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Global research trends of the studies on *Murraya koenigii* (L.) spreng: a Scopus-based comprehensive bibliometric investigation (1965–2023)

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Abstract

Background *Murraya koenigii* (L.) Spreng. has several well-established nutritional and therapeutic applications. Following our desire to investigate the global and scientific community's knowledge of medicinal plants, this study was intended to examine the evolution of knowledge related to *M. Koenigii* studies. The primary purpose of this paper is to clarify the status of these studies, investigate their methods, findings, and trends, and define their significance within the current research landscape.

Results To achieve these goals, bibliometric analysis was conducted, retrieving, and analyzing 934 original articles published between 1965 and 2023 based on Scopus Dataset results. Data were exported as CVS (comma-separated values) and BibTex files and analyzed using Bibliometrix and VOSviewer software. Articles from 502 sources have been identified, averaging 21.8 citations per document. The research in this plant has had exponential growth ($R^2 = 0.77$). International co-authorship is 13.08%. India and Malaysia are the top publishing countries. Debajo, A.C. (Nigeria), Phatak, R.S. (India), and Sukari, M.A. (Malaysia) are the most productive authors. The top source is the Journal of Ethnopharmacology. "Green synthesis," "nanoparticles," "oxidative stress," "Asian citrus psyllid," "apoptosis," "antimicrobial," "anticancer," "Chromatographic profile," "bioactive compounds," and "alkaloids" are strongly related to the current trends in *M. Koenigii* research. Regarding the specialized topics, *M. Koenigii*'s study concentrated on using this plant as an antioxidant agent in manufacturing and biological systems. Dynamic subjects like chromatographic profiles, essential oils, and Asian citrus psyllids were included in the motor theme.

Conclusions The current study used bibliometric techniques to evaluate research on *M. Koenigii* and identify trends and potential future research hot spots.

Keywords *Murraya koenigii*, Curry tree, Knowledge structure and impact, International networking, Vosviewer, R-package

Background

Curry leaf tree, or *Murraya koenigii*, was a small tree or shrub that grew up to a height of 6 m and belonged to the family Rutaceae. It was found in tropical and sub-tropical regions. Countries such as India, Bangladesh, and Sri Lanka all have it in their populations. Ayurveda, the traditional medical practice of India, makes use of almost every part of this plant to treat a wide variety of

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conditions. These parts include the plant's fresh leaves, fruits, bark, and roots. In traditional medicine, green curry leaves were frequently utilized for the treatment of piles, inflammation, itching, fresh cuts, dysentery, and edema. While the bark was helpful in treating snake-bites, the roots were traditionally used to alleviate pain throughout the body (Aniqa et al. 2022; Bhupatiraju et al. 2023; Husna et al. 2018; Mondal et al. 2022b; Singh et al. 2023; Tan et al. 2022). Even after drying, dried *M. Koenigii* leaves maintain their recognizable aroma, as well as their slightly spicy and somewhat astringent flavor profiles. *M. Koenigii* both fresh and dried are widely used in South Indian cooking as a seasoning and flavoring agent and are considered to be an essential ingredient in the cuisine of that region (El-Shiekh et al. 2023; Sablania et al. 2023; Singh et al. 2023).

Chromatographic and spectroscopic methods identified many structurally diverse natural products from *M. Koenigii* leaves, roots, stem bark, fruits, and seeds. In phytochemical studies for biologically active constituents, terpenoids, alkaloids, flavonoids, coumarins, polyphenols, and essential oils were isolated (Balakrishnan et al. 2020). *M. Koenigii* contains over fifty carbazole-type alkaloids with potent pharmacological activities. Major alkaloids koenimbine, mahanimboline, mahanine, murrayafoline, mahanimbine, isomahanine, murrayazoline, koenoline, mahanimboline, and mukoline were cytotoxic (Abeyasinghe et al. 2021a; Balakrishnan et al. 2020). Mahanimbinine, murrayacinine, isomahanine, and mahanimbine were antimicrobial, antioxidant, antidiabetic, and antihyperlipidemic. In *M. Koenigii*, antioxidant carbazole alkaloids included mukonicine, murrayanine, koenine, koenigine, mukoeic acid, murrayanol, 9-formyl-3-methylcarbazole, and O-methylmurrayamine A, while antimicrobial alkaloids included murrayanine, murrayacine, mahanine, mukoline, girinimbine, and pyrafolione D. The *M. Koenigii* non-alkaloidal compounds epicatechin, catechin, quercetin, naringin, myricetin, and rutin were antioxidant and anticancer compounds. Ferulic, vanillic, gallic, and acids also boost *M. Koenigii*'s antioxidant capacity (Aniqa et al. 2022; Bhupatiraju et al. 2023; Husna et al. 2018; Mondal et al. 2022a; Nawrot et al. 2022; Samanta et al. 2018).

Curry leaves were abundant in magnesium, potassium, calcium, and phosphorus, in addition to traces of zinc, manganese, selenium, and iron. In addition, lead, mercury, and cadmium were present. Diverse leaf samples of *M. Koenigii* were collected from various geographic locations, and due to varying climate, soil, and other geo-environmental conditions, the average elemental contents varied. Changes in plants grown in polluted soils revealed elevated levels of metals, which posed a serious threat to human health because they could affect the

kidney, liver, and central nervous system (Abeyasinghe et al. 2021b; Nagappan et al. 2012; Narendhirakannan et al. 2005).

M. Koenigii has a number of well-established therapeutic potentials, including hypoglycemic, hypolipidemic, nephroprotective, hepatoprotective, gastroprotective, cardioprotective, atherosclerotic, and cholesterol lowering effects in experimental animals. The alcoholic extract of the leaf possessed antioxidant, analgesic, anti-inflammatory, antipyretic, antitrichomonal, antibacterial, antifungal, antileishmanial, antidiarrheal, wound-healing, anti-obesity, anticancer, and immunomodulatory activities. The carbazole alkaloid mahanine, which was purified from *M. Koenigii*, acted as a proteasome inhibitor and displayed antihyperglycemic action. These two effects contributed to the mahanine's anticancer activity (Bhupatiraju et al. 2023; Mondal et al. 2022a, 2022b; Nazeer et al. 2022; Ramsewak et al. 1999b; Wadanambi et al. 2023; Wassmuth-Wagner et al. 1995).

Following our interest in exploring the global and scientific community's knowledge of medicinal plants, this paper provides an overview of the knowledge regarding the mechanisms of action and the essential bioactive components present in this plant. This work is also susceptible to the influence of the knowledge produced, its size, and its global dissemination. It also provides a real-time platform for all those interested in traditional medicine to learn about the parties working in this field to facilitate future scientific collaboration. To accomplish this, we utilized bibliometric methods to unearth our intent. Where no such reference is available for this tree. According to our knowledge, this paper is the first to conduct a bibliometric analysis of knowledge and research on this tree.

Methods

Database, data acquisition, and querying

The bibliometric study was carried out with the assistance of the Scopus database as a primary source. Scopus is a platform owned by Elsevier and comprises a sizable collection of bibliographic databases, citations, and references from scientific publications in any field of knowledge, including science, technology, social sciences, arts, and humanities (Al-Khoury et al. 2022). Scopus can be accessed through the Elsevier website. The search terms are related to "*Murraya koenigii*" (title, abstract, or keywords). The study's time frame was 1965–2023. The data were extracted on June 13, 2023. There were only journal articles present. The languages of the documents published are limited to English only. Conference proceedings, articles, books, etc., were also excluded. The procedure flow used to gather data and conduct queries are shown in Fig. 1.

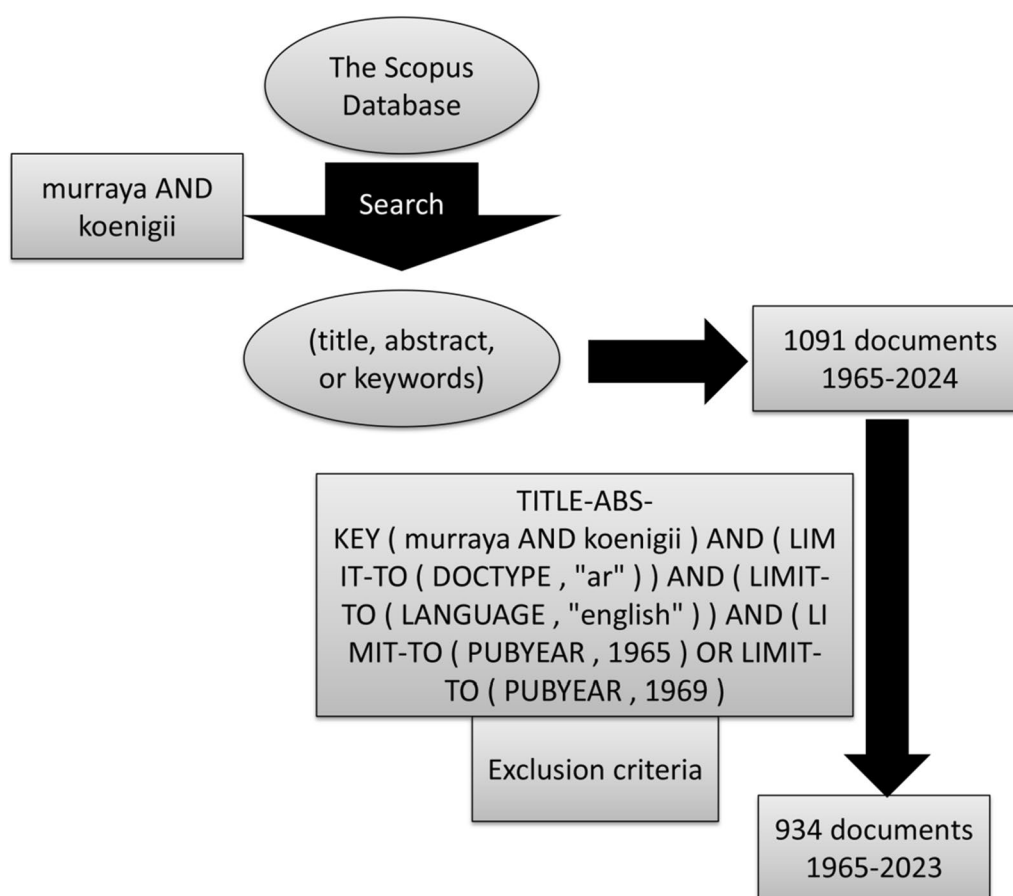


Fig. 1 Data search strategy in the Scopus database. ar: article; PUBYEAR: publication year; DOCTYPE: type of the document

Data filtering and sample size

From 1965 to 2024, 1091 *M. Koenigii*-related works were retrieved from the Scopus database. The researchers identified and analyzed 934 original articles. The final publication date for these papers is 2023. Therefore, all papers published after this date were excluded from the current study. The inclusion of these works in the present research, despite belonging to the same period defined in the search term, may distort the interpretation of the data, and the growth of the analysis because they belong to something other than the calendar year of the period under review. According to the guidelines for bibliometric investigations, any sample size greater than 200 research documents is sufficient to execute a reliable study (Rogers et al. 2020). The final data were exported from the Scopus database as two file types, CVS and Bib format.

Analysis tools: bibliometrix and vosviewer

Open-source tools for quantitative scientometric and bibliometric research that cover all the major

bibliometric methods of analyses include Bibliometrix (R Package) and Vosviewer (Oladinrin et al. 2023). These tools enable researchers to study and visualize the various research cooperation networks established or developing patterns in a particular field of knowledge, as well as to highlight the most pertinent documents, journals, nations, authors, and institutions. Bibliometrix (R Package) and Vosviewer have been used in a number of studies. Research in the areas of biology, artificial intelligence (Hou and Yu 2023), Pharmacology (Abdelwahab et al. 2023; Ge et al. 2022; Li et al. 2022; Wang et al. 2022), and social research (Hou and Yu 2023) and data science (Nobanee 2021) are a few examples.

Results

Main information about the collection

The main findings of the analysis—document type, document content, and author collaboration—are presented in Table 1. With 934 documents total and an average of 21.8 citations per document, the study covers the years 1965 to 2023. The study has shown that articles in 502 scientific sources. Only 2532 of the

Table 1 Main information

Timespan	1965:2023
Sources (Journals, Books, etc.)	502
Documents	934
Annual Growth Rate %	4.14
Document Average Age	10.4
Average citations per doc	21.8
Document contents	
Keywords Plus (ID)	8971
Author's Keywords (DE)	2532
Authors	
Authors	3047
Authors of single-authored docs	29
Authors collaboration	
Single-authored docs	33
Co-Authors per Doc	4.28
International co-authorships %	13.08
Document types	
Article	934

8971 keywords used in the study sample were used by authors, out of all the works that make up the study sample. It should be noted that this kind of publication contains relatively few single authors. Thirt-three of the 934 recovered works were written by just one author. The total number of scholars who participated to the literature of this tree is 3047.

Country, affiliation, and author scientific production

Figure 2 shows the distribution of scientific production frequencies worldwide by the affiliation country. A total of 66 countries have contributed to the publication of journal articles on *M. Koenigii*-related works. Within the top 5, we appreciate how India in 1st position (1167 freq.) and the Malaysia in 2nd position (192 freq.) stands out on the hegemony of academic-scientific production, followed in the 3rd position by the USA (60 freq.), in 4th position Pakistan (58 freq.) and 5th position China (53 freq.). Universiti Putra Malaysia, Universiti Teknologi MARA, (Malaysia), Bose Institute, University of Calcutta, Central Drug Research Institute (India) had the highest number of published articles on *M. Koenigii*. Debajo, A.C. (Obafemi Awolowo University, Nigeria), Phatak, R.S. (Deemed University, India), and Sukari, M.A. (Universiti Putra Malaysia, Malaysia) are the highest productive authors with nine documents for each.

Figure 3 shows the annual production volume (1965–2023) of research on *M. Koenigii*. The research in this area has experimented an exponential growth ($R^2=0.77$). In descending order: 2022 (with 72 articles published), 2012 and 2021 (61 articles), 2011 (59 articles), 2015 (58 articles), and 2014 (56 articles).

Three field plot

Observing the trends in the study topics, countries, and states of *M. Koenigii* publications in addition to the annual production is crucial. Author keywords are in the center of Fig. 4, authors are on the right, and countries

Country Scientific Production

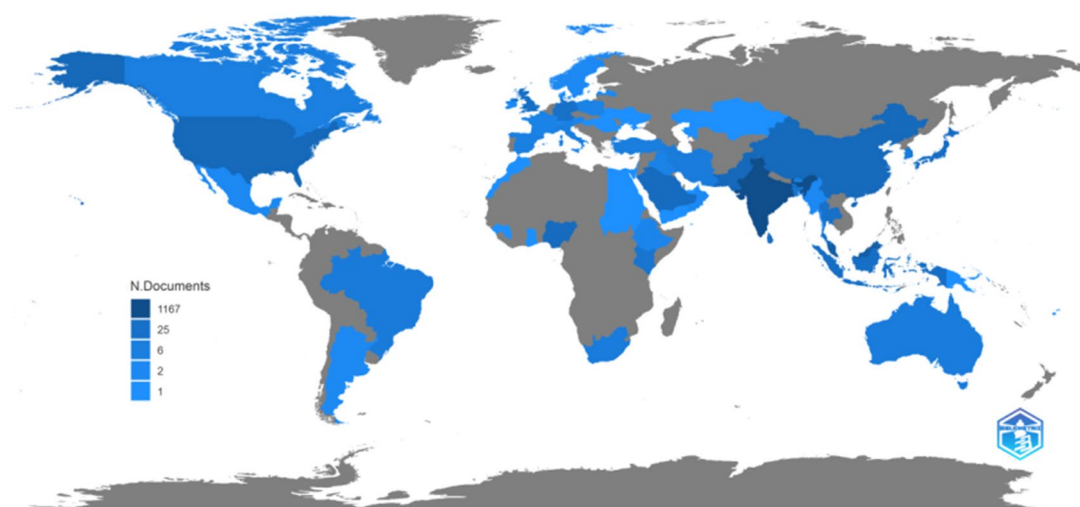


Fig. 2 Country production. The map illustrates the scientific productivity attributed to the plant under investigation in the research. The aforementioned figure was generated with the Bibliometrix program. There exists a positive correlation between the intensity of the blue hue and the level of scientific productivity

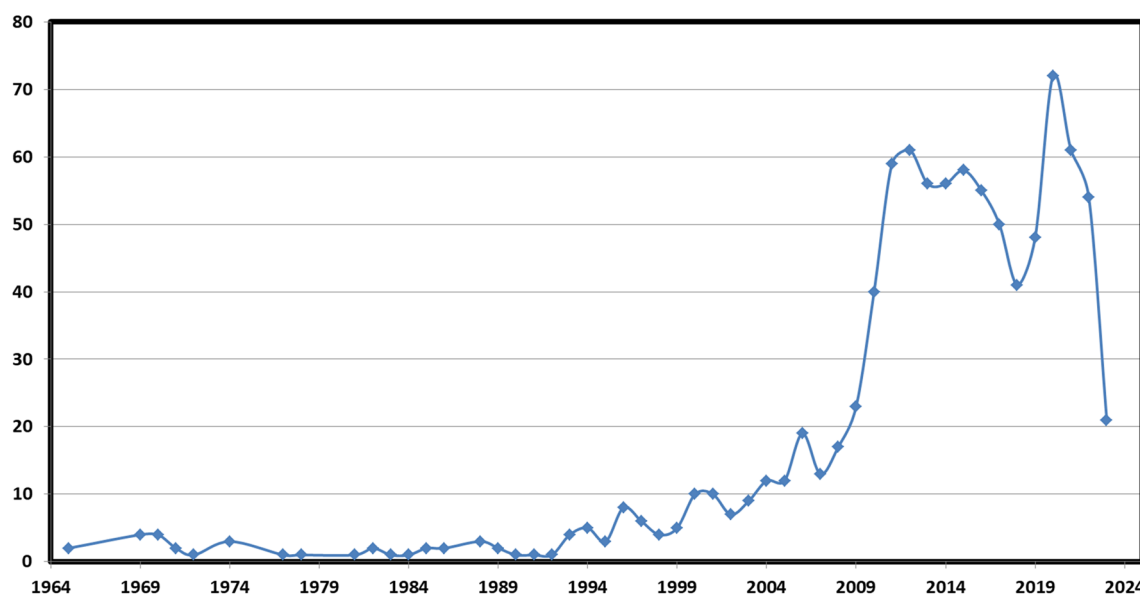


Fig. 3 Annual scientific production related to *M. Koenigii*. The figure was generated using MS-Excel ($n = 934$). The data were extracted on June 13, 2023

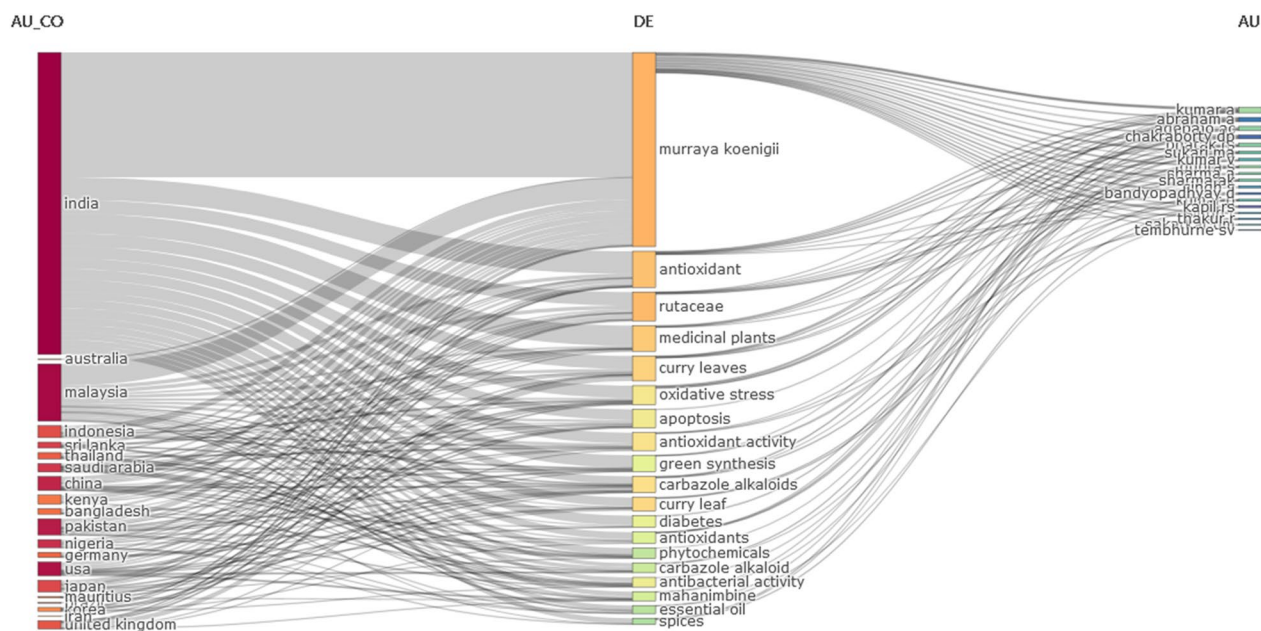


Fig. 4 Three field plots of country, keyword, and authors. The figure was generated using biblioshiny application in Bibliomatrix and Bib data format ($n = 934$). AU: author; AU_CO: country of the author; DE: keywords

are on the left. This Figure shows the threefold examination of *M. Koenigii* publications. The graph demonstrates that India leads Malaysia, Pakistan, Indonesia, and China regarding top countries for *M. Koenigii*-related publications. They are researching *M. Koenigii* with India because it is considered one of the countries where *M.*

Koenigii is planted. When examining the authors' keywords, we find that India has participated in all the research on this plant, as this is evident from the flow we notice in Fig. 4. As for some countries, such as the United Kingdom, their research was limited to a narrow range. Many researchers have studied leaves' biological and

chemical properties, such as antioxidant activities, anti-cancer properties, green synthesis, antibacterial activity, essential oil, and anti-diabetic properties.

Table 2 displays the top 20 journals in which the most papers on *M. Koenigii* were published. The total number of sources is 502. A total number of 934 articles regarding *M. Koenigii* were published in these journals between 1965 and 2023 and indexed in the Scopus database. The top four journals were the Journal of Ethnopharmacology (22 papers), International Journal Of Pharma And Bio-Sciences (18 documents), Phytochemistry (14 documents), and Asian Journal Of Chemistry (12 documents). Although the Journal of Ethnopharmacology has the highest number of citations, Food Chemistry and the Journal Of Agricultural And Food Chemistry have the highest average of citations. This means that the research published in these two journals has a more cognitive impact than those published in the first.

Trendy topics

Trendy topics have evolved over the last 60 years, as shown in Fig. 5. The analysis of trendy topics was performed in Bibliometrix applications using keywords. Keywords such as "green synthesis," "nanoparticles," "oxidative stress," "anti-diabetic," "Asian citrus psyllid," "apoptosis," "antimicrobial," "anticancer," "HPLC,"

"bioactive compounds," "phytochemicals," and "alkaloids" are strongly related to the current trends in *M. Koenigii* research. The term frequency is shown in blue circles (Fig. 5), and the time span of the keyword is shown in the horizontal line. The term "Rutaceae" has the most extended shelf life.

Thematic map

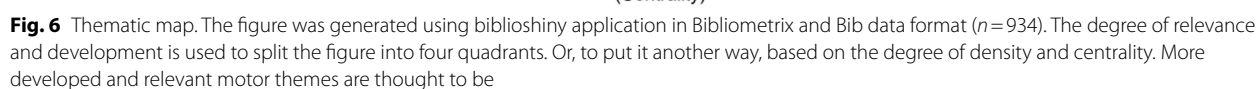
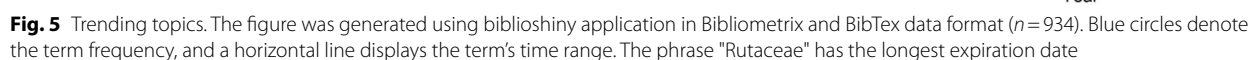
The thematic map divides the majority of topics into two groups: motor themes and fundamental themes, both of which have a high centrality but a low density. The basic and motor topics have a lot of potential, and researchers can successfully pursue them. The specialized and motor themes' topics are frequently covered in great detail in the *M. Koenigii* literature. Though they have been examined, the worries in the case of *M. Koenigii* have not fully developed. Due to the research that has been done and the requirement for more effort, this problem is moving from emergent to basic. The phrase "Huanglongbing (yellow dragon disease)," which is both an emerging subject and one of the core ideas, is one such example. Therefore, there is a clear need for more research. Figure 6 depicts where the themes are located. These themes are generated through clustering. A bibliometric analysis and enrichment method is clustering. Its main objective is to organize network clusters into topic clusters, track

Table 2 Top publishing sources according to Scopus database

Journal name	Number of articles	Citations	CA
1. Journal of Ethnopharmacology	22	2012	91.45
2. International Journal of Pharma and Bio Sciences	18	114	6.33
3. Phytochemistry	14	677	48.36
4. Asian Journal of Chemistry	12	53	4.42
5. Food Chemistry	11	1274	115.82
6. Asian Journal of Pharmaceutical and Clinical Research	10	77	7.70
7. Evidence-Based Complementary and Alternative Medicine	10	365	36.50
8. International Journal of Pharmacy And Pharmaceutical Sciences	10	68	6.80
9. International Journal of Pharmtech Research	10	86	8.60
10. Research Journal of Pharmacy And Technology	10	19	1.90
11. Fitoterapia	8	330	41.25
12. International Food Research Journal	8	306	38.25
13. International Journal Of Pharmacognosy And Phytochemical Research	8	17	2.13
14. Journal Of Food Science And Technology	8	147	18.38
15. Natural Product Communications	8	139	17.38
16. Pharmacognosy Journal	7	32	4.57
17. Asian Journal Of Microbiology, Biotechnology And Environmental Sciences	6	5	0.83
18. Asian Pacific Journal Of Tropical Biomedicine	6	180	30.00
19. Journal Of Agricultural And Food Chemistry	6	652	108.67
20. Journal Of Essential Oil Research	6	87	14.50

The sources were chosen based on the fact that they contain the largest number of documents related to the curry tree

CA: citation average or the average number of citation per year



these topic clusters' development, and understand how a study field emerges and changes. Antioxidant activity, antibacterial activity, diabetes, oxidative stress, and carbazole alkaloids were the main themes. Regarding the specialized topics, *M. Koenigii*'s study concentrated on using this plant as an antioxidant agent in manufacturing and biological systems. Dynamic subjects like HPLC profile, essential oil, and Asian citrus psyllid were included in the motor theme. No matter where the research on *M. Koenigii* is conducted, it is clustered in Table 3. There were discovered 14 clusters, which included Asian citrus psyllid, *Acacia nilotica*, Huanglongbing, *Psidium guajava*, and host plant. Other clusters included curry leaves, *Murraya koenigii*, medicinal plants, Rutaceae, free radical scavenging activity, mild steel, HPLC, and anti-inflammatory.

Thematic evolution

The topic development of *M. Koenigii* literature since 1965 is seen in Fig. 7. Using the author's keywords, the thematic progression demonstrates the development of topics through time. One-time breaks lead to two-time segments, and "biblioshiny" is used to develop thematically. To preserve a more realistic image of the issue's

progression, the researcher's judgment will choose how to divide the time period. The first section covers the years 1965 through 2014 and the second, 2015 through 2023. Over time, themes developed. The primary focus of *M. Koenigii* research has always been ethnopharmacological findings. Analysis shows that from 1965 to 2014, the studies began to include medicinal properties of the plant and its pure compounds including anti-inflammatory, antioxidant, antifungal, antinociception, and ethnobotanical studies. As a result, research on *M. Koenigii* shows an increasing tendency until 2022. From 2015 forward, the research on this tropical tree has advanced dramatically. The topics were more versatile. Researchers have explored new areas such as pure compound isolation, phytochemical screening, identity of curry leaves as spice, green chemistry, spray drying, biological activities of girinimbine, and mahanine, and mild steel. Figure 8 was generated by utilizing the VOSviewer program for the years 2015 through 2023 for the purpose of delving more into the dynamics of knowledge and locating research subjects that have surfaced more lately. According to the indicator that is located next to Fig. 8, recently discussed subjects include programmed cell death and green synthesis.

Table 3 Clustering of thematic structure*

Author's keywords**	Cluster	Name of the cluster
Plant Extracts, Antifungal Activity, Larvicidal Activity, In Vitro	1	Plant extracts
Curry Leaves, Antioxidant Activity, Antibacterial Activity, Essential Oils, Total Phenolic Content, Drying, DPPH assay, Minimum Inhibitory Concentration, Phenolic Content, Coriander, Ethnobotany	2	Curry leaves
<i>Murraya koenigii</i> , Antioxidant, Carbazole Alkaloids, Apoptosis, Green Synthesis, Mahanimbine, Carbazole, Alkaloid, Antimicrobial Activity, Antibacterial, Cytotoxicity, Mahanine, Alkaloids, Antimicrobial, Silver Nanoparticles, Anticancer, Breast Cancer, Antidiabetic Activity, Antifungal, Carbazole, Nanoparticles, Girinimbine	3	<i>Murraya koenigii</i>
Medicinal Plants, Oxidative Stress, Diabetes, Antioxidants, Phytochemicals, Spices, Diabetes Mellitus, Antidiabetic, Aegle Marmelos, Medicinal Plant, Streptozotocin, Alloxan, Aqueous Extract, Lipid Peroxidation, Phytochemical, Alzheimer's Disease, Bioactive Compounds, Free Radicals, Hepatotoxicity, Herbs, Molecular Docking, Acetylcholinesterase, Ayurveda, Cholesterol		
Hyperglycemia, India	2	Medicinal plants
Rutaceae, Curry Leaf, Essential Oil, Essential Oil Composition, GC-MS, A-Pinene, Bergera Koenigii, <i>M. Koenigii</i> , Monoterpenes, <i>Murraya koenigii</i> Spreng, B-Caryophyllene, B-Phellandrene	5	Rutaceae
Free Radical Scavenging Activity, Reducing Power, B-Carotene, Green Leafy Vegetables	6	Free radical scavenging activity
Mild Steel, Corrosion	7	Mild steel
HPLC	8	HPLC
Carotenoids, Chlorophyll, Flavonoids, Anti-Inflammatory, Anti-Diabetic, Moringa Oleifera, Analgesic, Coriandrum Sativum, Curcuma Longa	9	Anti-inflammatory
Asian Citrus Psyllid, Auranthioideae	10	Asian citrus psyllid
<i>Acacia Nilotica</i>	11	<i>Acacia nilotica</i>
Huanglongbing (Citrus greening disease)	12	Huanglongbing
<i>Psidium Guajava</i>	14	<i>Psidium guajava</i>
Host Plant	15	Host plant

*This table is linked to Fig. 6, which presents the terms used by the program to build each cluster. The cluster was named by giving it the name of the most frequent word in that cluster

**The clustering was conducted using biblioshiny application in Bibliometrix and Bib data format ($n=934$)

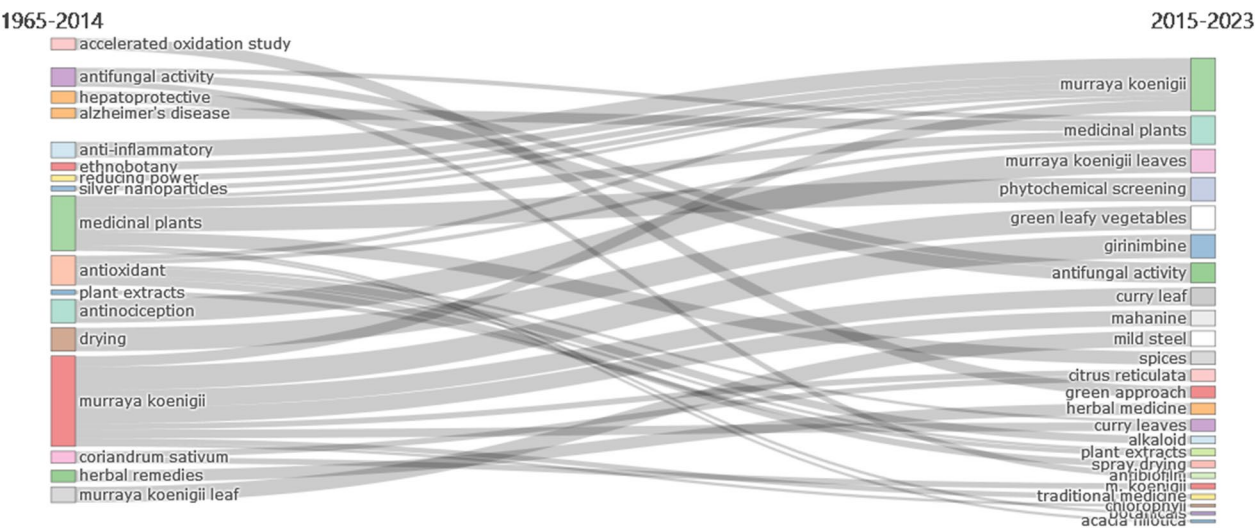


Fig. 7 Thematic evolution. The figure was generated using biblioshiny application in Bibliometrix and Bib data format ($n = 934$). Bigger boxes show the strength of the terms. The lines represent the intellectual correspondence link between the terms

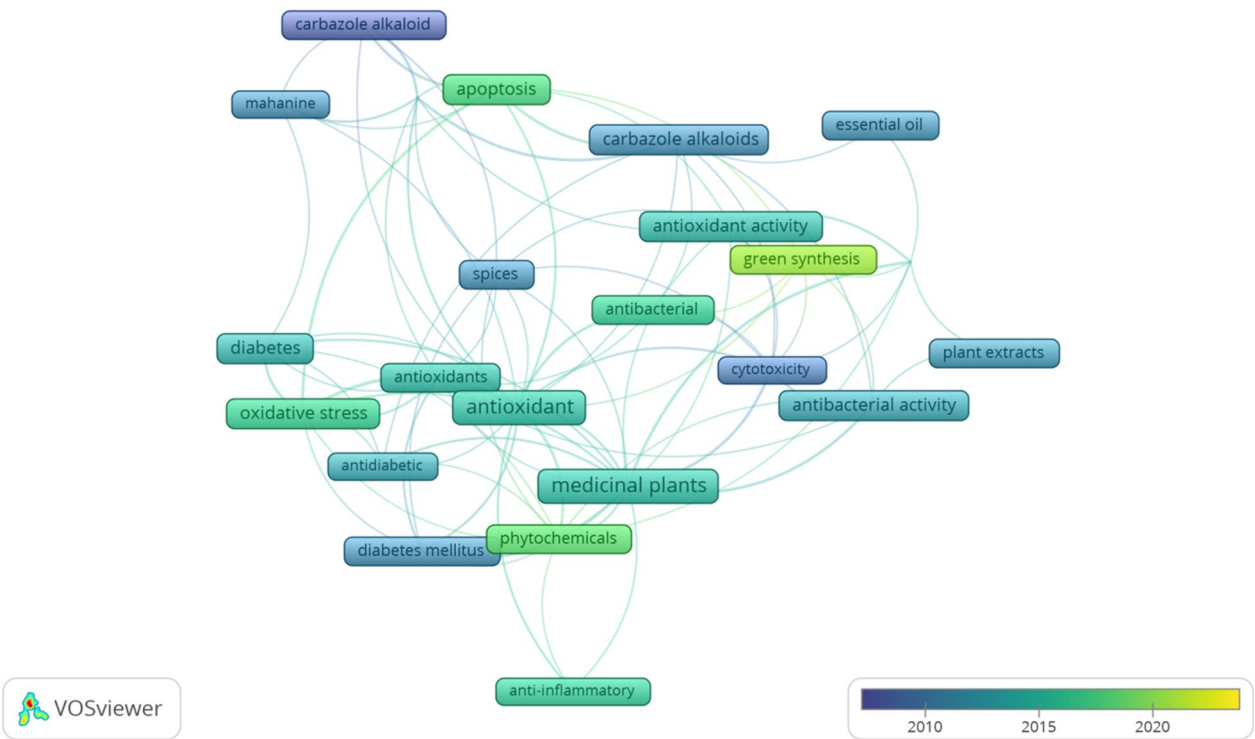


Fig. 8 Overlay visualization for the past fifteen years of author's keywords. Mapping was generated VOSviewer for the years 2015 through 2023 for the purpose of delving more into the dynamics of knowledge and locating research subjects that have surfaced more lately. The shapes represent the number of documents. The lines represent the intellectual correspondence link between the terms. The bar represents the temporal analysis of the keyword and their

Social analysis: co-authorship analysis

VOSviewer was used to assess the collaborative research globally. A total of 66 countries have contributed to the

publication of journal articles on *M. Koenigii*-related works. Six clusters were mapped for 23 countries, which met the criteria of minimum number 5 documents

(Fig. 9). India possessed the largest node in the red cluster with Total Link Strength of 52. Indian institutions collaborated significantly with Bangladesh, Pakistan, China, Australia, Canada, and Spain. Four countries formed the green cluster with Malaysia as the strongest collaborator. Germany, United States, UK, Saudi Arabia are the top collaborators in the blue, yellow, purple clusters, respectively. Biblioshiny parameters for author's collocation are shown in Table 1.

Impactful research: citation analysis

The total number of citations for all 934 is 20,366, with an H-index of 68 (Fig. 8). The H-index of 68 is marked by the yellow star (Fig. 10). Table 4 lists the most cited documents, their journals, citations, and citation average in regard to research on *M. Koenigii* between 1965 and 2023. The article "Antioxidant Activities of Aqueous Extracts of Selected Plants" received the highest number of citations (621) and citation average (36.53). The Journal of Ethnopharmacology and Food Chemistry score the highest citation numbers with 2012 and 1274, respectively. The Department of Pharmacognosy, Faculty of Pharmacy, Obafemi Awolowo University, Nigeria, received a score of 275, followed by the Central Drug

Research Centre, India ($n=134$). India, Malaysia, and the USA had citation numbers of 13000, 2087, and 1041, respectively.

Discussion

This paper examines studies' status, issues, methodologies, findings, and trends, as well as their relevance to current research related to *M. Koenigii*. Using Scopus Database findings, bibliometric analysis was performed on 934 publications published between 1965 and 2023. It has not been established in any of the previously conducted study that this plant, which is notable for its beneficial effects on both nutrition and health, has been the subject of any bibliometric investigations into the dynamics of existing knowledge or the identification of potential research topics.

The curry tree, also known as *M. Koenigii* or *Bergera koenigii*, is a species of tree that is endemic to Asia and may be found growing in both tropical and subtropical climates. The highest amount of articles devoted to studying this plant has come out of Asia, specifically from countries like India and Malaysia. This could be due to the fact that the tree originated in these nations, its widespread usage in medicine and cooking, and the fact that

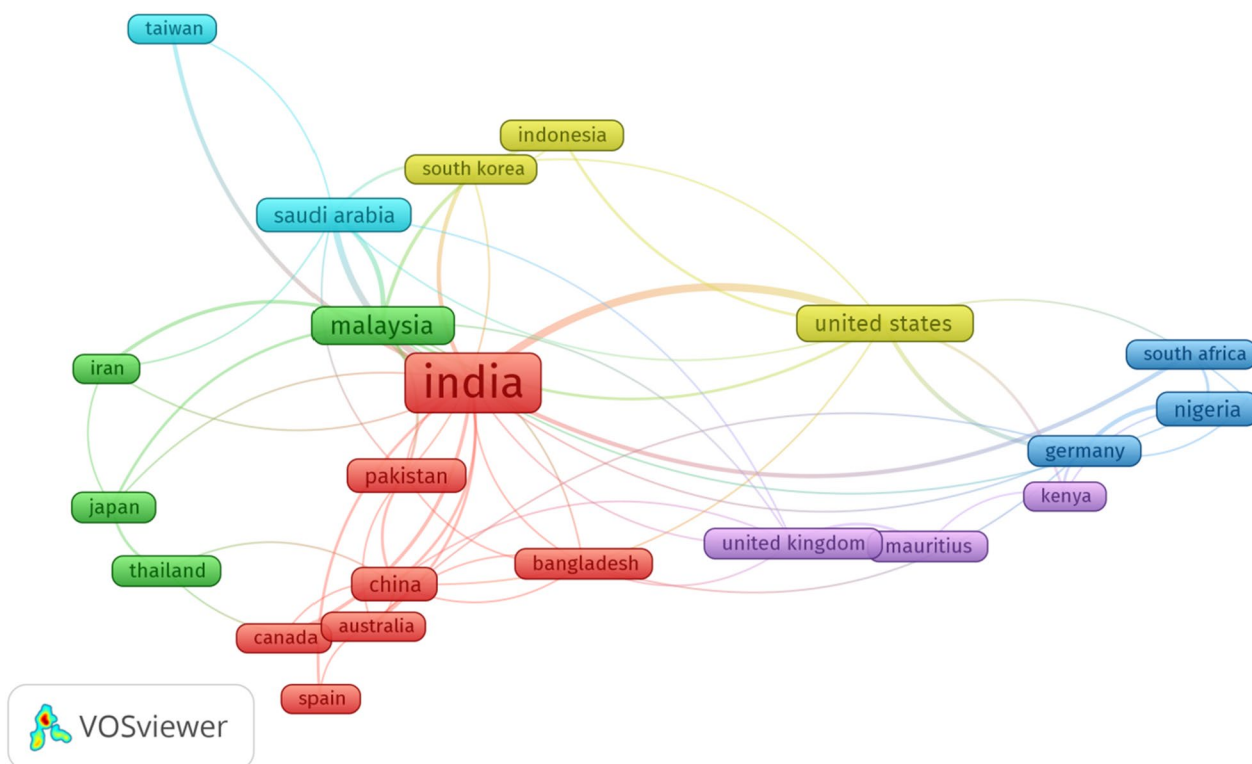


Fig. 9 International collaboration. VOSviewer mapping of the top 23 documents with more than five documents was performed. The shapes represent the number of documents. The lines represent the collaboration link between the countries. Countries with the same color had more collaboration among them

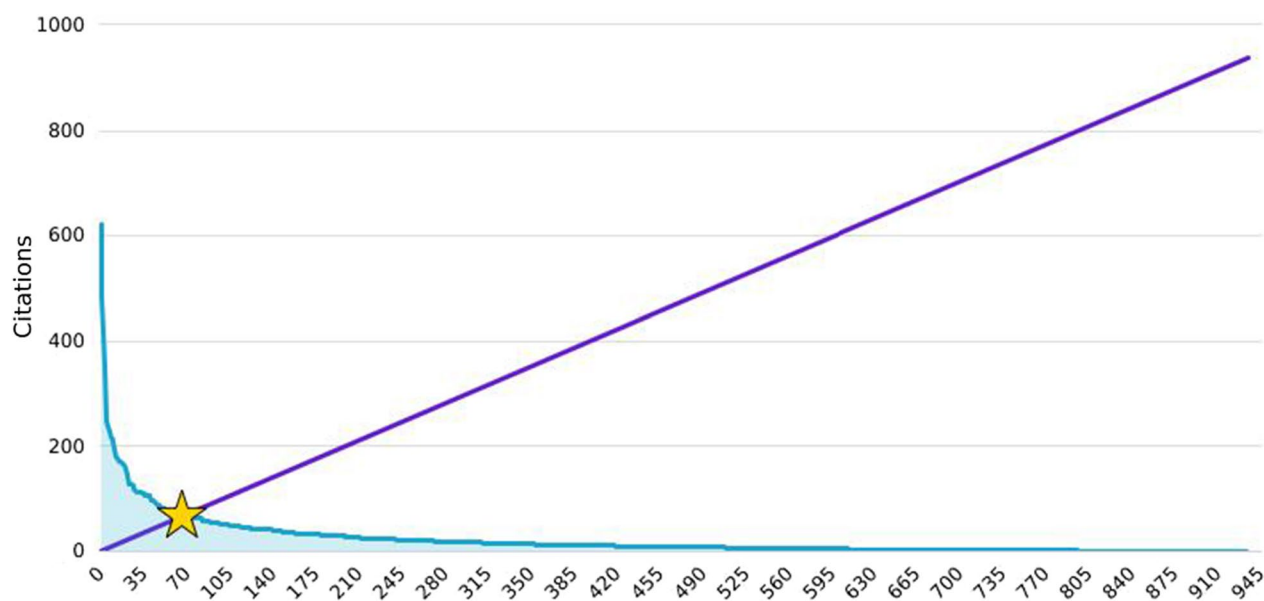


Fig. 10 Citation score (H-index = 68). Figure was generated using Scopus Analytics feature. High h-index is characterized by having published a minimum number of works that have received an equal or greater number of citations

Table 4 The most cited documents

No	Title of the document	Source	Year	Citation	Citation average (CA)
1	Antioxidant activities of aqueous extracts of selected plants	Food Chemistry	2006	621	36.53
2	Antimicrobial activity of certain Indian medicinal plants used in folkloric medicine	Journal of Ethnopharmacology	2001	482	21.91
3	Green approach to corrosion inhibition of mild steel in hydrochloric acid and sulfuric acid solutions by the extract of <i>Murraya koenigii</i> leaves	Materials Chemistry and Physics	2010	420	32.31
4	<i>Murraya koenigii</i> leaf-assisted rapid green synthesis of silver and gold nanoparticles	Spectrochimica Acta—Part A: Molecular and Biomolecular Spectroscopy	2011	352	29.33
5	Antioxidative activity of carbazoles from <i>Murraya koenigii</i> leaves	Journal of Agricultural and Food Chemistry	2001	254	11.55
6	Evaluation of antioxidant and anticancer activity of copper oxide nanoparticles synthesized using medicinally important plant extracts	Biomedicine and Pharmacotherapy,	2017	248	41.33
7	Green synthesis of iron nanoparticles using different leaf extracts for treatment of domestic waste water	Journal of Cleaner Production	2016	237	33.86
8	Biologically active carbazole alkaloids from <i>Murraya koenigii</i>	Journal of Agricultural and Food Chemistry	1999	215	8.96
9	Antioxidant activity of plants methanolic extracts containing phenolic compounds	African Journal of Biotechnology	2009	213	15.21
10	Antidiabetic medicinal plants as a source of alpha glucosidase inhibitors	Current Diabetes Reviews	2010	208	16.00
Total citations of the top cited articles		3250			

* Benalla et al. (2010), Devatha et al. (2016), Huda-Faujan et al. (2009), Philip et al. (2011), Quraishi et al. (2010), Ramsewak et al. (1999a), Rehana et al. (2017), Srinivasan et al. (2001), Tachibana et al. (2001) and Wong et al. (2006)

these countries make use of the collected research experience. Research in nations outside of Asia, including Nigeria, the United States, and the United Kingdom, has also demonstrated the plant's significance. Adebajo, A.C., a Nigerian researcher, accumulated a substantial body of knowledge about the curry tree. The biochemical, pharmacological, phytochemical, and toxicological activities of crude extract and some alkaloids obtained from the leaves of *M. Koenigii* grown in Nigeria were studied by him and his team from the Department of Pharmacognosy, Faculty of Pharmacy, Obafemi Awolowo University, Nigeria (Adebajo et al. 2006, 2009, 2014; Adebajo and Reisch 2000; Reisch et al. 1994).

The top journal in the dissemination of *M. Koenigii* research is the Journal of Ethnopharmacology. Nearly all of this plant's parts are used in Ayurveda, the Indian system of traditional medicine, to cure a wide range of ailments. The plant's new leaves, fruits, bark, and roots are among these components. Green curry leaves were commonly used in traditional medicine to treat piles, inflammation, itching, new cuts, diarrhea, and edema. While the roots were traditionally used to cure generalized pain, the bark proved useful for healing snakebites (Adebajo et al. 2009; Jain et al. 2017; Tan et al. 2022). About 30% of the papers published in the journal were ethnobotanical studies on this tree (Aniqa et al. 2022; Bhupatiraju et al. 2023; Husna et al. 2018; Kamsani et al. 2020; Mondal et al. 2022b; Singh et al. 2023). At the same time, the remaining number (16/22) reviewed experimental studies on many biological properties of this plant. Food Chemistry is the most impactful journal in *M. Koenigii* research as demonstrated in Table 2 with citation average of 115.82. This journal accommodated various articles on the antioxidant properties of this plant (Biswas et al. 2012; Choudhury and Garg 2007; Ningappa et al. 2008; Raju et al. 2007; Rao et al. 2007; Wong et al. 2006). It is generally known that consuming more vegetables and medicinal herbs along with antioxidants lowers the chance of developing certain ailments (Zahin et al. 2013). The dietary use of this plant may explain the research interest in its antioxidant properties and the intensity of studies on this property.

Trendy topics have evolved over the last 60 years, as shown in Fig. 5. Publication keywords are frequently employed to expose the knowledge structure of study domains and are regarded as the fundamental components of conveying knowledge concepts in bibliometric research. Research topic analysis based on co-word clustering, knowledge mapping based on co-word networks, and hotspot discovery and trend analysis based on keyword frequency analysis are all covered in related studies (Aniqa et al. 2022; Bhupatiraju et al. 2023; Husna et al. 2018; Mondal et al. 2022b; Singh et al. 2023). The

latest trending topics in *M. Koenigii* research are green synthesis and nanoparticles. In the field of phytochemistry, biogenetically manufacturing nanoparticles from plant derivatives and exploring their potential for usage as novel therapeutics has been one of the hot research issues. The focus of current research on nanoparticles is the range of applications for green synthesis (Shreyash et al. 2021). In recent studies, green chemistry was used to synthesize zinc oxide nanoparticles using zinc nitrate and the bioactive ingredients in *M. Koenigii* leaf extract (Lakshmikandhan 2020; Qais et al. 2019). One of the important topics that will shape future research on this tree is green synthesis. This can be linked to the fact that this tree began to enter other environmental ranges and leave its original habitat. The tree is tropical or subtropical and indigenous to Bangladesh, India, and Pakistan. More recently, in Australia, commercial plantations have been built. It is grown throughout tropical Africa in nations like Nigeria, Kenya, Tanzania, and the majority of the islands in the Indian Ocean, where Indian immigrants landed (Adebajo et al. 2006, 2009, 2014, 2004; Adebajo and Reisch 2000; Balakrishnan et al. 2020; Nazeer et al. 2022; Panda 2014; Sharma et al. 2013).

In this study, we used bibliometric analysis to explore the intellectual structure of *M. Koenigii* literature. The majority of topics are divided into two groups on the thematic map: motor themes and fundamental themes, both of which have a high centrality but low density. Basic and motor topics have great potential, and researchers can pursue them successfully. In the literature on *M. Koenigii*, the specialized and motor themes are frequently and thoroughly discussed. Fourteen clusters were generated using author's keywords. These clusters were divided into four themes to represent the intellectual structure of *M. Koenigii* literature. Knowing the knowledge structure of any research field helps researchers and decision-makers shape the future and current map for this research field and save effort and money (Karakose et al. 2022). Global evaluation of the collaborative research was done using VOSviewer. Significant collaboration took place between Indian institutions and Bangladesh, Pakistan, China, Australia, Canada, and Spain. Phytochemistry is a multi- and inter-disciplinary field of study that focuses on the chemical compounds produced by plants, particularly secondary metabolites, as well as their structural formulations, biosynthetic pathways, functions, mechanisms of action, and applications. Historically, bibliometric techniques were used to quantitatively obtain a structural overview of research collaboration (Wilson 2022).

Measuring scientific output is a more involved and consequential task than at first glance. Many other approaches have been offered for quantitative analysis, but none of them are without flaws. Analysis of the

frequency with which a given article, author, or institution is mentioned by other works or writers is known as a "citation analysis" (Cariveau et al. 2020). According to the established definition, an author or journal with a high h-index is characterized by having published a minimum number of works that have received an equal or greater number of citations. The h-index is not a complicated concept to understand. Simply plot the number of papers published against the number of citations received, and the h-index is the point at which the 45-degree line (citations = papers) intersects the curve. The h-index is useful because it provides a single metric that takes into account both productivity (the number of papers published) and impact (the number of citations). Therefore, a high h-index requires both production and impact; having either a small number of highly cited publications or a large number of papers with few (or no) citations will not provide a high h-index (Bertran et al. 2020). 20,366 citations and 68 H-indexes for all 934 (Fig. 8). Yellow stars indicate 68 H-index. Table 4 shows the 1965–2023 *M. Koenigii* research papers with the most citations, journals, and citation averages. "Antioxidant Activities of Aqueous Extracts of Selected Plants" has the most citations (621) and average (36.53). It was discovered that the leaves of *M. Koenigii* exhibit the highest levels of antioxidant activity as well as total phenolic content (Bhupatiraju et al. 2023; Mondal et al. 2022b; Nazeer et al. 2022; Singh et al. 2023).

Limitations

This study, which offered thorough data on the intellectual development, influence of knowledge, and performance of *M. Koenigii* literature, had certain drawbacks. First off, our data set only included Scopus-indexed journal articles; it did not include books or book chapters, dissertations, or conference proceedings. Despite Scopus' extensive coverage of high-impact journals, our study may have unintentionally left out certain crucial studies. Second, as implied by its methodology, the study is distinct from conventional review studies. As a result, the results do not correspond to those of earlier studies but rather demonstrate the bibliometric and evolutionary characteristics of the literature on *M. Koenigii* in accordance with the study of meta-data related to these studies. Our study still has the potential to lay the groundwork for upcoming analyses and investigations into *M. Koenigii* by defining the thematic progression of the subject field.

Conclusions

The current study employed a broad investigation into the scientific evolution of *M. Koenigii* research field, and exhibited the intellectual and conceptual architecture of the knowledge related to this plant established during the

last six decades. Despite the fact that the methodology used in this study establishes the value of this tree from a medicinal and dietary standpoint, it also creates a crucial framework for future investigations in the search for novel pharmacological values, particularly by highlighting the primary research topics and encouraging the continuation of research in the areas under investigation. A major implication of the current study is that, despite the breadth and extent of research on this tree, it is promising as a comparative source for many botanical studies. Based on this result, we believe that research in this field is still in its infancy, although the distributed perspective has made great inroads in medicinal plant research. The study spans the years 1965 through 2023, with a total of 934 documents and an average of 21.8 citations per document. India and Malaysia are the top-publishing countries. Debajo, A.C. (Nigeria), Phatak, R.S. (India), and Sukari, M.A. (Malaysia) are the highest productive authors. The top source is the Journal of Ethnopharmacology. Regarding the specialized topics, *M. Koenigii*'s study concentrated on using this plant as an antioxidant agent in manufacturing and biological systems. Dynamic subjects like HPLC profile, essential oil, and Asian citrus psyllid were included in the motor theme. In conclusion, filling these study gaps in this plant research would make a significant contribution to our optimal exploitation of it in terms of health and nutrition. Additionally, it would advance the knowledge base to a more mature stage, which can also be examined in future scientific mapping studies.

Limitations

There are certain limitations to the present research. Even though the author tried his utmost to minimize this sort of inaccuracy, false-positive and false-negative outcomes are possible. Furthermore, the use of Scopus to retrieve documents may have resulted in the loss of certain papers published in non-English nations' natively unindexed journals. The proportion of papers connected to *M. Koenigii* that focused on non-English studies was 0.22%.

Abbreviations

MS Excel	Microsoft Excel
CSV	Comma-separated values
AR	Article
CP	Conference paper

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Author contributions

SIA planned the investigation, evaluated the findings, wrote the article, and oversaw the administrative aspects. MMET gathered the information and revised the text. Both authors have read and approved the manuscript.

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Availability of data and materials

The datasets used and/or analyzed during the current study available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

There is no form of human subject involved in this manuscript; therefore, ethics approval is not required.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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