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Kaempferia parviflora in Erectile Dysfunction: An Integrative Bibliometric and Narrative Synthesis

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ABSTRACT

Kaempferia parviflora Wall. Ex Baker, commonly known as black ginger, has attracted increasing scientific interest because of its diverse phytochemical and pharmacological properties, including potential relevance to male sexual function and erectile dysfunction. This study aimed to map global research trends on *K. parviflora* and synthesize the available evidence concerning its relevance to erectile dysfunction. Bibliographic records published between 2015 and 2025 were retrieved from the Scopus database using predefined search terms. Following a PRISMA-adapted screening process, 69 publications were included in the final dataset. Bibliometric analyses were performed using the Bibliometrix package through the Biblioshiny interface and VOSviewer, while a narrative synthesis was used to interpret the principal phytochemical and mechanistic findings. Publication output increased during the study period, with research contributions predominantly originating from Asian countries, particularly Thailand. The research landscape evolved from phytochemical characterization and preliminary biological activity studies toward pharmacological, mechanistic, pharmacokinetic, and computational investigations. Polymethoxyflavones emerged as the principal bioactive constituents of interest, while phosphodiesterase type 5 inhibition, nitric oxide–cyclic guanosine monophosphate signaling, vascular modulation, and antioxidant activity represented mechanisms potentially relevant to erectile function. Keyword mapping also indicated increasing use of molecular docking and network pharmacology to explore compound–target interactions. Nevertheless, the literature remains dominated by preclinical studies, whereas controlled clinical evidence, standardized extract formulations, dose–response data, long-term safety evaluations, and assessments of herb–drug interactions remain limited. This integrative bibliometric and narrative review provides a structured overview of the *K. parviflora* research landscape and identifies priorities for future pharmacological and clinical investigations. The findings indicate potential relevance to erectile dysfunction research but do not establish clinical efficacy or therapeutic effectiveness.

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ABSTRAK

Kaempferia parviflora Wall. Ex Baker, yang dikenal sebagai jahe hitam, semakin banyak diteliti karena memiliki beragam kandungan fitokimia dan aktivitas farmakologis, termasuk potensi relevansinya terhadap fungsi seksual pria dan disfungsi ereksi. Penelitian ini bertujuan memetakan tren penelitian global mengenai *K. parviflora* dan menyintesis bukti yang tersedia terkait relevansinya terhadap disfungsi ereksi. Data bibliografis publikasi tahun 2015–2025 diperoleh dari basis data Scopus menggunakan istilah pencarian yang telah ditentukan. Setelah melalui proses seleksi yang diadaptasi dari PRISMA, sebanyak 69 publikasi dimasukkan ke dalam dataset akhir. Analisis bibliometrik dilakukan menggunakan paket Bibliometrix melalui antarmuka Biblioshiny dan VOSviewer, sedangkan sintesis naratif digunakan untuk menginterpretasikan temuan fitokimia dan mekanistik utama. Jumlah publikasi meningkat selama periode penelitian, dengan kontribusi penelitian terutama berasal dari negara-negara Asia, khususnya Thailand. Fokus penelitian berkembang dari karakterisasi fitokimia dan skrining awal aktivitas biologis menuju penelitian farmakologis, mekanistik, farmakokinetik, dan komputasional. Polimetoksiflavon merupakan kelompok senyawa bioaktif utama yang paling banyak diteliti, sedangkan penghambatan fosfodiesterase tipe 5, jalur pensinyalan nitric oxide–cyclic guanosine monophosphate, modulasi vaskular, dan aktivitas antioksidan merupakan mekanisme yang berpotensi relevan terhadap fungsi ereksi. Pemetaan kata kunci juga menunjukkan meningkatnya penggunaan *molecular docking* dan *network pharmacology* untuk mengkaji interaksi senyawa–target. Meskipun demikian, bukti yang tersedia masih didominasi penelitian praklinis, sementara uji klinis terkontrol, standardisasi formulasi ekstrak, data hubungan dosis–respons, evaluasi keamanan jangka panjang, dan kajian interaksi herbal–obat masih terbatas. Tinjauan bibliometrik dan naratif integratif ini memberikan gambaran terstruktur mengenai lanskap penelitian *K. parviflora* serta mengidentifikasi prioritas penelitian farmakologis dan klinis selanjutnya. Temuan ini menunjukkan relevansi potensial terhadap penelitian disfungsi ereksi, tetapi belum membuktikan efikasi klinis atau efektivitas terapeutiknya.

Kata Kunci: *Kaempferia parviflora*; Jahe hitam; Disfungsi ereksi; Analisis bibliometrik; Polimetoksiflavon; Fosfodiesterase tipe 5

1. Introduction

Erectile dysfunction (ED) is one of the most prevalent male reproductive health disorders worldwide. This condition not only compromises quality of life and psychosocial well-being but is also closely associated with systemic diseases such as diabetes mellitus, cardiovascular disorders, and metabolic syndrome. To date, synthetic *phosphodiesterase type 5* (PDE5) inhibitors, including sildenafil, tadalafil, and vardenafil, remain the first-line pharmacological therapy for ED. However, long-term use of these agents has been associated with adverse effects, limited clinical responses in specific patient populations, and potential drug-drug interactions, thereby motivating the search

for safer and more sustainable therapeutic alternatives, including those derived from medicinal plants [1]

In this context, tradisional medicinal plants have gained attention as potential sources of therapeutic agents for erectile dysfunction and sexual function enhancement. One prominent example is *Kaempferia parviflora* Wall. Ex Baker (black ginger), a member of the *Zingiberaceae* family that has long been used in Thailand and other southeast Asian countries as an aphrodisiac, vitality enhancer, and male health tonic [2], [3]. Phytochemically, the rhizomes of *K. parviflora* are rich in *polymethoxyflavones* (PMFs), including *5,7-dimethoxyflavones*, *5,7,4′-trimethoxyflavone*, and *3,5,7,3′,4′-pentamethoxyflavones*, which are considered major contributors to the plant's diverse biological activities [4].

A growing body of experimental evidence has demonstrated that *K. parviflora* exhibits a broad spectrum of pharmacological activities, including anti-inflammatory, antioxidant, antimicrobial, neuroprotective, and antihypertensive effects, as well as improvements in physical performance and sexual function [5], [6]. Notably, the aphrodisiac activity of this plant has been closely linked to its ability to inhibit PDE5, thereby enhancing nitric oxide-cyclic guanosine monophosphate (NO-cGMP) signaling pathway. This mechanism resembles that of conventional synthetic ED medications, while potentially offering a more favorable safety profile [7]. In addition, both *in vitro* and *in vivo* studies have demonstrated that *K. parviflora* extracts and their active constituents can increase testosterone levels and improve parameters related to sexual behavior and male reproductive function [8]. Alongside growing interest in the development of plant-based phytopharmaceuticals, the number of scientific publications on *Kaempferia parviflora* has increased markedly over the past decade. Nevertheless, despite the rapid growth of the literature, comprehensive studies that systematically map the research landscape of *K. parviflora* remain limited. In particular, previous studies have not fully explored scientific collaboration networks, the evolution of research themes over time, and erectile dysfunction-specific mechanistic research clusters, especially those related to phosphodiesterase type 5 (PDE5) inhibition and the nitric oxide–cyclic guanosine monophosphate (NO–cGMP) signaling pathway. As a result, a comprehensive understanding of the intellectual structure, research trends, and emerging directions of *K. parviflora* research in the context of erectile dysfunction remains lacking.

Therefore, the present study aims to conduct an integrative narrative and bibliometric review of scientific publications on *K. parviflora* published between 2015 and 2025 to systematically identify publication trends, leading authore and institutions, geographical distribution of research, scientific collaboration networks, and dominant research themes. By integrating bibliometic analysis with a narrative synthesis, this study seeks to provide a comprehensive knowledge map of the research landscape on *K. parviflora*, highlight its role in the development of plant-based aphrodisiacs and erectile dysfunction therapies, and identify current research gaps and future directions.

2. Methods

Data Source and Search Strategy

The literature search was conducted on 14 October 2025, with the publication period restricted to 2015–2025. The search strategy was designed to retrieve scientific publications addressing *Kaempferia parviflora* from phytochemical, pharmacological, and computational perspectives, as well as in relation to male sexual function and erectile

dysfunction, particularly through mechanisms involving phosphodiesterase type 5 (PDE5) inhibition. The search terms were combined using Boolean operators as follows:

("Kaempferia parviflora" OR "black ginger" OR Kaempferia) AND (aphrodisiac OR PDE5 OR "phosphodiesterase type 5" OR "sexual function" OR "erectile dysfunction" OR "sexual behavior" OR testosterone OR "network pharmacology" OR "GC-MS" OR "chromatography" OR "densitometry" OR "chemical profile")

The search was applied to the title, abstract, and keyword fields. Because the term "Kaempferia" may retrieve publications related to other species within the genus, an additional screening and data-cleaning process was conducted. Records primarily focusing on other *Kaempferia* species (e.g., *K. galanga*, *K. rotunda*, and other non-*parviflora* species) were excluded during title, abstract, and full-text screening. Only publications specifically addressing *Kaempferia parviflora* were retained in the final dataset.

Inclusion and Exclusion Criteria

Inclusion and exclusion criteria were established to ensure that the analyzed publications were relevant to the research objectives and met adequate scientific quality standards. Articles were included if they met the following criteria: (1) original research articles or review papers published in reputable international journals; (2) *Kaempferia parviflora* as the primary research subject; (3) relevance to aphrodisiac activity, sexual function, erectile dysfunction, or related biological mechanisms such as *phosphodiesterase type 5* (PDE5) inhibition; (4) inclusion of phytochemical, pharmacological, toxicological, or computational approaches (e.g., network pharmacology or molecular docking); and (5) publication within the period between 2015 and 2025 availability in the English language. Conversely, articles were excluded if they: (1) did not specifically focus on *K. parviflora* or only mentioned it superficially; (2) focused on other *Kaempferia* species without relevant data on *K. parviflora*; (3) were conference proceedings, abstract, editorials, letters to the editor, short communications, or non-peer reviewed publications; (4) represented duplicated data or preliminary versions of the same publications; or (5) lacked complete bibliographic metadata required for bibliometric analysis.

Study Selection and Data Analysis

Subsequently, titles and abstracts were screened to identify publications relevant to *Kaempferia parviflora*, aphrodisiac activity, sexual function, erectile dysfunction, and phosphodiesterase type 5 (PDE5) inhibition.

Articles that passed the title and abstract screening underwent full-text evaluation. Full-text screening was conducted to confirm: (1) the relevance of the study to *K. parviflora* and erectile dysfunction-related research, including aphrodisiac activity, sexual function, PDE5 inhibition, or nitric oxide–cGMP signaling mechanisms; and (2) the completeness of bibliometric metadata required for subsequent analysis, including author information, affiliations, publication source, publication year, keywords, abstracts, citations, and references. Studies that focused primarily on other *Kaempferia* species or lacked sufficient bibliometric information were excluded.

Articles meeting all selection criteria were included in the final dataset and subjected to bibliometric analysis. The literature selection flow and the number of records at each stage, from identification to final inclusion, are presented in the PRISMA flow diagram (**Figure 1**).

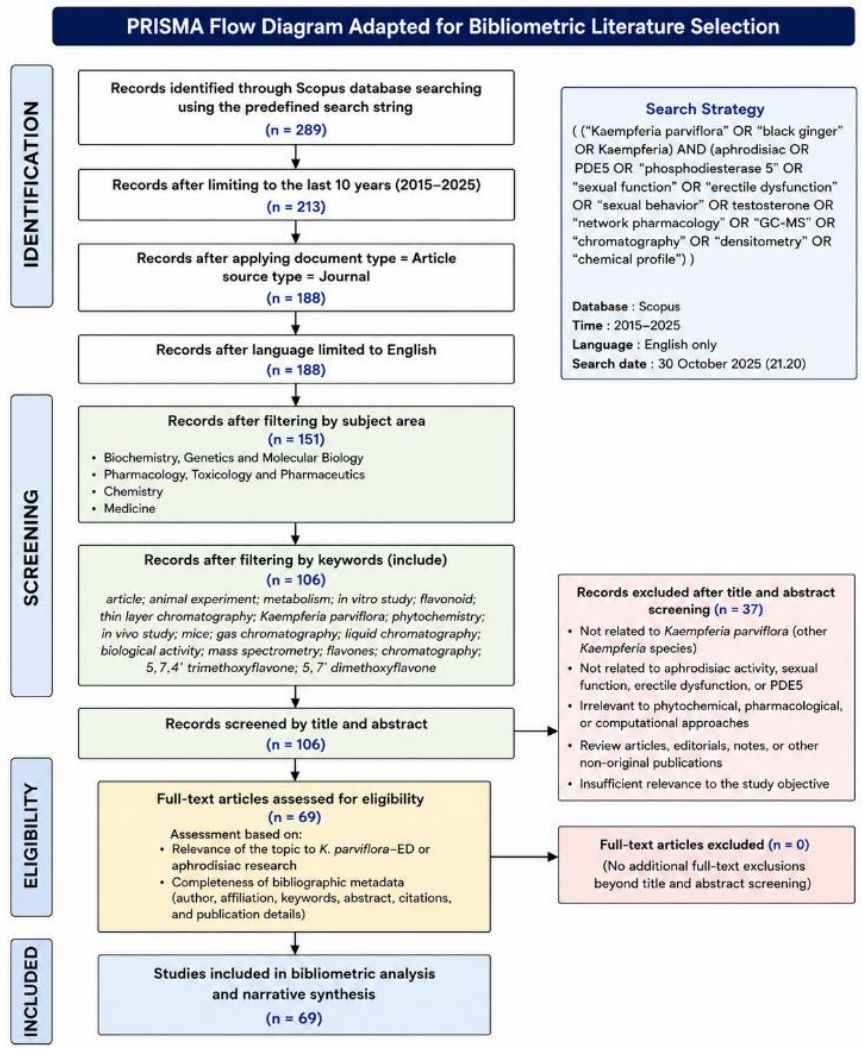


Figure 1. PRISMA flow diagram

Software and Visualization Tools

All bibliometric analyses were conducted using the Bibliometrix R package [9] through the Biblioshiny interface to process bibliographic data and perform descriptive statistical analyses, including publication trends, productivity indicators, citation analysis, and thematic structure mapping [10–12]. Bibliographic records were exported from the Scopus database in CSV format on 30 October 2025 and included metadata fields such as authors, affiliations, titles, abstracts, author keywords, indexed keywords, source titles, publication years, citations, references, and document types.

Prior to analysis, data cleaning and keyword standardisation procedures were performed to improve consistency. Synonymous terms and spelling variations were merged using thesaurus-based cleaning rules, including "PDE5" and "phosphodiesterase type 5", "NO-cGMP" and "nitric oxide–cGMP pathway", as well as variations of *Kaempferia parviflora* terminology. Irrelevant or overly generic keywords were removed from co-occurrence analyses where appropriate.

Bibliometric networks were normalised using the association strength method. Threshold parameters were applied to improve interpretability of the visualisations, including minimum occurrence thresholds for keyword analyses and minimum

document thresholds for author, institution, and country collaboration networks. Advanced visualisation and network analyses were performed using VOSviewer [13], including co-authorship, country collaboration, keyword co-occurrence, and thematic clustering analyses.

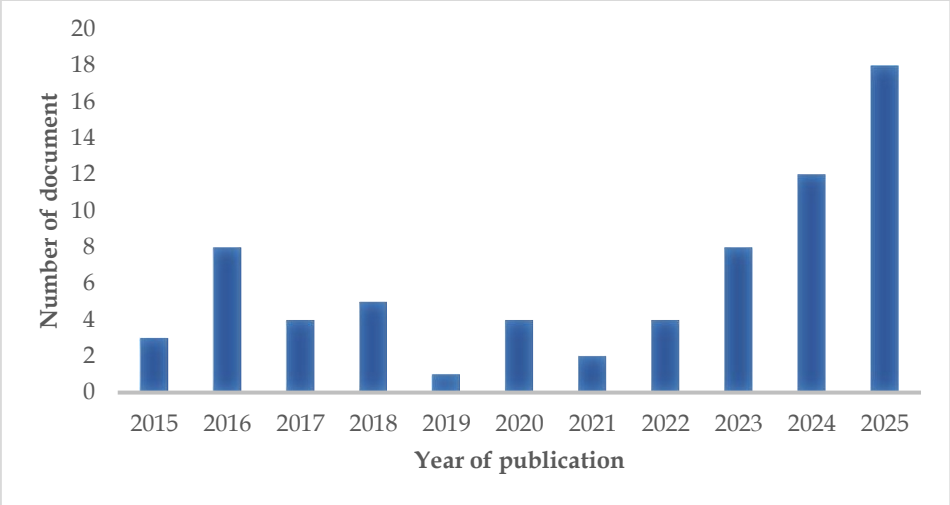
Disclosure of AI use

The authors use ChatGPT (OpenAI) to assist with language editing and improve the clarity and structure of the manuscript. The AI tool was not used for data generation, analysis, or scientific interpretation. The authors take full responsibility for the integrity, accuracy, and conclusions of this work.

3. Results and Discussion

Publication Trends

The bibliometric analysis showed a steady increase in publications on *K. parviflora* between 2015 and 2025 (**Figure 2**). During the early period (2015-2017), the annual publication output remained relatively limited. Studies published in this phase mainly focused on fundamental investigations, including phytochemical identification and preliminary biological activity screening, particularly those related to nitric oxide-medicated vascular function [4], [9].



Note: Data were retrieved from the Scopus database and exported on 30 October 2025. The analysis included 69 final records selected after duplicate removal and application of the predefined inclusion and exclusion criteria.

Figure 2. Temporal Evolution of Scientific Publications on *K. parviflora* (2015-2025)

A substantial increase in publications was observed during the 2018-2020 period. This growth was accompanied by an increasing number of studies on the aphrodisiac activity and the inhibition of *phosphodiesterase type 5* (PDE5). Several publications during this period highlighted *polymethoxyflavones* as major bioactive constituents associated with modulation of the NO-cGMP pathway and supportive antioxidant and anti-inflammatory effects [7], [9].

The upward trend became more pronounced during 2021-2025, when publication output reached its highest level. In this period, studies increasingly included early clinical investigations, formulation development, and computational approaches such as network pharmacology and molecular docking, in addition to *in vitro* and *in vivo*

experiments [10], [11]. Overall, the annual publication trend indicates sustained growth in scientific output related to *K. parviflora* over the last decade.

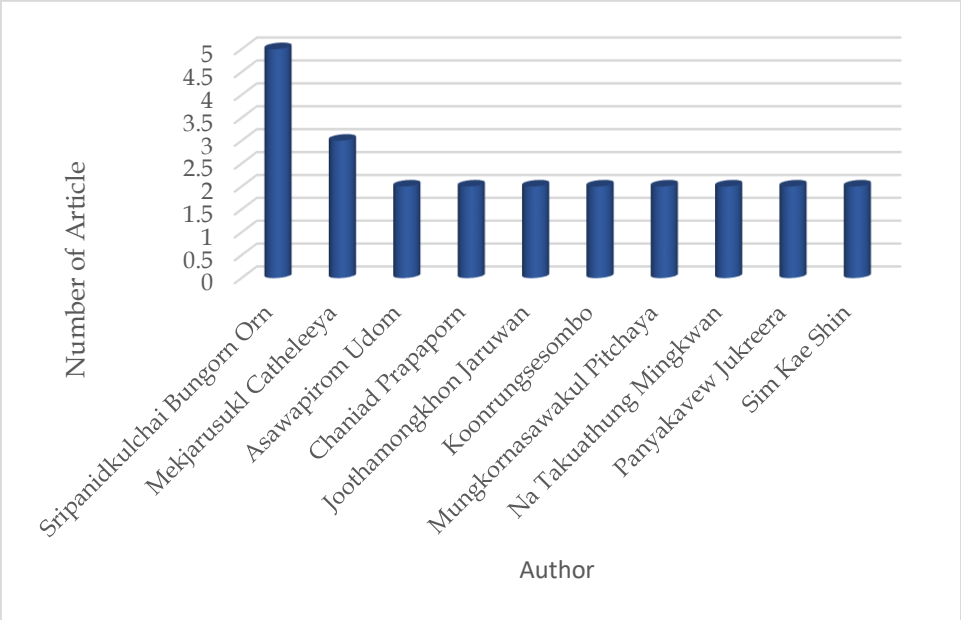
Most Productive Authors and Institutions

An analysis of author and institutional productivity was conducted to identify key contributors and major research centers involved in *K. parviflora* research during the period 2015-2025. The results indicated that scientific output in this field was concentrated among a limited number of authors and institutions, reflecting sustained research activity and continuity [12], [13].

Based on publication counts, several authors emerged as the most productive contributions to *K. parviflora* research (**Table 1** and **Figure 3**). These authors were predominantly involved in phytochemical characterization and pharmacological evaluation of *K. parviflora*, including investigations of biological mechanisms associated with sexual function and *phosphodiesterase type 5* (PDE5) inhibition [7], [14].

Table 1. Most Productive Authors and Their Main Affiliations (2015-2025)

Rank	Author	No. of articles	Main Affiliation	Country
1	Sripanidkulchai Bungorn Orn	5	Khon Kaen University	Thailand
2	Mekjarusukl Catheleeya	3	Mahasarakham University	Thailand
3	Asawapirom Udom	2	National Nanotechnology Center (NANOTEC)	Thailand
4	Chaniad, Prapaporn	2	Prince of Songkla University	Thailand
5	Joothamongkhon, Jaruwan	2	Thailand National Nanotechnology Center	Thailand
6	Koonrungsesomboon, Nut	2	Faculty of Medicine, Chiang Mai University	Thailand
7	Mungkornasawakul, Pitchaya	2	Chiang Mai University	Thailand
8	Na Takuathung, Mingkwan	2	Faculty of Medicine, Chiang Mai University	Thailand
9	Panyakaew, Jukreera	2	Chiang Mai University	Thailand
10	Sim, Kae Shin	2	Institute of Biological Sciences	Malaysia

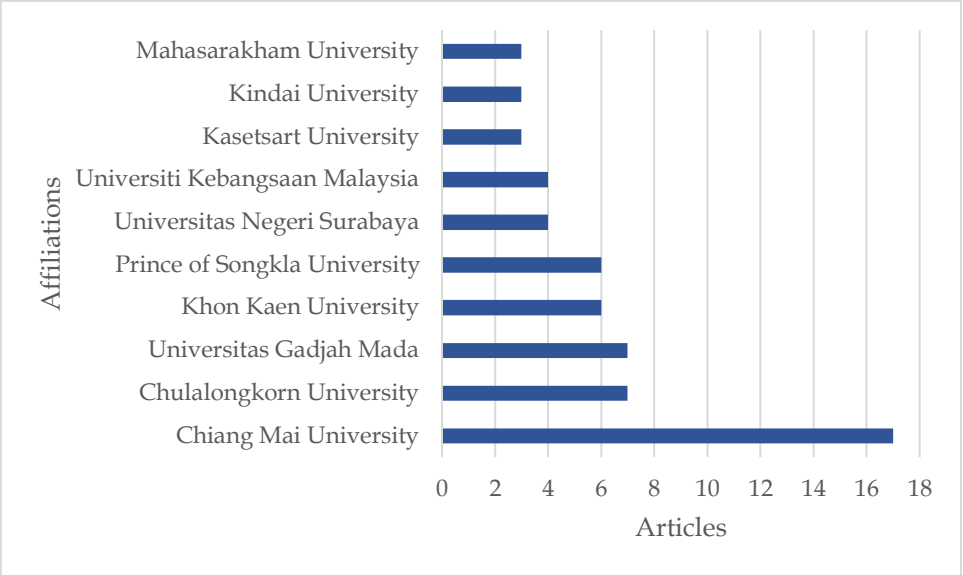


Note: The bar chart presents the top 10 authors ranked by publication output within the final bibliometric dataset (n = 69). Bar height represents the number of Scopus-indexed documents attributed to each author during the study period (2015–2025). Author productivity was calculated using publication counts derived from the Scopus export after duplicate removal and application of the predefined inclusion and exclusion criteria.

Figure 3. Top 10 most productive authors in Kaempferia parviflora research based on the number of Scopus-indexed documents (2015–2025).

From an institutional perspective, universities and research centers in Southeast Asia, particularly in Thailand, accounted for the majority of publications. Chiang Mai University, Khon Kaen University, and Chulalongkorn University were identified as the most productive institutions during the study period (**Figure 4**).

The thematic orientation of publications from these leading authors and institutions was largely associated with erectile dysfunction and male reproductive health. Several highly productive research groups reported PDE5 inhibitory activity, activation of the nitric oxide-cyclic guanosine monophosphate (NO-cGMP) pathway, and improvements in sexual function parameters in both *in vitro* and *in vivo* models [7], [14], [15].



Note: Institution productivity was calculated using the full-counting method based on affiliation metadata extracted from Scopus. All author affiliations associated with a publication were included in the analysis; therefore, a single publication could contribute to more than one institution when multiple affiliations were reported. The bar chart presents the number of documents attributed to each institution within the final bibliometric dataset (n = 69).

Figure 4. Top productive institutions in Kaempferia parviflora research based on the number of Scopus-indexed documents (2015–2025)

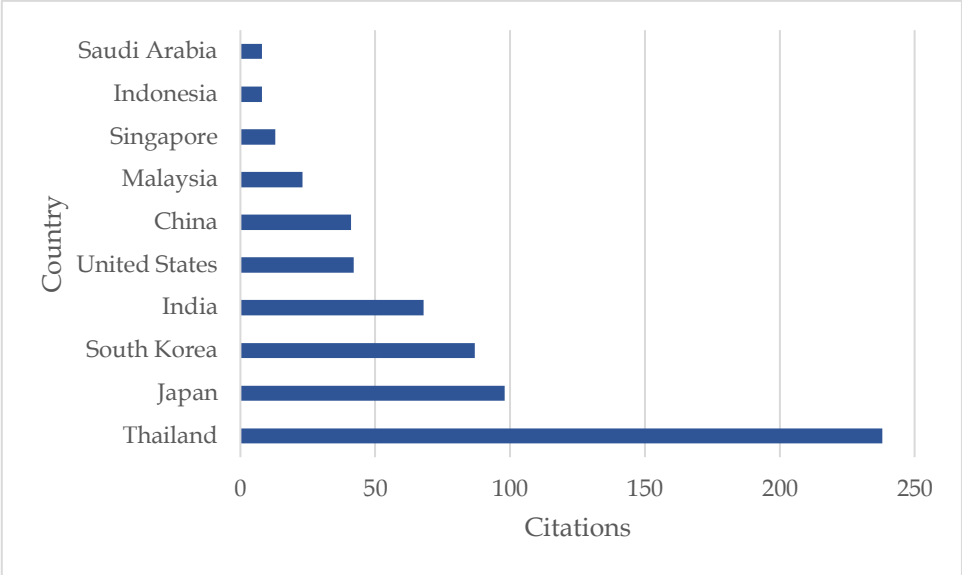
Most Productive Countries

The geographical distribution of publications showed that research on *K. parviflora* was predominantly concentrated in Asia, particularly in Southeast Asian and East Asia. Thailand ranked first in terms of both publication output and citation counts, indicating its leading position in *K. parviflora* research [7], [15]. Japan, South Korea, and China also contributed substantially to the literature, with numerous studies addressing phytochemical characterization and experimental investigations of *polymethoxyflavones*, a major bioactive constituent [9], [10].

Additional contributions were observed from the United States, India, Malaysia, and Indonesia, with increasing publication activity during the later years of the study period. Publications from these countries frequently addressed phytochemical standardization, computational approaches, and exploratory therapeutic studies, including network pharmacology and molecular docking [10], [11]. The top ten contributing countries, together with their publication and citation counts, are summarized in **Table 2.** The distribution of citations by country is presented in **Figure 5**.

Table 2. Top ten countries contributing to *Kaempferia parviflora* research (2015-2025)

Rank	Country	Publications	Citations	Leading Institutions
1	Thailand	28	238	Chiang Mai University, Khon Kaen University, Chulalongkorn University
2	Japan	12	98	Kindai University, University of Tsukuba
3	South Korea	10	87	Kyungpook National University
4	India	9	68	University of Delhi
5	United States	8	42	University of California, NIH
6	China	8	41	Beijing University of Chinese Medicine
7	Malaysia	7	23	University Kebangsaan Malaysia, Universiti Putra Malaysia
8	Singapore	5	13	National University of Singapore
9	Indonesia	5	8	Universitas Gadjah Mada, Universitas Negeri Surabaya
10	Saudi Arabia	4	8	King Saud University

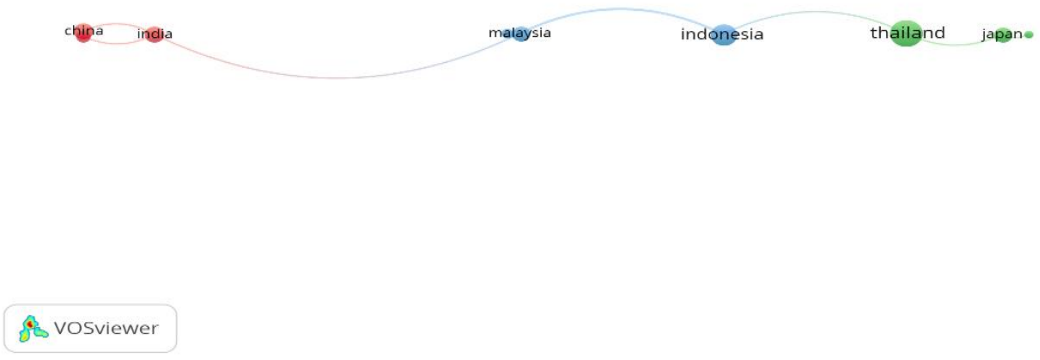


Note: The figure presents a citation-based analysis only and does not represent the total number of publications contributed by each country. Citation counts were calculated from Scopus records included in the final dataset (n = 69) and were recorded at the time of data export (30 October 2025). Citation values may change over time as the Scopus database is updated.

Figure 5. Distribution of total citations by country in Kaempferia parviflora research publications (2015–2025)

Collaboration Network

An analysis of author collaboration networks was conducted to examine patterns of scientific cooperation among researchers and across countries in *K. parviflora* research during the period 2015-2025. The mapping results showed that collaborative activities were primarily concentrated within Southeast Asia and East Asia (**Figure 6**). Thailand occupied a central position in the collaboration network, with strong linkages among domestic institutions and with research groups from Japan, South Korea, and China [7], [14]. Collaborations involving East Asian countries were frequently associated with experimental studies focusing on phytochemical characterization, including *polymethoxyflavones*, and biological activity evaluation using *in vitro* and *in vivo* models [9], [11]. In contrast, collaboration links with countries outside Asia, including the United States and European countries, were relatively limited. These collaborations primarily involved computational approaches such as network pharmacology and molecular docking. The international country-level collaboration network is presented in Figure 6, illustrating the structure and intensity of collaborative relationships among contributing countries [12], [16]



Note: Nodes represent countries contributing to the final bibliometric dataset (n = 69), while links indicate international co-authorship collaborations between countries. Node size reflects the number of documents associated with each country, and link thickness represents the strength of collaborative relationships. The network was generated using VOSviewer based on Scopus data exported on 30 October 2025 and visualised using association-strength normalization.

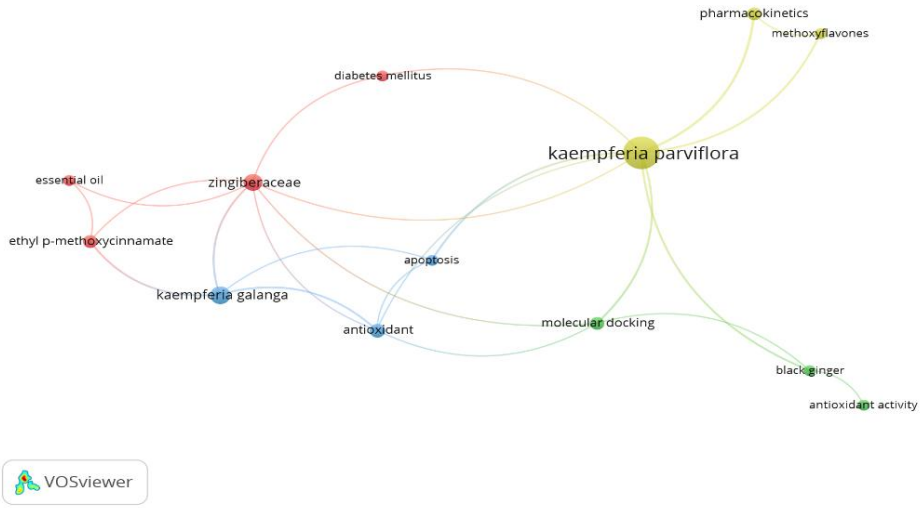
Figure 6. International country-level collaboration network in *K. parviflora* research (2015-2025)

Keyword Co-occurrence and Thematic Clustering

Keyword co-occurrence analysis was conducted to identify the thematic focus and intellectual structure of Kaempferia parviflora research. The network was generated from author keywords using association-strength normalization, and thematic clusters were identified using the Walktrap clustering algorithm. Prior to analysis, keyword standardisation was performed to harmonise synonymous terms and improve network consistency [16].

As shown in **Figure 7**, three major thematic clusters were identified. The blue cluster, centred on the keyword "Kaempferia parviflora", represents the core research area and includes keywords such as "methoxyflavones", "pharmacokinetics", "phytochemicals", "inflammation", "apoptosis", and "herbal-drug interaction". This cluster reflects studies focusing on phytochemical characterisation, pharmacological activities, and biological mechanisms of K. parviflora and its bioactive constituents.

The red cluster is associated with chemical profiling and biological activity evaluation, represented by keywords including "Kaempferia galanga", "Zingiberaceae", "antioxidant", "GC-MS", "ethyl p-methoxycinnamate", and "wound healing". This cluster highlights research related to chemical composition analysis, analytical characterisation, and evaluation of biological activities of plants within the Zingiberaceae family.



Note: The network was generated from author keywords using Biblioshiny. Nodes represent keywords, while links indicate co-occurrence relationships between keywords within the same publication. Node size reflects keyword frequency, and link thickness represents co-occurrence strength. Different colours represent thematic clusters identified using the Walktrap clustering algorithm. The network was visualised using association-strength normalization and included the 50 most relevant connected keywords after removal of isolated nodes.

Figure 7. Keyword co-occurrence network and thematic clustering of Kaempferia parviflora research (2015–2025)

The green cluster represents emerging computational approaches and is characterised by keywords such as "molecular docking" and "network pharmacology". This cluster reflects the increasing application of in silico methods to investigate compound–target interactions and explore potential molecular mechanisms underlying the biological activities of K. parviflora.

Overall, the keyword co-occurrence network suggests that research on K. parviflora has evolved from phytochemical and analytical investigations towards pharmacological studies and more advanced computational approaches. The prominence of phytochemical, pharmacokinetic, and molecular docking-related keywords indicates growing interest in understanding the bioactive compounds and mechanistic basis of K. parviflora for future therapeutic applications.

Citation Analysis

Citation analysis was conducted to identify publications with the highest scientific impact in *K. parviflora* research during the study period. The results showed that highly cited articles were predominantly studies reporting key biological mechanisms, particularly *phosphodiesterase type 5* (PDE5) inhibition and aphrodisiac-related pharmacological activity relevant to male reproductive health. In addition, several highly cited publications examined the anti-inflammatory and antioxidant activities of *K. parviflora*, indicating that these studies covered a broad range of pharmacological effects beyond erectile dysfunction-related topics.

The citation distribution further showed that articles published by highly productive authors and institutions tended to receive higher citation counts, suggesting

a concentration of scientific influence among leading research groups in this field. A summary of the most highly cited articles is presented in **Table 3**.

Table 3. Most cited article in *Kaempferia parviflora* research (2015-2025)

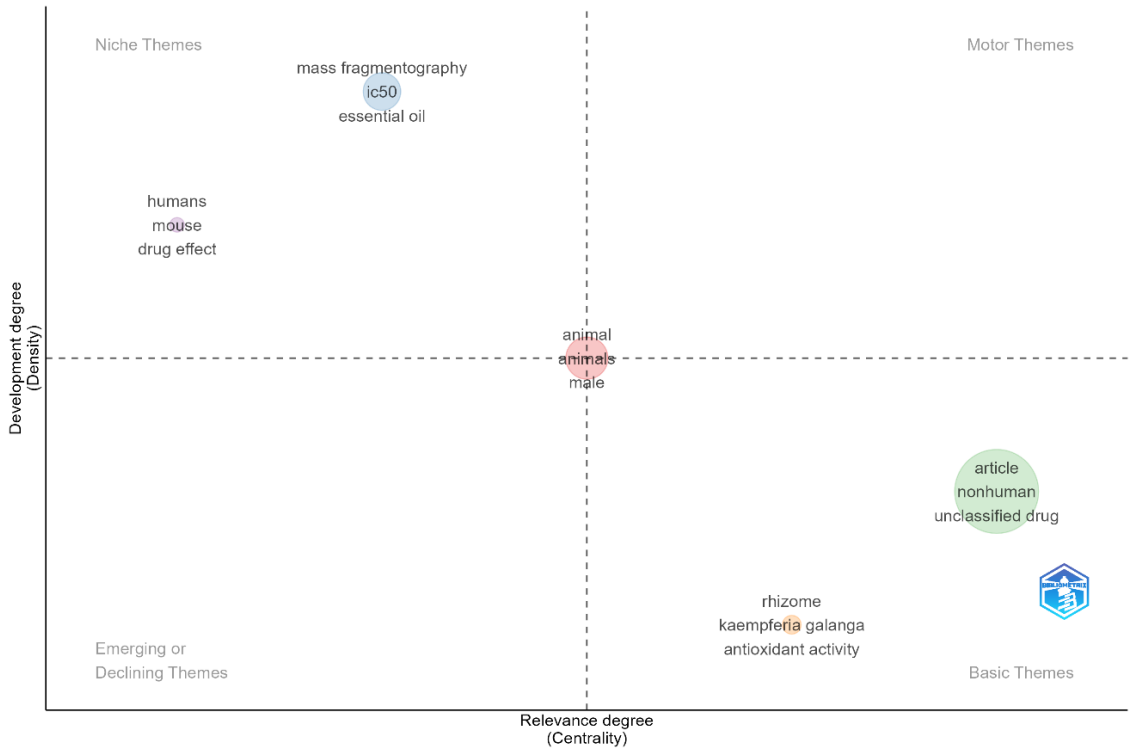
Rank	Author (Year)	Total Citations	Journal	Research Focus
1	Temkitthawon et al. (2011) [7]	189	*Journal of Ethnopharmacology*	PDE5 inhibition, aphrodisiac activity
2	Tewtrakul et al. (2009) [4]	162	*Food Chemistry*	Anti-inflammatory activity, flavonoid
3	Chen et al. (2018)[9]	148	*Evidence-Based Complementary and Alternative Medicine*	Phytochemistry and biological activities of methoxyflavones
4	Elshamy et al. (2019) [10]	132	*Nutrients*	Phytochemistry and biological activities of Kaempferia species
5	Stein et al. (2018)[5]	94	*Journal of Integrative Medicine*	Clinical study, sexual health improvement

Note: Total citations were obtained from Scopus and calculated as of the export date (30 October 2025). Citation counts may change over time as the database is updated.

Thematic Map Analysis

The thematic map analysis was conducted to assess the maturity and relevance of research themes in *K. parviflora* studies using centrality and density as analytical dimenions. The results showed that theme related to *polymethoxyflavones*, aphrodisiac activity, and *phosphodiesterase type 5* (PDE5) inhibition were positioned as motor themes, indicating their high relevance and strong development within the research field.

In addition, themes associated with network pharmacology and molecular docking were identified as emerging research areas, reflecting increasing application of computational approaches to support multi-target and systems-based phytopharmaceutical development. The thematic map summarizing the evolution and structural dynamics of *K. parviflora* research during the study period is presented in **Figure 8**.



Note: The thematic map was generated using Bibliometrix/Biblioshiny based on author keywords. Themes are positioned according to centrality (x-axis), representing the degree of interaction with other research themes, and density (y-axis), representing the level of internal development of a theme. The upper-right quadrant contains motor themes (well-developed and important themes), the upper-left quadrant contains niche themes (well-developed but isolated themes), the lower-right quadrant contains basic themes (important but less developed themes), and the lower-left quadrant contains emerging or declining themes (weakly developed and marginal themes). Bubble size reflects keyword frequency within each thematic cluster.

Figure 8. Thematic map of Kaempferia parviflora research (2015–2025) based on keyword co-occurrence analysis

Evolution of research on *K. parviflora*

Research on *K. parviflora* has evolved substantially over the past decade, as reflected by the increasing number of publications and diversified research themes identified in this bibliometric analysis. Early phytochemical investigations established *K. parviflora* as a source of polymethoxyflavones, a class of flavonoid compounds that contribute to the plant's broad pharmacological profiles, including anti-inflammatory, antioxidant, and vascular modulatory activities [9],[10]. A pivotal foundation for mechanistic research was provided by studies demonstrating that *K. parviflora* rhizome extract and its methoxyflavone constituents inhibit *phosphodiesterase type 5* (PDE5), a key enzyme involved in cyclic nucleotide signaling. This inhibitory activity supports the plant's traditional use as a sexual performance enhancer and aligns with modern therapeutic targets in erectile dysfunction [7].

Over time, research has expanded from descriptive phytochemistry and basic bioactivity screening to more integrated biological and pharmacological investigations. For example, numerous studies have characterized the chemical diversity of methoxyflavones in K. parviflora and discussed their potential roles in modulating vascular function, inflammatory responses, and cellular signaling pathways[10]. The

bibliometric trends observed in this study indicate a maturation of the field, with increasing employment of multidisciplinary approaches such as computational modelling (e.g., network pharmacology and molecular docking) and early clinical evaluations, reflecting efforts to translate traditional knowledge into evidence-based therapeutic leads. This evolution underscores the growing scientific relevance of *K. parviflora* and highlights its transition from a traditional herbal remedy to a subject of rigorous pharmacological investigation.

Implication for Erectile Dysfunction Research and Future Directions.

The findings of this integrative narrative review and bibliometric analysis indicate that *K. parviflora* has emerged as one of the most extensively studied medicinal plants in the context of natural aphrodisiacs and male reproductive health. These findings are consistent with previous experimental reports demonstrating that extracts and bioactive compounds of *K. parviflora* exhibit mechanisms of action comparable to those of synthetic PDE5 inhibitors, potentially with a more favorable safety profile [7], [14]. PMFs have been identified as key bioactive compounds underlying the vascular and reproductive health effects of *K. parviflora* [3], [10]. Nevertheless, bibliometric evidence indicates that most existing studies remain dominated by in vitro and in vivo investigations, with relatively few clinical trials. Therefore, future research should prioritize well-designed controlled clinical studies to evaluate therapeutic efficacy, long-term safety, and optimal dosage of *K. parviflora* in patients with erectile dysfunction. These findings are expected to serve as a scientific foundation for future research and phytopharmaceutical innovation, while highlighting the potential of K. parviflora as a promising subject for further pharmacological and clinical investigation in erectile dysfunction-related research.

Comparison with other herbal candidates

Several medicinal plants have been investigated as potential natural therapies for erectile dysfunction, including *Panax ginseng, Eurycoma longifolia, Tribulus terrestris*, and *Epimedium* species. These herbal candidates are commonly reported to improve sexual function through hormonal modulation, enhancement of nitric oxide production, or antioxidant activity. However, in many cases, the underlying molecular mechanisms remain incompletely characterized and are supported mainly by limited experimental or observational evidence. In comparison, *K. parviflora* demonstrates a relatively stronger mechanistic evidence base. Experimental studies have consistently reported direct *phosphodiesterase type 5* (PDE5) inhibitory activity of its extracts and polymethoxyflavones constituents, providing a clearly defined pharmacological pathway that parallels the mechanisms of clinically established synthetic PDE5 inhibitors [7].

In addition, pharmacokinetic and clinical investigations have begun to characterize its systemic behavior and safety profile in human subjects [14]. Furthermore, comprehensive phytochemical reviews indicate that *K. parviflora* contains a well-defined group of polymethoxyflavones that exhibit reproducible biological activities, including vasodilatory, anti-inflammatory, and antioxidant effects, which are relevant to endothelial function and erectile physiology [3], [10].

Such consistency in chemical composition and pharmacological targets is less frequently documented for many other herbal aphrodisiacs, where extract variability often limits reproducibility and clinical translation. Collectively, these characteristics suggest that *K. parviflora* occupies a distinctive position among herbal candidates for erectile dysfunction therapy.

Research gaps and future directions

Despite the substantial growth of research on *K. parviflora* over the past decade, several important gaps remain. Bibliometric evidence indicates that most existing studies rely on *in vitro* assay and animal models, while well-designed clinical trials remain relatively limited. This imbalance restricts the direct translation of promising mechanistic findings, particularly those related to *phosphodiesterase type 5* (PDE5) inhibition, into clinical recommendations. Another major gap concerns the lack of standardized extract formulations and harmonized quality control parameters. Variability in cultivation conditions, extraction methods, and polymethoxyflavone composition complicates the comparison of results across studies and may contribute to inconsistent pharmacological outcomes.

Dose-response relationships and long-term safety profiles remain insufficiently characterized. Although early pharmacokinetic and clinical studies suggest acceptable tolerability, systematic evaluation of chronic administration, potential drug-herb interactions, and effects in patients with comorbidities is still needed. Emerging computational approaches, including network pharmacology and molecular docking, represent promising tools for addressing the multi-target nature of *K. parviflora*. Integration of these methods with experimental validation could clarify compound-target networks and support rational phytopharmaceutical development. Overall, future research should adopt a multidisciplinary strategy integrating standardized phytochemistry, mechanistic enzymatic assay, pharmacokinetic modelling, and controlled clinical studies.

Strengths and limitations

This study has several limitations. First, the bibliometric analysis was restricted to publications indexed in the Scopus database; therefore, relevant articles published in other databases or non-English sources may not have been captured. Second, bibliometric methods rely on publication metadata and may not fully reflect the methodological quality or evidentiary strength of individual studies.

Despite these limitations, this study provides a structured overview of global research trends on K. parviflora, identifies influential research themes, and highlights directions for future investigation. These findings may serve as a reference framework for future pharmacological, preclinical, and clinical studies exploring the biological activities and therapeutic potential of K. parviflora.

4. Conclusion

This study integrates bibliometric analysis and narrative synthesis to characterize the evolution of research on *Kaempferia parviflora* in the context of erectile dysfunction and plant-based aphrodisiac development. The findings reveal a sustained increase in scientific interest over the past decade, accompanied by growing attention to phytochemical characterization, pharmacological mechanisms, phosphodiesterase type 5 (PDE5) inhibition, NO–cGMP signaling, and computational approaches such as network pharmacology and molecular docking. The bibliometric mapping identified major research themes, influential publications, leading authors and institutions, and emerging directions within the *K. parviflora* research landscape. In addition, the narrative synthesis highlighted the importance of polymethoxyflavones as key bioactive constituents and emphasized the increasing integration of phytochemical, pharmacological, and computational investigations. Overall, this study provides a structured overview of global research trends and identifies important knowledge gaps, particularly the need for standardized formulations, mechanistic validation, and well-

designed clinical studies. It should be noted that the present study maps research trends and thematic developments in the literature and does not, by itself, establish clinical efficacy or therapeutic effectiveness of *K. parviflora*. Nevertheless, the findings provide a useful reference framework for future experimental, pharmacological, and clinical investigations exploring the therapeutic potential of *K. parviflora* and its bioactive constituents in erectile dysfunction and male reproductive health.

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Conflicts of Interest:
The authors declare no conflicts of interest related to this study or its publication.

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