhamad Nor, N. A., Abu Bakar, N. H., & Ugusman, A. 2022. Etlingera elatior Flower Aqueous Extract Protects against Oxidative Stress-Induced Nephropathy in a Rat Model of Type 2 Diabetes. *Evidence-Based Complementary and Alternative Medicine*, 2022(1):, 2814196. doi:https://doi.org/10.1155/2022/2814196.

Nor, N. A. M., Noordin, L., Bakar, N. H. A., & Ahmad, W. A. N. W. 2020. Evaluation of antidiabetic activities of Etlingera elatior flower aqueous extract in vitro and in vivo. *Journal of Applied Pharmaceutical Science*, 10(8):, 043-051. doi:https://10.7324/JAPS.2020.10805.

Nor, N.A., Azmi, N.A., Noordin, L., ABU, N.H. 2019. Aqueous extract of Etlingera elatior flowers improved blood glucose control, kidney function and histology of streptozotocin-induced diabetic rat. *Journal of Sustainability Science and Management*, 14(3):, 80-91.

Oktavia, G. A. E., Kuswantoro, F., & Wardhani, P. K. 2019. Traditional utilization of ginger torch (Etlingera elatior (Jack) RM Sm.) in Bedugul, Bali and its conservation in Bali Botanic Garden. In AIP Conference Proceedings (Vol. 2120, No. 1). AIP Publishing.

Poulsen AD. 2006. *Etlingera of Borneo*, 1st ed. Natural History Publications (Borneo).

Poulsen AD. 2007. Etlingera Giseke of Java. *Garden's Bulletin Singapore*, 59(1&2):, 145-72.

POWO., 2022: https://powo.science.kew.org/taxon/urn:lsid:ipni.org:names:328393-2; accessed 16th May 2024.

Pranckutė R. 2021. Web of Science (WoS) and Scopus: The titans of bibliographic information in today's academic world. *Publications*, 9(1): ,12. doi:https://doi.org/10.3390/publications9010012.

Saensouk, P., & Saensouk, S. 2021. Diversity, traditional uses and conservation status of Zingiberaceae in Udorn Thani Province, Thailand. *Biodiversitas Journal of Biological Diversity* , 22(8). doi:https://doi.org/10.13057/biodiv/d220801

Sajovic, I., & Boh Podgornik. B. 2022. Bibliometric analysis of visualizations in computer graphics: a study. *Sage Open*. 12(1): 21582440211071105. doi:https://doi.org/10.1177/21582440211071105.

Sujarwo, W., Keim, A. P., Savo, V., Guarrera, P. M., & Caneva, G. 2015. Ethnobotanical study of Loloh: Traditional herbal drinks from Bali (Indonesia). *Journal of Ethnopharmacology*, 169:, 34-48. doi:https://doi.org/10.1016/j.jep.2015.03.079.

Sulaiman, S.F., Sajak, A.A., Ooi, K.L., Seow, E.M. 2011. Effect of solvents in extracting polyphenols and antioxidants of selected raw vegetables. *Journal of Food Composition and analysis*, 24(4-5):, 506-15. doi:https://doi.org/10.1016/j.jfca.2011.01.020.

Ud-Daula, A. S., & Basher, M. A. 2019. Genus Etlingera-A review on chemical composition and antimicrobial activity of essential oils. *Journal of Medicinal Plants Research*, 13(7):, 135-156. doi:https://doi.org/10.5897/JMPR2019.6740.

Wijekoon, M.J., Bhat, R. &, Karim, A.A. 2011. Effect of extraction solvents on the phenolic compounds and antioxidant activities of bunga kantan (Etlingera elatior Jack.) inflorescence. *Journal of food composition and analysis*, 24(4-5):, 615-9. doi:https://doi.org/10.1016/j.jfca.2010.09.018.

Yuan, H., Ma, Q., Ye, L. , & Piao, G. 2016. The traditional medicine and modern medicine from natural products. *Molecules*, 21 (5).

Yunus, M.F., Meenakshi Sundram, T.C., Zainuddin, Z., Ismail, N.A., Mohd Rosli, N., & Mohamad Hamdan, M.S. 2022. Current status and biotechnological development of Etlingera elatior, a promising horticultural and medicinal plant. *The Journal of Horticultural Science and Biotechnology*, 97(4):, 429-36. doi:https://doi.org/10.1080/14620316.2021.2021812.