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An overview of *Garcinia* species research based on bibliometric analysis using VOSviewer, CiteSpace and HistCite

Fengke Lin [a,*], Zihao Liu [a], Zhongxin Duan [b], Rui Zhao [a], Binsheng Luo [b,*]

[a] *School of Chemistry and Chemical Engineering, Tianjin University of Technology, Tianjin 300384, China*
[b] *Lushan Botanical Garden, Jiangxi Province and Chinese Academy of Sciences, Lushan 332900, China*

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ABSTRACT

Garcinia species are renowned for their bioactive constituents and diverse applications in food and medicine; however, a comprehensive evaluation of related research remains lacking. This study aimed to systematically assess global research trends and emerging topics in *Garcinia* studies over the past three decades using a bibliometric analysis combining VOSviewer, CiteSpace, and HistCite. Results revealed a steady increase in publication output and citations, with major research areas including pharmacology and food science and technology. Among the 30 most cited articles, 60.0 % focused on edible and medicinal *G. mangostana*. A total of 12,182 authors from 2777 institutions across 107 countries contributed to *Garcinia* research, with China, India, Thailand, the USA, and Malaysia leading in publication volume. Collaboration networks revealed limited cooperation among core authors, institutions, and countries. Hotspot analysis highlights phytochemistry and pharmacology, especially anticancer activity and xanthones. Emerging frontiers include bioactive and phenolic compounds, molecular docking, and green synthesis of nanoparticles. This study provides a comprehensive overview of the scientific landscape of *Garcinia*, offering valuable insights to guide future research on its chemical compositions, functional properties, and nutraceutical potential, while also demonstrating the effectiveness of an integrated bibliometric approach for analyzing research dynamics in other food and medicinal plants.

1. Introduction

The genus *Garcinia* Linnaeus, belonging to the Clusiaceae family, comprises approximately 450 species of trees and shrubs distributed worldwide, predominantly across the tropical regions of Asia, southern Africa, and western Polynesia (Lin et al., 2021b). A total of 22 species of *Garcinia* have been documented in China, including 13 endemic and three introduced species. They are primarily distributed across Yunnan, Guangxi, Hainan, and Guangdong provinces (Lin et al., 2021b). *Garcinia* species have long been valued for their dual roles in traditional food and medicinal systems (Kaprakkaden & Ali, 2025). Among them, *G. mangostana*, commonly known as mangosteen or *Shanzhu* in Chinese, is widely recognized as the "*Queen of Fruits*" and holds considerable economic and nutritional importance (Aizat et al., 2019). Various parts of this plant, including fruit hulls, roots, bark, and leaves, have been used for centuries in Southeast Asia to treat ailments such as skin infections and wounds (Ansori et al., 2020). In China, the food and medicinal uses of several *Garcinia* plants, such as *G. hanburyi, G. multiflora*, and *G. oblongifolia*, are documented in Chinese pharmacopoeias like *Zhong Hua Ben Cao* (Chinese Materia Medica) and *Zhong Guo* Min *Zu Yao Zhi Yao* (Chinese Ethnomedicines) (Lin et al., 2021b).

The food and medicinal applications of *Garcinia* species have drawn considerable interest from researchers, entrepreneurs, and consumers, with extracts from these plants ranking among the best-selling health products and dietary supplements worldwide (Angami et al., 2021; Guedje, 2020). Extensive research on the phytochemistry and bioactivity of *Garcinia* spp. has revealed that they are rich sources of bioactive compounds, including xanthones, benzophenones, and flavonoids (Ansori et al., 2024; Kaprakkaden & Ali, 2025; Zheng et al., 2021). These compounds demonstrate a broad range of pharmacological activities, such as anticancer (Lin et al., 2021a), anti-HIV (Kharisma et al., 2024), anti-SARSCoV-2 (Ansori et al., 2022; Kharisma et al., 2023), and diabetic activities (Husen et al., 2020). As such, *Garcinia* has become an important genus in the search for novel bioactive ingredients with potential applications in functional foods and therapeutic products (Kaprakkaden & Ali, 2025).

* Corresponding authors.
E-mail addresses: fengkelin2023@email.tjut.edu.cn (F. Lin), luobins@lsbg.cn (B. Luo).

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Despite the growing number of scientific studies on *Garcinia*, the research landscape remains fragmented and largely species-specific, with limited efforts to analyze findings across the genus. This fragmentation hinders a comprehensive understanding of global research progress and emerging directions. Bibliometric analysis, which applies quantitative methods to evaluate scientific literature, provides a robust approach to uncovering publication patterns, research trends, and thematic development in a field of study (Hassan & Duarte, 2024). Tools such as VOSviewer (Ghazaly et al., 2025), CiteSpace (Miao et al., 2023), and HistCite (Tho et al., 2017) are widely used to map knowledge structures and identify research frontiers. Although VOSviewer-based bibliometric analyses have been conducted on *Garcinia* species, such as *G. brasiliensis* (de Melo et al., 2021) and *G. humilis* (Ikeda et al., 2022), a comprehensive genus-level quantitative overview is still lacking. To our knowledge, no research has combined VOSviewer, CiteSpace, and HistCite to analyze any plant genus and species in an integrated manner. It is hypothesized that using these three tools together can more effectively capture the global research dynamics of *Garcinia*, identify underexplored areas, and reveal key hotspots and frontiers related to its food and medicinal value.

To test this hypothesis, VOSviewer, HistCite, and CiteSpace were used to conduct a bibliometric analysis of *Garcinia*-related research published over the past three decades. By systematically examining publication trends, influential authors, core journals, and keywords, this study provides a comprehensive overview of the current research landscape and identifies key hotspots and emerging frontiers in *Garcinia* studies. The findings aim to support the efficient and sustainable use of *Garcinia* resources by highlighting the functional food potential of its bioactive compounds. Additionally, this work serves as a methodological reference for quantitatively mapping research trends in other food-medicine homologous plants.

2. Materials and methods

2.1. Data collection

A literature search was conducted in January 2025 using the Web of Science (WoS) Core Collection (https://webofscience.clarivate.cn/), with the topic search keyword "*Garcinia*", to identify publications related to *Garcinia* species from the past 30 years (January 1, 1995 to December 31, 2024). The document types were limited to articles and reviews, while no restrictions were applied regarding language, affiliations, or countries. Retrieved records were saved in the WoS marked list to preserve the search results. Irrelevant and duplicate publications were then removed through manual screening. The search and selection processes were independently performed by two investigators, with any discrepancies resolved through discussion with a third investigator, who provided an independent evaluation to ensure data reliability (Kim et al., 2015). The final dataset was exported in either Plain Text or Tab-Delimited format, including complete records and cited references.

2.2. Data processing and bibliometric analysis

The literature dataset was imported into VOSviewer (version 1.6.20), CiteSpace (version 6.4.R1), and HistCite (version 12.03.17) for bibliometric analyses. In VOSviewer, analysis of authors, countries, and institutions was conducted. In the Create Map window, co-authorship was selected for analysis type, and the Full Counting method was selected without limiting the maximum number of authors per document. The minimum publication threshold to identify core authors in VOSviewer was set to 8, calculated using the formula: N=0.749 $(n_{max})^{1/2}$, where N is the minimum publication threshold for core authors and n_{max} represents the number of publications by the most prolific author (Price, 1963). The minimum number of publications was set to 5 for countries and 15 for institutions. For the visualization analysis, the association strength method was used for normalization, with the attraction and repulsion parameters set to 2 and 1. The resolution and minimum clustering size were set to 1. "Links" represents the number of connections between a node (*e.g.*, country, author or institution) and other nodes, indicating collaboration frequency. "Total link strength" (TLS) indicates the overall strength of these collaborations. In CiteSpace, keyword analysis was conducted to identify research hotspots and emerging trends. The time slicing ranged from January 1995 to December 2024, with "Years Per Slice" set to 2. Text processing included titles, abstracts, author keywords, and keywords plus. The keyword was selected as the node type. The selection criteria were G-index = 25, Top N = 50, and Top N (%) = 10. The pruning options applied were Pathfinder, Pruning Sliced Networks, and Pruning the Merged Network. HistCite was used to generate a citation evolution map highlighting the most influential references in *Garcinia*-related studies. The graph was filtered by Local Citation Score (LCS) and publication count, with the number of publications limited to 30. Publication data, citation counts, journals, and research areas were extracted from the WoS platform and visualized using software such as GraphPad Prism (version 8.0.1 (244)) and ArcGIS Desktop (version 10.7). A study flowchart illustrating data collection and bibliometric analyses is shown in Fig. 1.

3. Results

3.1. Analysis of literature publication and citation

A comprehensive search of the Web of Science (WoS) Core Collection identified 3416 references using the keyword "*Garcinia*" over the past three decades. A total of 3213 publications were obtained after filtering by document type. Following the removal of irrelevant and duplicate records, 2994 publications (2965 in English) were retained for bibliometric analysis, comprising 2797 research articles and 197 review papers. These publications have garnered 77,380 citations, yielding an *H*-index of 106 and an average of 25.85 citations per publication. Annual trends in publication and citation counts were analyzed to evaluate the development of *Garcinia* research (Fig. 2). The data revealed a marked increase in research output, with a steadily accelerating growth rate over time. The average number of publications per year rose to 108 after 2011, exceeded 150 after 2016 and peaked at 207 in 2024 (Fig. 2). This upward trend is mirrored by citation data, which show a steady increase over the past 30 years, reaching a peak of 7882 citations in 2024 (Fig. 2). Together, these findings underscore the growing academic interest and increasing scientific impact of *Garcinia*-related research.

3.2. Productive journals and research areas

Over the past 30 years, research on *Garcinia* has appeared in 919 journals. Among them, *Journal of Natural Products* leads with 85 related articles, followed by *Molecules* (67), *Natural Product Research* (65), *Phytochemistry* (55), *Fitoterapia* (45), and both the *Journal of Agricultural and Food Chemistry* and *Journal of Ethnopharmacology* with 43 each. The top 10 journals publishing the most *Garcinia*-related articles are presented in Fig. 3, with the top 30 listed in **Table S1** for reference. This information serves as a useful reference for researchers seeking appropriate journals to publish their findings on the *Garcinia* species. In terms of research areas, Pharmacology and Pharmacy ranked highest with 923 records, followed by Chemistry (733), Plant Sciences (491), Food Science and Technology (452), and Biochemistry and Molecular Biology (411) (**Table S2**).

3.3. Key publications within the Garcinia field

To identify the influential publications on *Garcinia*, a citation evolution map was constructed using HistCite, featuring the top 30 references with the highest LCS values (Fig. 4). Detailed information on these references, including titles, authors, and LCS values, is provided in **Table S3**. As shown in Fig. 4, the network is divided into three distinct

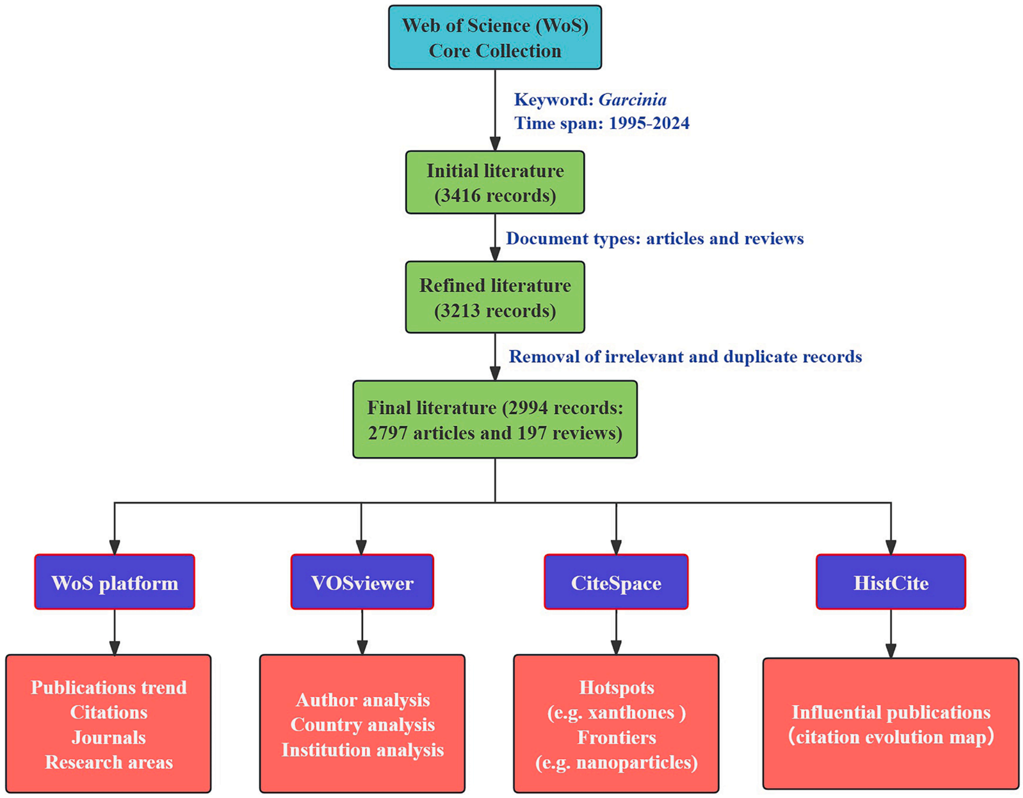

Fig. 1. The study flow chart illustrating data collection and bibliometric analyses.

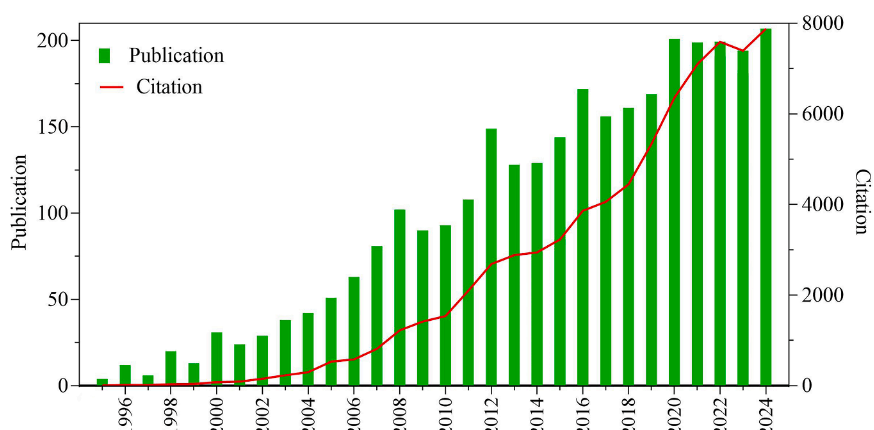

Fig. 2. Annual publications and citations related to the genus *Garcinia*.

clusters, marked in red, blue, and green from left to right. Most references cluster in the red, forming a dense citation network that reflects the core focus of *Garcinia* research and mutual scholarly reinforcement. The blue cluster is linked to the red primarily through reference 780, while publications 7 and 186 appear disconnected from the others, suggesting independent or niche research directions at the time. Notably, reference 292, published in *Journal of Agricultural and Food Chemistry* in 2006, has the highest LCS value (231), followed by references 580 (177), 443 (152), 115 (114), and 288 (110), underscoring their significant impact on the field. These top 30 references provide valuable insights into key influential contributions within *Garcinia* research. It is also worth noting that 18 of these references (60.0 %) focus on *G. mangostana* (**Table S3**), emphasizing its leading role in studying the *Garcinia* genus.

3.4. Analysis of authors and their cooperation network

From 1995 to 2024, 12,182 authors worldwide contributed to 2994 *Garcinia*-related publications, reflecting strong research interest in this field. A total of 109 core authors were identified, each having published more than eight papers. Among them, Xu H is the most prolific with 91 publications, followed by Chen Y (42), dos Santos MH (39), Farombi EO (38), and Fu W (32). Notably, 10 of the top 15 authors (66.7 %) are affiliated with institutions in China, underscoring the country's leading role in *Garcinia* research (**Table S4**).

To better understand the collaboration patterns among leading researchers, an author co-occurrence network was created using VOSviewer (Fig. 5). The analysis revealed 38 distinct clusters, with the largest (in red) comprising 19 authors led by Xu H, Fu W, and Tan H. Other notable clusters are a green cluster of 12 authors led by

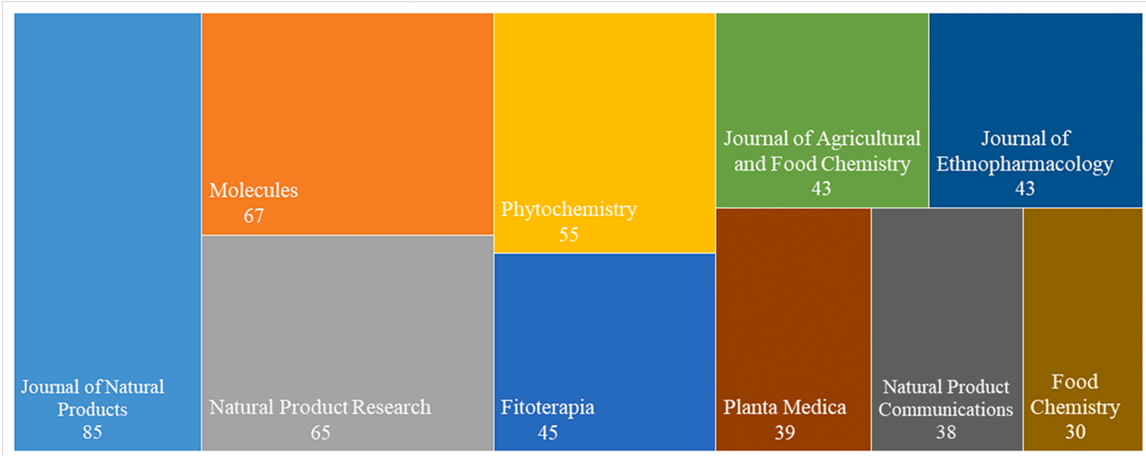

Fig. 3. The top 10 journals with the highest number of *Garcinia*-related publication.

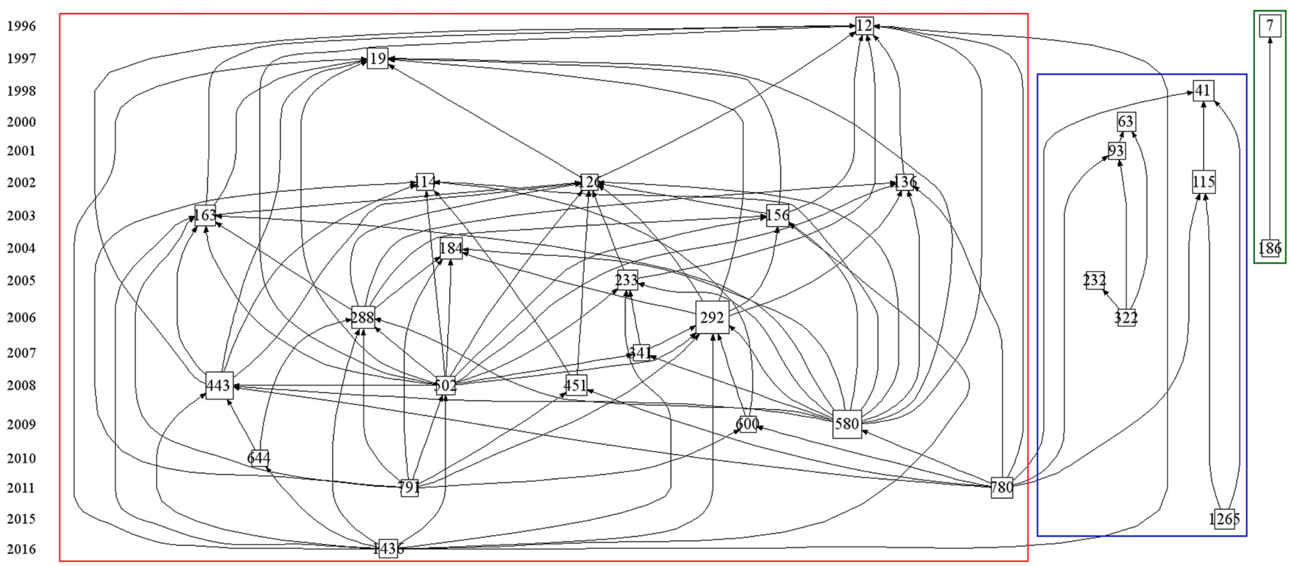

Fig. 4. Citation evolution map of the top 30 references with the highest LCS values generated by HistCite. The numbers on the far left represent the publication years of the references. Arrows between the boxes indicate citation relationships, with the direction of the arrow pointing to the cited reference. The number inside each box corresponds to the reference ID as assigned in the HistCite dataset, while the size of the box reflects the LCS values of the reference. Boxes outlined in red, blue, and green represent distinct clusters. Detailed information on these key publications such as title and specific LCS values can be found in Table S3.

Phongpaichit S and Rukachaisirikul V; a dark blue cluster of 8 authors led by Chen Y, Yang G and Xu J; and a yellow cluster of 6 authors led by Siripong P (Fig. 5). Several other clusters contain fewer than five authors, with some consisting of a single researcher, indicating a highly fragmented collaboration landscape (Fig. 5). Among the top 15 core authors by publication volume, nine authors (60 %), including dos Santos MH and Farombi EO have fewer than five collaboration links and TLS values below 50 (**Table S4**). Xu H, Farombi EO and dos Santos MH, ranked first, third and fourth in publication volume, have yet to establish collaborative relationships (Fig. 5). These results suggest room to enhance collaboration among prolific authors in *Garcinia* research.

3.5. Distribution of countries and institutions

Over the past three decades, research on *Garcinia* has involved 107 countries, demonstrating its global significance. Ten countries have each contributed >100 publications, among which, China leads with 656 publications, followed by India (426), Thailand (408), the USA (319), and Malaysia (263) (**Table S5**). Participating countries are distributed across six continents excluding Antarctica, with most of the top 10 located in Asia, particularly Southeast Asia, indicating the region's key role in *Garcinia* research (Fig. 6A). In terms of institutional contributions, 2777 organizations have been identified. The Chinese Academy of Sciences ranks first with 113 publications, followed by Prince of Songkla University (92), Universiti Putra Malaysia (76), Mahidol University (70), and Shanghai University of Traditional Chinese Medicine (67) (**Table S6**).

To explore international collaboration patterns, a co-authorship analysis was conducted using VOSviewer, focusing on 55 core countries with at least five publications. The network reveals widespread connections, with countries exhibiting between 2 and 36 collaboration links and TLS values ranging from 5 to 250 (Fig. 6B). The USA has the highest number of collaborative links (35), reflecting its extensive international engagement in *Garcinia* research, followed by India (34), Thailand (33) and Malaysia (32) (Fig. 6B, **Table S5**). In contrast, 19 countries (34.5 %), including Sri Lanka and Singapore, have fewer than 10 links, suggesting more limited participation in global research networks. Thailand recorded the highest TLS value (250), followed by the USA (241) and China (186), indicating strong co-authorship ties. However, 37 of the 55 countries (67.27 %), such as Brazil, Vietnam and South

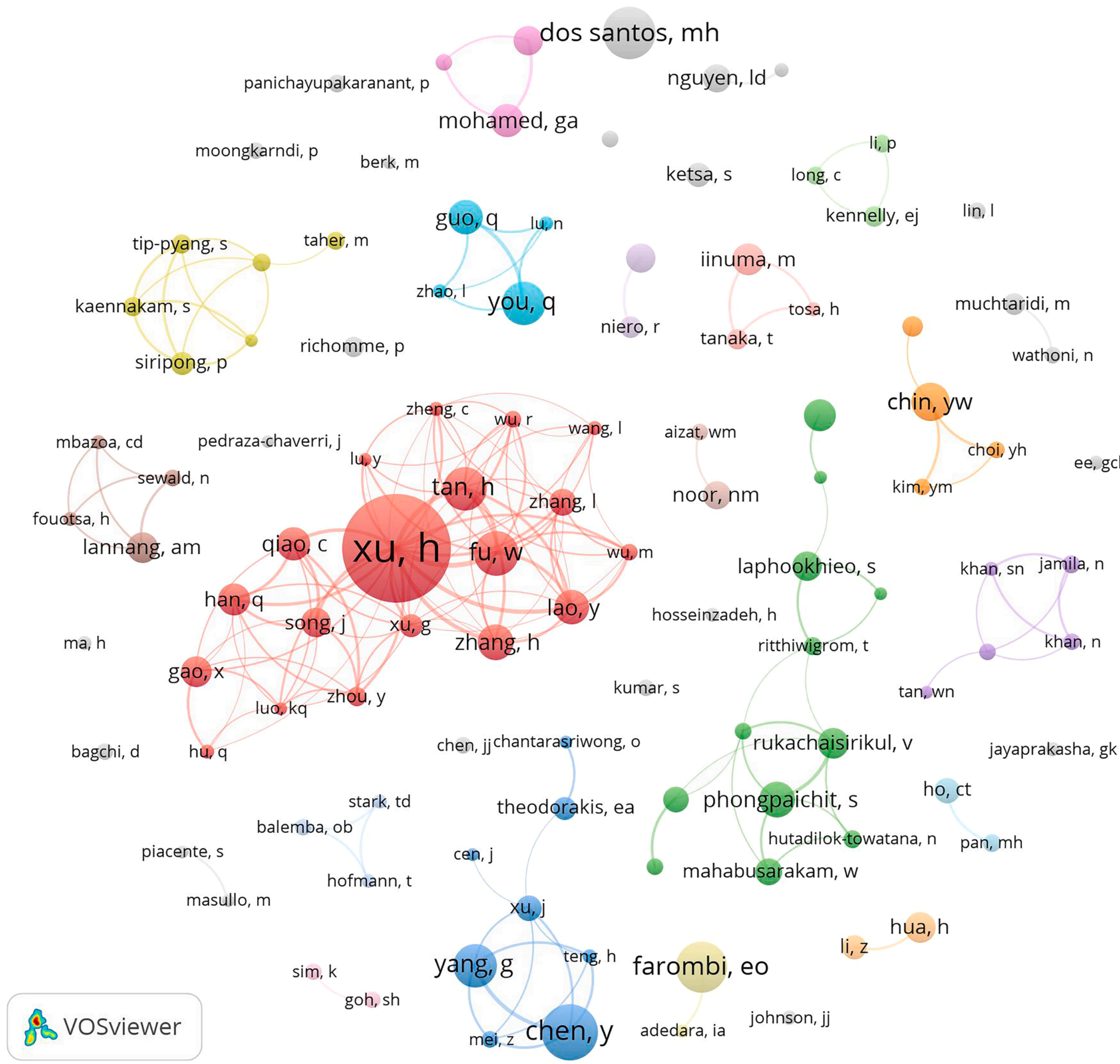

Fig. 5. Collaboration network among core authors in the *Garcinia* research field using VOSviewer. The size of each circle represents the number of publications by an author. Connecting lines indicate collaborative relationships, with line thickness reflecting the intensity of collaboration. Assorted colors represent different collaboration clusters.

Africa, have TLS values below 50, reflecting weaker collaboration intensity (**Table S5**). While a strong link intensity exists between China and the USA and between Thailand and Japan, most international collaborations (83.13 %) remain weak, involving fewer than five joint publications (Fig. 6).

At the institutional level, a co-authorship network was generated for 59 major organizations with at least 15 publications (Fig. 7). Compared to country-level collaborations, institutional networks appear less interconnected, with collaborative links ranging from 0 to 14 and TLS values between 0 and 54 (Fig. 7, **Table S6**). The Chinese Academy of Sciences ranks highest in links, TLS, and publications among institutions involved in *Garcinia* research. Among the 59 prolific institutions, 53 (89.83 %) have fewer than 10 collaborative links and 34 (57.63 %) have fewer than 5, indicating generally low inter-institutional collaboration (**Table S6**). Institutions, such as China Pharmaceutical University and Dongguk University Seoul, show no recorded collaborations with other organizations (Fig. 7). Collaboration among the top five institutions is also limited. For example, although the Chinese Academy of Sciences, Universiti Putra Malaysia, and Mahidol University rank first, third, and fourth in publication output (**Table S6**), no collaborative links exist among them (Fig. 7).

3.6. Hotspot analysis in Garcinia research

Keywords provide concise representations of a publication’s main content and are crucial in identifying dominant research themes (Miao et al., 2023). CiteSpace was used to generate a keyword co-occurrence network that reveals the primary areas of focus in *Garcinia* studies. The final network comprises 687 nodes (keywords) and 957 edges, following the removal of non-informative terms such as “alpha”, “l”, “Linn” and “plants”, and merging of synonymous terms like “xanthone” and “xanthones”, and “antiinflammatory activity” with “anti-inflammatory activity” (Fig. 8). As illustrated in Fig. 8, the most frequent keyword is *Garcinia mangostana* (536 occurrences), followed by

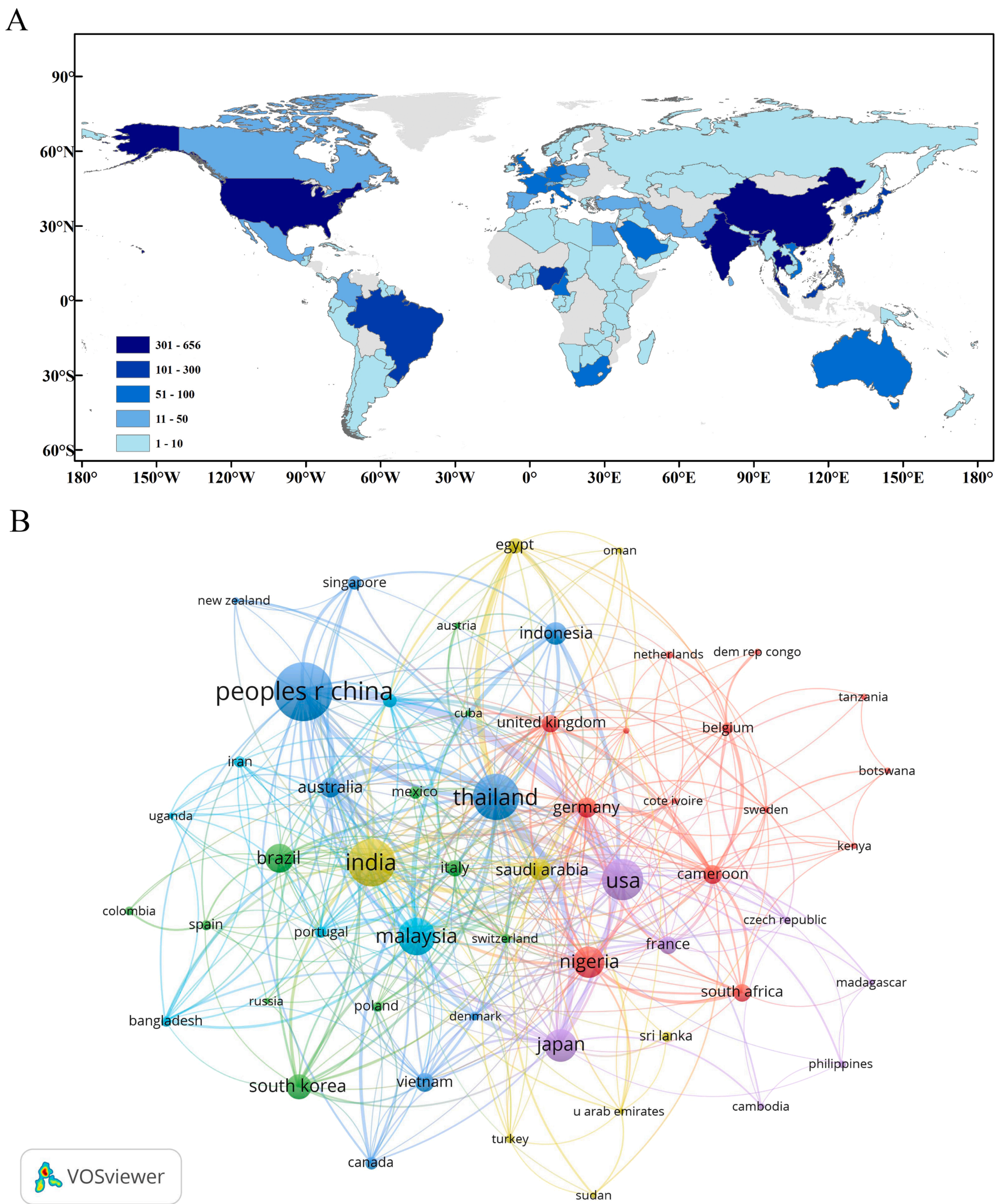

Fig. 6. Geographic distribution of countries involved in *Garcinia* research (A) and the collaboration network among the countries with at least five publications using VOSviewer (B). The size of each circle represents the number of publications by a country. Connecting lines indicate collaborative relationships, with line thickness reflecting the intensity of collaboration. Assorted colors represent different clusters.

xanthones (499), antioxidant (353), constituents (288) and apoptosis (238), highlighting their prominence as research hotspots. These high-frequency keywords suggest that phytochemical and pharmacological investigations, particularly those related to bioactive compounds, constitute the main focus of *Garcinia* research.

Among *Garcinia* species, *G. mangostana, G. cambogia*, and *G. kola* have received the greatest attention. Commonly studied plant parts include the fruit, leaf, pericarp, and bark. Anticancer potential is particularly prominent in biological activity, indicated by keywords such as apoptosis and cancer, followed by antioxidant and antibacterial

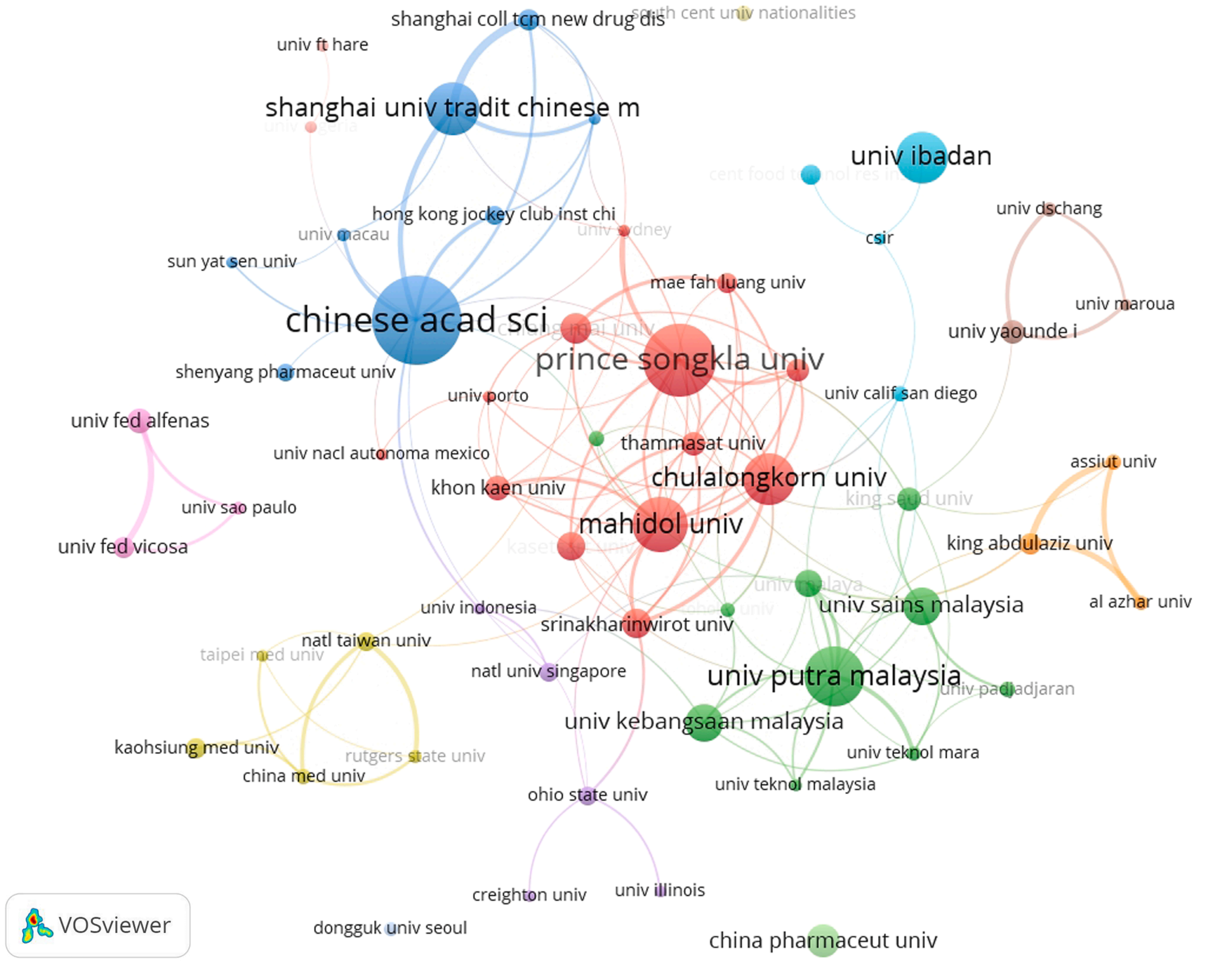

Fig. 7. Collaboration network among key institutions with at least 15 publications in *Garcinia* research field generated by VOSviewer. Circle size represents the number of publications from each institution. Connecting lines indicate collaborative relationships, with line thickness reflecting the strength of collaboration. Assorted colors denote distinct clusters.

activities. The most extensively investigated compound classes include xanthones, prenylated xanthones, benzophenones, bioflavonoids, and acids. Reported compounds such as (-)-hydroxycitric acid (a key acid), α-mangostin, and gambogic acid (prenylated xanthones), kolaviron (bioflavonoids), and garcinol and oblongifolin C (benzophenones) have emerged as focal points of research (Fig. 8). The structures of these important compounds are shown in **Fig. S1**.

3.7. Research frontier of the Garcinia studies

Keyword citation bursts highlight terms that rapidly increase in frequency over a short period, signaling shifts in research focus and reflecting the dynamic evolution of emerging frontiers (Chen, 2006). In this study, keyword burst analysis was used to identify research themes related to *Garcinia* plants across different time periods. The 25 keywords with the strongest bursts are shown in Fig. 9. In general, these emerging terms persist for several years before declining as new keywords gain prominence. Early and long-lasting burst keywords, such as *Garcinia hanburyi* and *Garcinia subelliptica*, indicate that these species were research frontiers during their peak periods (Fig. 9). More recently, research has focused on topics including green synthesis (2017–2024), molecular docking (2019–2024), bioactive compounds (2019–2024), silver nanoparticles (2019–2024), nanoparticles (2021–2024) and phenolic compounds (2021–2024). These emerging topics reflect current trends and provide valuable insights for identifying promising directions and potential breakthroughs in *Garcinia*-related studies.

4. Discussion

The genus *Garcinia*, the second largest in the Clusiaceae family with approximately 450 species, represents an important plant resource with diverse applications, such as food, ethnomedicinal, ornamental, and cultural uses (Lin et al., 2021a, 2021b; Tauchen et al., 2023). To our knowledge, this is the first study to apply an integrated bibliometric approach combining VOSviewer, CiteSpace, and HistCite to comprehensively analyze the global research landscape of *Garcinia*. Although a few studies (less than ten) have employed a combination of these three tools in fields such as cancer research (Ma et al., 2022), most bibliometric analyses in food science and medicinal plant studies have used only one or two, without integrating all three for a comprehensive assessment (Kamdem et al., 2019; Oubannin et al., 2024; Sheikh et al., 2023). The multi-tool strategy offers complementary strengths: VOSviewer effectively visualizes co-authorship networks among core authors, countries, and institutions by minimizing irrelevant nodes (van Eck & Waltman, 2010); CiteSpace excels at identifying research hotspots and frontiers through dynamic keyword analysis (Chen, 2006); and HistCite specializes in tracing the development of influential publications through citation evolution maps (Garfield et al., 2003). Integrating

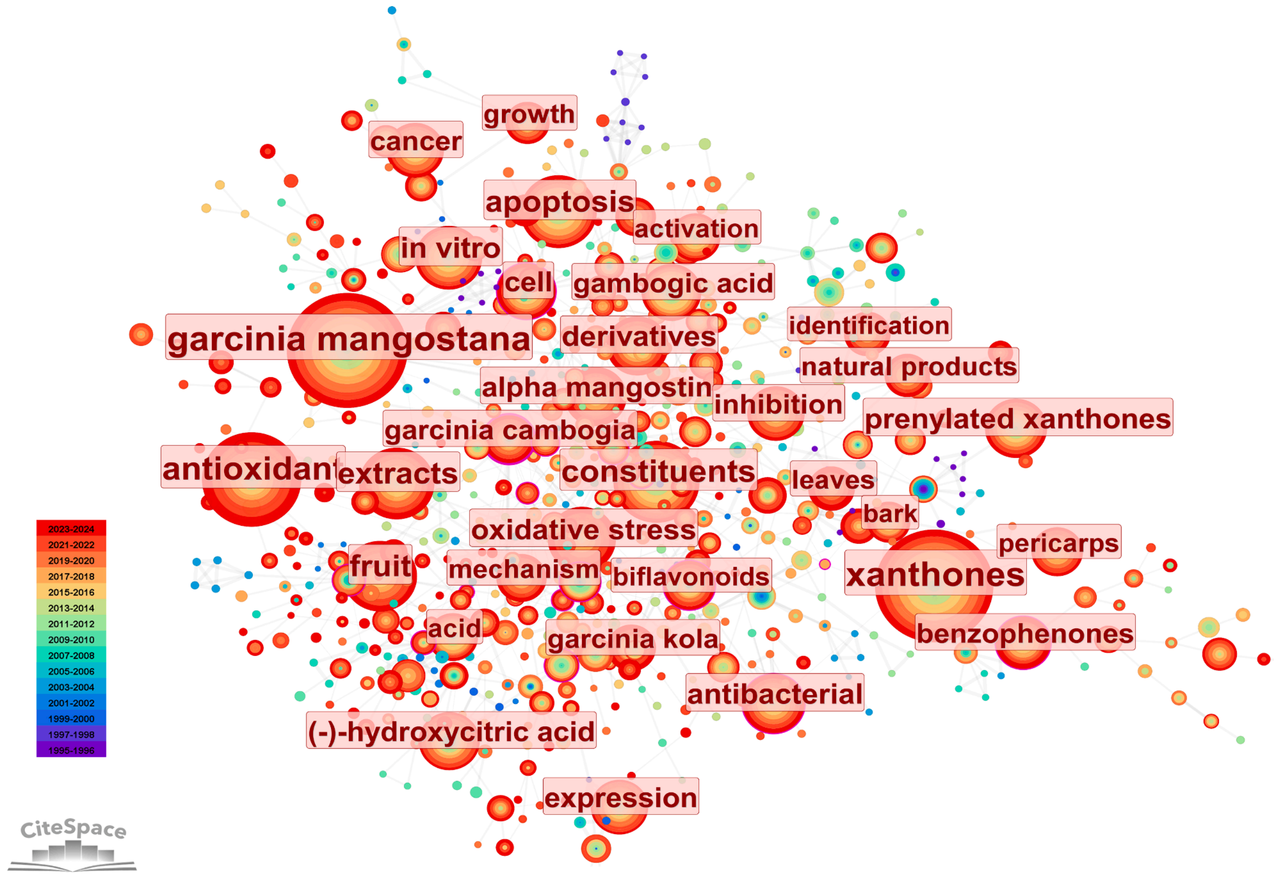

Fig. 8. Co-occurrence network of high-frequency keywords in *Garcinia* studies by CiteSpace. The size of each circlerepresents the frequency of keyword occurrences, and the connecting lines indicate co-occurrence relationships. The colors reflect time-related information: the innermost color of each node shows the year when the keyword first appeared, while the outermost color indicates the year of its most recent appearance.

these tools provides a more multidimensional understanding of *Garcinia* research and offers a solid basis to inform future studies in both food and medicinal fields. This analytical framework may also serve as a valuable reference for investigating other food and medicinal plants with dual-use potential, thereby contributing more broadly to the advancement of nutraceutical food research.

From 1995 to 2024, approximately 3000 articles and reviews on *Garcinia* were published. Both annual publication counts and citation frequencies showed a steady upward trend, reaching a peak in 2024 with 207 publications and 7822 citations (Fig. 2), reflecting growing scholarly interest in the genus. This trend suggests that *Garcinia*-related research will continue to expand. A similar increase in publication trend has been observed in studies on other food and medicinal plant genera, such as *Curcuma* (Lai et al., 2024). *Garcinia* studies are dispersed across >900 scientific journals, with *Journal of Natural Products, Molecules, Natural Product Research, Phytochemistry* and *Fitoterapia* being the most productive, each publishing 40 to 85 articles (Fig. 3). Nonetheless, these top journals collectively account for only 10.25 % of the total 2994 publications identified, indicating an extensive dissemination of *Garcinia* research across diverse readerships and fields. The predominant research areas include pharmacology and pharmacy, food science and technology, and nutrition and dietetics (**Table S2**). This distribution highlights the dual contributions of *Garcinia* species to both medicinal and nutritional sciences, a theme consistently emphasized in recent reviews on *Garcinia* species (Kaprakkaden & Ali, 2025; Noreen et al., 2023). This dual role highlights the genus's importance both as a source of bioactive compounds with therapeutic benefits and as a valuable ingredient in food and dietary uses. Among the top 30 most cited references, over half focus on *G. mangostana*, commonly known as the "*Queen of Fruits*" (**Table S3**). Owing to its abundance of bioactive compounds and associated health benefits, this species has been extensively studied for its nutritional composition, functional properties, and potential applications in the food and pharmaceutical industries (Aizat et al., 2019; Winarni et al., 2022).

A total of 12,182 authors affiliated with 2777 institutions across 107 countries have contributed to *Garcinia* studies, reflecting the genus's global research significance and partly explaining the large volume of publications. The number of contributing authors, institutions, and countries in *Garcinia* research is significantly higher than that reported for the genus *Cistanches*, which also holds important food and medicinal values (Wu et al., 2023). Network analysis (Fig. 6B) indicates that while international collaboration in *Garcinia* research is widespread, the intensity and depth of such cooperation remain moderate. Since *Garcinia* species are primarily distributed in tropical and subtropical regions (Lin et al., 2021b), fostering collaboration between countries with native *Garcinia* species and those without is especially important. Limited international cooperation may impede knowledge exchange, standardization of compositional analysis, and the global development of functional foods or nutraceutical products derived from *Garcinia*. Although several research teams have been established (Fig. 5), their membership remains limited, and many key authors have yet to collaborate. These findings indicate significant potential to strengthen cooperation and broaden research networks among leading scholars in the field. Similar patterns were observed at the institutional level (Fig. 7), indicating further opportunities for collaboration improvement. Analysis of publication data further reveals limited collaboration between prolific authors and leading institutions. For instance, despite being the most prolific author, Xu H. has not collaborated with Prince of Songkla University and Universiti Putra Malaysia, which rank second and third in publication output. Similarly, Dos Santos Marcelo H., the

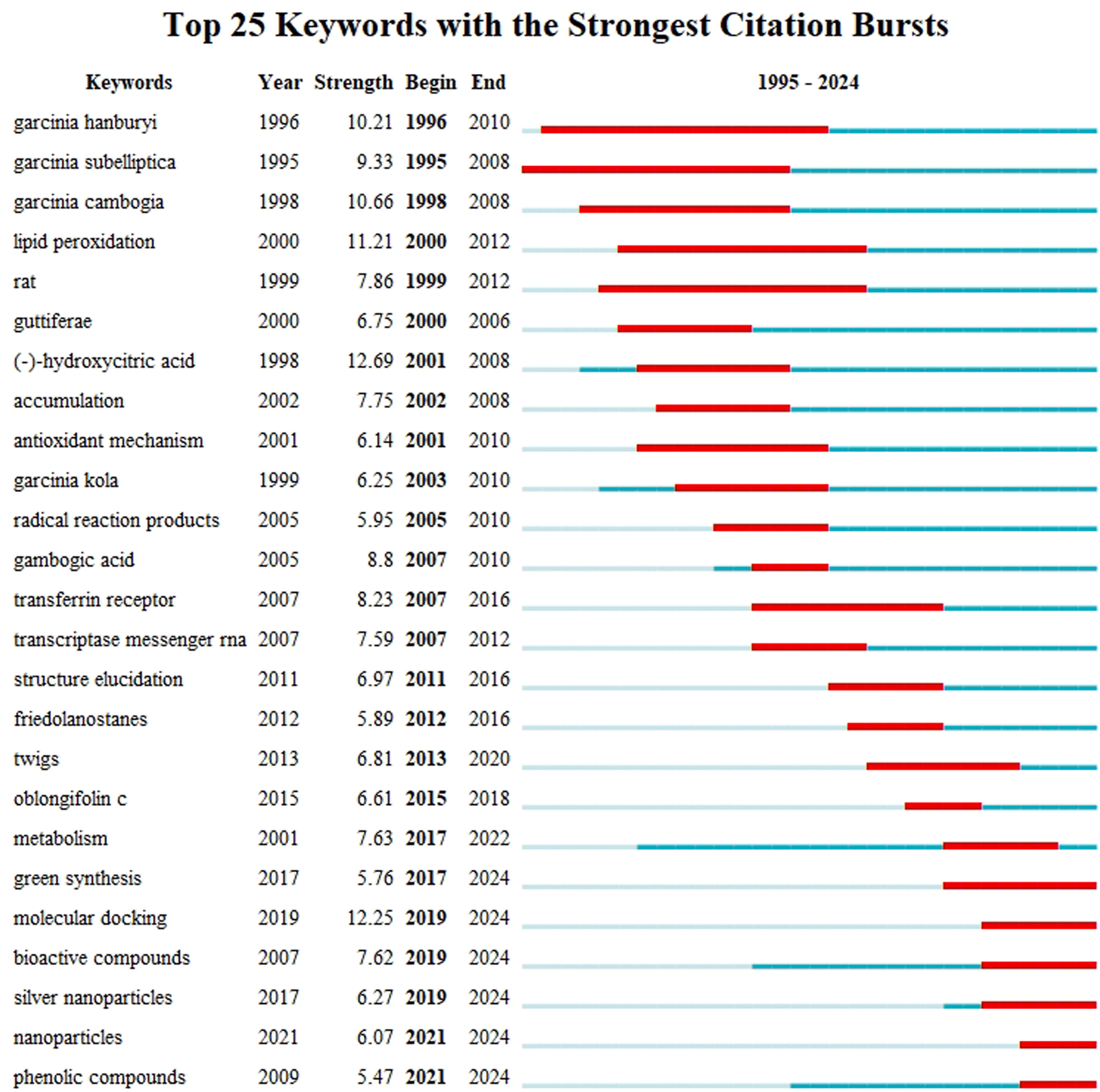

Fig. 9. Top 25 keywords with the strongest citation burst within *Garcinia* research obtained from CiteSpace. Red bars indicate the periods of citation bursts for each keyword, dark blue marks the years when the keywords appeared in publications, and light blue denotes years with no occurrence.

third most prolific author, has not yet partnered with the Chinese Academy of Sciences, the institution with the highest publication volume. These findings shed light on the current collaboration landscape in *Garcinia* research and provide valuable insights for authors, institutions, and countries seeking potential research partners.

Keyword analysis highlights phytochemistry and pharmacology as the primary research focuses, revealed by frequently occurring keywords (Fig. 8). Pharmacological studies predominantly concentrate on anticancer, antioxidant, and antibacterial activities. The most extensively studied classes of compounds from *Garcinia* species include xanthones, benzophenones, bioflavonoids and organic acids, many of which exhibit promising health-promoting properties. These trends are corroborated by recent reviews that consistently emphasize key phytochemicals, such as xanthones, and their associated pharmacological effects, particularly anticancer and antioxidant activities (Kaprakkaden & Ali, 2025; Kumatso & Sigge, 2024). Representative compounds widely recognized for their biological efficacy include α-mangostin, gambogic acid, kolaviron, garcinol, oblongifolin C, and (-)-hydroxycitric acid (Lin et al., 2021a). For example, α-Mangostin Majdalawieh et al. (2024), gambogic acid (Liu et al., 2020), oblongifolin C (Yang et al., 2018), and garcinol (Liu et al., 2015) exhibit potent cytotoxicity against various cancer cell lines. Kolaviron has demonstrated strong antioxidant, anti-inflammatory, and cardioprotective effects (Erukainure et al., 2021), while hydroxycitric acid and *Garcinia*-based extracts containing this compound have been widely used as functional food ingredients and dietary supplements for weight management and obesity control (Jena et al., 2002). These findings highlight the potential of *Garcinia*-derived phytochemicals as functional food components or nutraceutical ingredients for chronic disease prevention and overall health promotion.

Due to the significant bioactivity of *Garcinia* metabolites, increasing attention has been directed toward their quantitative analysis to better understand the distribution of key compounds across different species and plant parts (Acuna et al., 2012). Quantitative data and analytical methods used to determine these compounds in *Garcinia* species are summarized in Table 1. Various techniques, including high-performance liquid chromatography (HPLC), high-performance thin-layer chromatography (HPTLC), and ultra-performance liquid chromatography coupled with a quadrupole time-of-flight mass spectrometry (UPLC-QTOF-MS), have been employed to quantify these bioactive constituents (Table 1). Among them, the quantification of (-)-hydroxycitric acid has been widely studied in multiple *Garcinia* species. Notable variations in (-)-hydroxycitric acid content have been observed both among species and between different plant parts within the same species (Table 1). For instance, Asish et al. (2008) reported that (-)-hydroxycitric acid contents ranged from 0.07 to 5.98 g/100 g in fruits and 0.013 to 3.10 g/100 g in leaves of four *Garcinia* species (*G. gummi-gutta, G. indica, G. cowa*, and *G. tinctoria*), with generally higher levels in fruits, indicating significant inter- and intraspecific variation. α-Mangostin is particularly abundant in *G. mangostana* fruits, especially in hexane extracts, with concentrations reaching up to 10.36 g/100 g as determined by UHPLC. In contrast, it was undetectable in other species, such as *G. cambogia, G. pedunculata, G. indica* and *G. morella*, suggesting species specificity (Kureshi et al., 2020). However, later studies using HPTLC reported relatively high α-mangostin levels (2.50–2.79 g/100 g) in *G. morella* and *G. pedunculata* (Paul et al., 2024b), implying that geographic, genotypic, or methodological factors may contribute to the observed differences. Garcinol has been detected in the fruits of species such as *G. xanthochymus, G. sopsopia*, and *G. morella*, with content levels ranging from 0.58 to 28.64 g/100 g (Dutta et al., 2023; Paul et al., 2024a). Notable intraspecific variation has also been observed among different genotypes of *G. indica* (0.020–4.88 g/100 g) (Shedge et al., 2025). Zhou et al. (2010) quantitatively analyzed sixteen polycyclic polyprenylated acylphloroglucinols (PPAPs), including oblongifolin C, in various plant parts of ten *Garcinia* species, such as *G. xanthochymus* and *G. oblongifolia*. Oblongifolin C content varied from below the limit of quantification to 1.21 g/100 g, with the highest concentrations commonly found in the bark across the surveyed species (Zhou et al., 2010). In contrast, the quantification of kolaviron in *Garcinia* species remains unreported, highlighting the need for future studies to investigate its content variation among species and to identify high-yielding sources.

Analysis of keywords with strong citation bursts further reveals that current frontiers in *Garcinia* research include green synthesis (2017–2024), molecular docking (2019–2024), bioactive compounds (2019–2024), silver nanoparticles (2019–2024), nanoparticles (2021–2024) and phenolic compounds (2021–2024) (Fig. 9). Although terms such as "bioactive compounds" and "phenolic compounds" appeared earlier, their emergence as burst keywords after 2019 and 2021, highlights their increasing importance in contemporary research. Advanced techniques like LC-MS (Lin et al., 2023, 2025) and supercritical carbon dioxide extraction (Kok et al., 2021) have been increasingly applied to extract and characterize bioactive and phenolic compounds. For instance, Lin et al. (2023) identified 26 bioactive compounds with potential anticancer, anti-inflammatory, or antibacterial activities from edible *G. yunnanensis* and *G. xanthochymus* using UPLC-QTOF-MS-based metabolomic analysis. Kok et al. (2021) developed a supercritical CO_2 extraction method employing virgin coconut oil as a co-extractant to efficiently isolate bioactive xanthones such as α- and γ-mangostin from *G. mangostana* pericarps. Nawawi et al. (2023) investigated the impact of drying methods on phenolic compound production in *G. mangostana* pericarps and identified two anthocyanins using LC-MS. Molecular docking, an *in silico* technique, has been utilized to explore the binding affinity, potential targets, and mechanisms of *Garcinia*-derived compounds, providing valuable insights into their pharmacological potential (Rifaldi et al., 2024; Saenkham et al., 2020).

Nanotechnology, particularly the green synthesis of nanoparticles such as silver nanoparticles using plant extracts and metabolites, has emerged as a significant advancement in pharmaceutical sciences (Rafique et al., 2017). As illustrated in Fig. 9, "green synthesis", "nanoparticles", and "silver nanoparticles" have become prominent research frontiers in *Garcinia* studies. Extracts from species such as *G. mangostana, G. kola, G. indica*, and *G. hanburyi* (Aizat et al., 2019; Sarip et al., 2022), along with compounds like garcinol (Sarip et al., 2022) and α-mangostin (Jamila et al., 2021), have been used in the green synthesis of nanoparticles to enhance therapeutic efficacy. For example, nanoparticles synthesized from *G. hanburyi* resin via hydrothermal reaction demonstrated antibacterial efficacy against Gram-positive bacteria and disrupted Gram-negative bacteria by inducing transient nanopores under microwave assistance (Qiao et al., 2022). Similarly, silver nanoparticles mediated by *G. mangostana* fruit pericarps and α-mangostin exhibited significant anticancer activity against DU-145 prostate cancer cells (Jamila et al., 2021). Beyond silver nanoparticles, studies have explored the synthesis of other nanomaterials such as copper/copper oxide nanoparticles (Hegde et al., 2025; Radhakrishnan et al., 2025), MXene-polymer nanocomposites (Amani et al., 2025), and $Fe_3O_4@SiO_2$/Schiff-base/Zn(II) nanocomposites (Azadi et al., 2025), demonstrating versatile bioactivities including anticancer, anti-inflammatory, and antimicrobial effects. However, unlike silver nanoparticles, these other nanoparticles types have rarely or not yet been explored in *Garcinia* plants, highlighting a critical research gap in *Garcinia*-based nanotechnology. Expanding the green synthesis of nanoparticles to include a broader range of *Garcinia* species and their bioactive constituents, as well as incorporating more diverse metal- or polymer-based materials, represents a promising and sustainable direction for advancing *Garcinia*-based nanomedicine. A recent study conducted by Luo et al. (2025) elucidated the anti-glioma mechanisms of exosome-like nanoparticles from *G. mangostana* using an integrated strategy combining metabolomics and network pharmacology, suggesting promising directions for future research on *Garcinia*-based nanotherapeutics and other bioactive compounds using these innovative approaches.

As discussed above, molecular docking has become an indispensable tool for elucidating the mechanisms of action of individual natural compounds and nanoparticles. Bioactive compounds derived from *Garcinia*, along with their corresponding nanoparticles, exhibit significant therapeutic potential. The current bibliometric analysis highlights emerging frontiers, such as phenolic bioactive compounds, molecular docking, and nanoparticles, that are poised to drive future innovations in harnessing *Garcinia*-derived compounds for functional food and nutraceutical development. These advances will be supported by a deeper understanding of their underlying mechanisms.

The findings of this study are based on data from WoS Core Collection, a widely adopted bibliometric database known for its extensive coverage of high-quality journals, reliable and standardized citation data, and strong compatibility with analytical tools (Birkle et al., 2020). However, a notable limitation of WoS is its strong bias towards English-language publications. In our dataset of 2994 references, only 21 were published in languages other than English. This language bias may result in the underrepresentation of relevant non-English literature and therefore affecting the comprehensiveness of the findings. For researchers interested in examining research trends at a national or regional level rather than from an international perspective, WoS coverage may be insufficient. In such cases, incorporating local or regional databases is recommended to provide a more inclusive and balanced understanding of the research landscape.

5. Conclusions

This study presents the first comprehensive bibliometric analysis of the genus *Garcinia,* known for its significance in food and medicine, using VOSviewer, CiteSpace, and HistCite. Over the past three decades, publications and citations related to *Garcinia* have steadily increased with an accelerating growth rate, reflecting rising academic interest and impact. Research on *Garcinia* has been published across a wide range of

Table 1
Quantitative data on hotspot compounds from *Garcinia* plants identified through keyword analysis.

Compound	Species	Plant part	Content (g/100 g)[a]	Analytical method[b]	Reference
(-) Hydroxycitric acid	*G. gummi-gutta*	Fruit	5.98	HPLC	(Asish et al., 2008)
		Leaf	3.10	HPLC	(Asish et al., 2008)
	G. indica	Fruit	5.05	HPLC	(Asish et al., 2008)
			15.60–22.92	HPLC	(Singh et al., 2022)
		Leaf	2.13	HPLC	(Asish et al., 2008)
			5.71	HPLC	(Bheemaiah & Kushalappa, 2019)
	G. cowa	Fruit	3.42	HPLC	(Asish et al., 2008)
			37.95	HPLC	(Dutta et al., 2023)
		Leaf	3.01	HPLC	(Asish et al., 2008)
	G. tinctoria	Fruit	0.07	HPLC	(Asish et al., 2008)
		Leaf	0.013	HPLC	(Asish et al., 2008)
	G. cambogia	Leaf	7.95	HPLC	(Bheemaiah & Kushalappa, 2019)
	G. xanthochymus	Leaf	0.02	HPLC	(Bheemaiah & Kushalappa, 2019)
		Fruit	8.33	HPLC	(Dutta et al., 2023)
	G. morella	Leaf	nd	HPLC	(Bheemaiah & Kushalappa, 2019)
		Fruit	39.47	HPLC	(Dutta et al., 2023)
	G. pedunculata	Fruit	44.59	HPLC	(Dutta et al., 2023)
	G. lancifolia	Fruit	53.91	HPLC	(Dutta et al., 2023)
	G. kydia	Fruit	39.61	HPLC	(Dutta et al., 2023)
	G. cuspida	Fruit	53.03	HPLC	(Dutta et al., 2023)
	G. sopsopia	Fruit	35.68	HPLC	(Dutta et al., 2023)
α-Mangostin	*G. mangostana*	Fruit	0.044–10.36	UHPLC	(Kureshi et al., 2020)
		Pericarp	3.32	HPLC-MS/MS	(Wittenauer et al., 2012)
		Aril	0.21	HPLC-MS/MS	(Wittenauer et al., 2012)
	G. lanceifolia	Fruit	2.50	HPTLC	(Paul et al., 2024b)
	G. morella	Fruit	3.14	HPTLC	(Paul et al., 2024b)
	G. pedunculata	Fruit	2.79	HPTLC	(Paul et al., 2024b)
Garcinol	*G. lanceifolia*	Fruit	0.58	HPTLC	(Paul et al., 2024a)
	G. morella	Fruit	0.98	HPTLC	(Paul et al., 2024a)
			5.33	HPLC	(Dutta et al., 2023)
	G. pedunculata	Fruit	0.62	HPTLC	(Paul et al., 2024a)
			4.40	HPLC	(Dutta et al., 2023)
	G. lancifolia	Fruit	0.39	HPLC	(Dutta et al., 2023)
	G. sopsopia	Fruit	19.60	HPLC	(Dutta et al., 2023)
	G. xanthocymus	Fruit	28.64	HPLC	(Dutta et al., 2023)
	G. kydia	Fruit	bq	HPLC	(Dutta et al., 2023)
	G. cowa	Fruit	bq	HPLC	(Dutta et al., 2023)
	G. cuspida	Fruit	bq	HPLC	(Dutta et al., 2023)
	G. indica	Fruit	0.020–4.88	LC-MS/MS	(Shedge et al., 2025)
Oblongifolin C	*G. xanthochymus*	Bark	0.0010	UPLC-QTOF-MS	(Zhou et al., 2010)
		Leaf	nd	UPLC-QTOF-MS	(Zhou et al., 2010)
		Fruit	0.0032	UPLC-QTOF-MS	(Zhou et al., 2010)
	G. oblongifolia	Bark	0.34	UPLC-QTOF-MS	(Zhou et al., 2010)
		Twig	0.15	UPLC-QTOF-MS	(Zhou et al., 2010)
		Leaf	0.023	UPLC-QTOF-MS	(Zhou et al., 2010)
	G. lancilimba	Bark	0.47	UPLC-QTOF-MS	(Zhou et al., 2010)
		Twig	0.092	UPLC-QTOF-MS	(Zhou et al., 2010)
		Leaf	0.0053	UPLC-QTOF-MS	(Zhou et al., 2010)
	G. xipshuangbannaensis	Bark	0.0011	UPLC-QTOF-MS	(Zhou et al., 2010)
		Twig	0.0051	UPLC-QTOF-MS	(Zhou et al., 2010)
		Leaf	0.0024	UPLC-QTOF-MS	(Zhou et al., 2010)
		Fruit	0.0096	UPLC-QTOF-MS	(Zhou et al., 2010)
	G. cowa	Bark	0.43	UPLC-QTOF-MS	(Zhou et al., 2010)
		Twig	0.38	UPLC-QTOF-MS	(Zhou et al., 2010)
		Leaf	0.020	UPLC-QTOF-MS	(Zhou et al., 2010)
	G. subelliptica	Twig	0.0016	UPLC-QTOF-MS	(Zhou et al., 2010)
		Leaf	0.0061	UPLC-QTOF-MS	(Zhou et al., 2010)
		Fruit	0.012	UPLC-QTOF-MS	(Zhou et al., 2010)
	G. paucinervis	Leaf	0.0011	UPLC-QTOF-MS	(Zhou et al., 2010)
	G. multiflora	Bark	0.60	UPLC-QTOF-MS	(Zhou et al., 2010)
		Twig	0.36	UPLC-QTOF-MS	(Zhou et al., 2010)
		Leaf	0.058	UPLC-QTOF-MS	(Zhou et al., 2010)
	G. yunnanensis	Bark	0.68	UPLC-QTOF-MS	(Zhou et al., 2010)
		Twig	0.20	UPLC-QTOF-MS	(Zhou et al., 2010)
		Leaf	0.23	UPLC-QTOF-MS	(Zhou et al., 2010)
		Fruit	1.21	UPLC-QTOF-MS	(Zhou et al., 2010)
	G. esculenta	Bark	bq	UPLC-QTOF-MS	(Zhou et al., 2010)
		Twig	bq	UPLC-QTOF-MS	(Zhou et al., 2010)
		Leaf	bq	UPLC-QTOF-MS	(Zhou et al., 2010)
		Fruit	bq	UPLC-QTOF-MS	(Zhou et al., 2010)

[a] nd: not detected, bq: below the limit of quantification.
[b] HPLC: high-performance liquid chromatography, UPLC: ultra-high-performance liquid chromatography, HPTLC: high-performance thin-layer chromatography, UPLC: ultra-performance liquid chromatography, QTOF-MS: quadrupole time-of-flight mass spectrometry.

academic journals. More than half of the top 30 most influential references focus on *G. mangostana*, highlighting its pivotal role in the field. A total of 12,182 authors from 107 countries and 2777 institutions have contributed to *Garcinia* research, demonstrating its broad global appeal. While international collaborations are common, the intensity of cooperation among countries, authors, and institutions still has room for improvement. Keyword analysis reveals that *Garcinia* research primarily centers on phytochemistry and pharmacology, with pharmacological studies focusing on anticancer, antioxidant, and antibacterial activities and chemical studies on xanthones, benzophenones, bioflavonoids, and organic acids. Emerging research frontiers include green synthesis, molecular docking, bioactive compounds, silver nanoparticles, nanoparticles and phenolic compounds. These hotspots suggest that future investigations on *Garcinia*-derived compounds or extracts for functional food and nutraceutical development will remain a major research priority. To advance the field, it is essential to address existing gaps, such as the comprehensive quantification of bioactive compounds like kolaviron and the broader application of green synthesis techniques across diverse *Garcinia* species and nanomaterials. Overall, this study provides a thorough global overview of *Garcinia* research and valuable insights to inform future studies, particularly in developing functional foods and health-promoting products derived from *Garcinia* species. The findings also demonstrate the effectiveness of combining VOSviewer, CiteSpace, and HistCite in capturing global research trends in food and medicinal plants, thereby supporting their sustainable utilization for food and medicinal purposes.

Ethical statement

The authors declare that this study did not involve any experiments on human participants or animals. All data used in this research were obtained from publicly available bibliographic databases, and no ethical approval was required.

Fengke Lin, Ph.D.,

On behalf of all authors of this paper

Data availability

Data will be made available on request.

CRediT authorship contribution statement

Fengke Lin: Conceptualization, Data curation, Funding acquisition, Investigation, Methodology, Project administration, Software, Validation, Writing – original draft. **Zihao Liu:** Data curation, Investigation. **Zhongxin Duan:** Data curation, Investigation. **Rui Zhao:** Data curation, Investigation. **Binsheng Luo:** Conceptualization, Funding acquisition, Project administration, Validation, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.afres.2025.101392.

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