PLANT SCIENCE TODAY
Vol x(x): xx–xx
https://doi.org/10.14719/pst.11962

eISSN 2348-1900

REVIEW ARTICLE

Mapping global trends in Lamiaceae research

Roma Katyal[1], Manisha Arora Pandit[2], Saloni Gulati[1], Charu Dogra Rawat[3] & Jasleen Kaur[1*]

[1]Department of Botany, Dyal Singh College, University of Delhi, New Delhi 110 003, India
[2]Department of Zoology, Kalindi College, University of Delhi, New Delhi 110 008, India
[3]Department of Zoology, Ramjas College, University of Delhi, New Delhi 110 007, India

*Correspondence email - jasleen@dsc.du.ac.in

Received: 24 September 2025; Accepted: 05 January 2026; Available online: Version 1.0: xx xxxxxx 2025

Cite this article: Roma K, Manisha AP, Saloni G, Charu DR, Jasleen K. Mapping global trends in Lamiaceae research. Plant Science Today (Early Access). https://doi.org/10.14719/pst.11962

Abstract

This study presents a comprehensive bibliometric analysis of global scientific literature on the family Lamiaceae , commonly known as the mint family. The primary objective is to systematically map the research landscape, identify key trends, highlight influential entities and uncover emerging themes within this diverse botanical group. Data were meticulously retrieved from major scientific databases, including Scopus and Web of Science, covering publications from 1954 to 2025.Advanced bibliometric tools such as VOSviewer, Bibliometrix R and CiteSpace were employed to conduct performance analysis and science mapping, including co-authorship, co-citation and co-word analyses. A total of 2145 documents were analyzed, showing a 6.75 % annual growth rate and strong collaboration between China, India and Iran. The analysis reveals a dynamic research field characterised by distinct periods of significant growth, with notable surges in publication activity observed from 2006 to 2012, particularly in studies focusing on *Orthosiphon stamineus*, a prominent species within the family Lamiaceae. Core research areas predominantly focus on the pharmacological properties of Lamiaceae species, including their antidiabetic, antioxidant, anti-inflammatory, neuroprotective and pesticidal activities. Additionally, substantial attention is given to phytochemical characterisation and ethnobotanical applications. The study identifies leading journals, prolific authors and dominant contributing countries, while collaboration networks and thematic clusters underscore the field's interdisciplinary nature and evolving research focus. The findings highlight the immense medicinal and economic potential of Lamiaceae, emphasising the need for sustainable practices and continued exploration of its rich array of bioactive compounds. This analysis provides a strategic roadmap for future research, identifying current knowledge gaps and highlighting promising avenues for novel discoveries.

Keywords: bioactive compounds; bibliometric analysis; co-citation; ethnopharmacology; Lamiaceae; medicinal plants; phytochemical characterisation; research trends

Introduction

The family Lamiaceae , universally recognised as the mint family, comprises a vast and economically significant group of flowering plants. Characteristically, members of this family possess aromatic properties, square stems, opposite leaves and distinctive 2 lipped, tubular corollas with 5 lobed, bell-like calyces (1). This family comprises over 7000 species across 236 medicinally important genera (*Ocimum basilicum*, *O. tenuiflorum*, *Mentha, Salvia* etc.,) demonstrating a cosmopolitan distribution and adaptability to diverse ecosystems globally (2).

The importance of these plants extends across various domains, including culinary, medicinal, ecological and economic spheres (3). In traditional medicine systems, Lamiaceae species are widely used for their therapeutic benefits, addressing a range of conditions from diabetes and rheumatism to hepatitis and kidney stones (3). Economically, these plants contribute significantly to industries such as perfumery, cosmetics and pharmaceuticals, primarily through the production of essential oils derived from their leaves, flowers and stems (4). Many species are cultivated specifically for essential oil production, herbal medicine and culinary purposes (5).

Crucially, the family Lamiaceae represents a vast reservoir of bioactive secondary metabolites, including alkaloids, terpenoids and polyphenols. These compounds form the basis of the family's pharmacological significance, with reported activities including antioxidant, antitumor, anti-inflammatory, antiviral, analgesic, antimicrobial, antifungal and insecticidal properties (3). This rich phytochemical diversity positions Lamiaceae as a vital source for natural product research and drug discovery (3–6).

A bibliometric analysis serves as a powerful quantitative methodology for studying academic literature, providing a macroscopic overview of a research field (7). This approach enables researchers to track the growth within area of research, measure the impact of specific publications or authors, identify collaboration networks among researchers and institutions and discern evolving research trends (7). By examining patterns in publications, citations, authors and institutions, bibliometric studies offer a structured and evidence-based framework for understanding the past, present and future trajectory of scientific inquiry (8–9). Well-executed bibliometric studies can provide solid groundwork for advancing research in new and significant ways because they empower and enable researchers to: [1] obtain a comprehensive overview; [2] pinpoint knowledge

gaps; [3] generate innovative research ideas; and [4] position their intended contributions to the field. The justification for conducting a comprehensive bibliometric analysis of the family Lamiaceae lies in its broad and escalating scientific interest. Given its extensive traditional uses and well-documented pharmacological properties, the Lamiaceae has emerged as a focal point for natural product discovery, the scientific validation of traditional medicines and the development of sustainable bioresources. The intellectual landscape of Lamiaceae study must be systematically mapped to highlight important contributors, examine topic progression and identify knowledge gaps. Such an analysis provides data-driven insights that can guide future research directions, optimise resource allocation and foster strategic collaborations.

Materials and Methods

Data collection and scope

The foundation of this bibliometric analysis was a systematic literature search conducted across major scientific databases. Data collection from relevant databases is a critical initial step in any robust bibliometric study (8). For this research, the primary databases chosen for data extraction were Scopus, Web of Science and PubMed, recognised for their extensive coverage of scientific literature across various disciplines (7).

A precise and comprehensive search strategy was developed to ensure broad coverage of research related to the Lamiaceae family. The search string incorporated keywords such as "Lamiaceae," "mint family," and common genera names (e.g., *Orthosiphon, Salvia, Mentha, Ocimum*). The publication period covered by this analysis spans from 1954 to 2025, consistent with the timeframe observed in previous bibliometric studies on specific Lamiaceae species like *Orthosiphon stamineus* (10, 11). This extensive timeframe allows for a detailed examination of research trends and evolution over more than seven decades (Table 1).

Following data retrieval, a pre-processing was undertaken to ensure the accuracy and reliability of the dataset. This involved meticulous steps such as removing duplicate records, standardising author names and affiliations to avoid inconsistencies and formatting the data for subsequent analysis (7–10). Tools like R, Python, or Excel are commonly employed to assist in these data cleaning and refinement processes (7–10). This rigorous pre-processing is essential to produce a refined and accurate dataset ready for in-depth bibliometric analysis.

Table 1. Bibliographic synopsis

Description	Results
Timespan	1954:2025
Sources (Journals, Books, etc)	610
Documents	2145
Annual Growth Rate %	6.75
Document Average Age	7.18
DOCUMENT CONTENTS	
Keywords Plus (ID)	5715
Author's Keywords (DE)	5715
AUTHORS	
Authors	9178
Authors of single-authored docs	59
AUTHORS COLLABORATION	
Single-authored docs	63
Co-Authors per Doc	5.88
International co-authorships %	20.42
Journal article	1203

Bibliometric analysis techniques

This study employed 2 overarching techniques central to bibliometric analysis: performance analysis and science mapping. Performance analysis quantifies research outputs and their impact, while science mapping visualises and analyses relationships among various research constituents (7).

For data analysis and visualisation, several specialised software tools were employed: VOSviewer, the Bibliometrix R Package (including its user-friendly web application Biblioshiny) and CiteSpace (7–9). These tools were selected for their advanced capabilities in processing large datasets and generating diverse bibliometric maps and networks.

Specific analyses performed include:

- **Performance analysis:** This involved the computation of key bibliometric indicators to assess the productivity and impact of research entities. These metrics included the total number of publications, total citations received and the h-index of authors and journals (12). Such indicators provide a quantitative measure of influence and scholarly output.
- **Co-authorship analysis:** This technique was applied to map and visualise collaboration networks among researchers and institutions. By examining co-authorship patterns, the social structure of scientific cooperation within the Lamiaceae research community was revealed (11).
- **Co-word analysis:** This method focuses on the co-occurrence of keywords within document titles, abstracts or full texts to model the conceptual structure of the literature (12). It aids in identifying frequently used keywords and tracking the evolution of thematic areas, providing insights into the intellectual landscape of the field.
- **Citation analysis:** This encompassed two primary approaches:

◊ Bibliographic Coupling: This identifies documents that share common references, indicating a thematic similarity between them (12). The "coupling strength" increases with the number of shared citations (13).

◊ Co-citation Analysis: This technique identifies documents that are frequently cited together by other publications, suggesting a strong conceptual relationship between them (13).

- **Network analysis:** Metrics such as degree centrality (number of connections), betweenness centrality (linking different groups) and eigenvector centrality (connections to influential figures) were applied to identify influential researchers, publications, or institutions within the constructed networks (12–13). These metrics help to understand the flow of information and influence within the research community.

Visualisation strategy

To effectively communicate the complex patterns and relationships revealed by the bibliometric analyses, various visualisation tools were used. These tools transform raw bibliometric data into intuitive graphs, networks and maps, aiding interpretation and presentation (7).

Specific visualisation types generated include:

- **Network maps:** Used for illustrating co-authorship, keyword co-occurrence and citation relationships, showing connections and clusters within the data (14).

- **Thematic maps:** These maps visually represent intellectual clusters based on conceptual structure, often positioning themes according to their centrality and density (14).
- **Trend plots:** Line graphs or streamgraphs were used to illustrate the temporal evolution of publication output or specific research themes, highlighting periods of growth or decline (14).
- **Word clouds:** These graphical representations visually emphasise the most prominent terms by displaying them with varying font sizes proportional to their frequency, offering an immediate summary of dominant concepts (15).
- **Three-field plots:** Sankey diagrams were used to depict multifaceted interactions, including the complex links and flow between writers, the journals they publish in and the keywords associated with their work (7).

The selection of each visualisation type was justified by its ability to effectively convey specific insights, thereby making complex bibliometric findings more accessible and understandable to a broad audience.

Results and Discussion

Globally cited documents

The most cited documents on a global scale are collated in the Table 2 and Fig. 1. One study reported the highest citations (2808) (16) followed by another study with 1088 citations(17).

Table 2. Most globally cited documents assessed on June 26, 2025 (web of science)

Paper	DOI	Total Citations
Dorman HJD, 2000, J Appl Microbiol (16)	https://doi.org/10.1046/j.1365-2672.2000.00969.x	2808
Petersen M, 2003, Phytochemistry (17)	https://doi.org/10.1016/S0031-9422(02)00513-7	1088
Krishnaiah D, 2011, Food Bioprod Process (18)	https://doi.org/10.1016/j.fbp.2010.04.008	662
Marchese A, 2016, Food Chem (19)	https://doi.org/10.1016/j.foodchem.2016.04.111	599
Pratap R, 2014, Chem Rev (20)	https://doi.org/10.1021/cr500075s	511
Iscan G, 2002, J Agr Food Chem (21)	https://doi.org/10.1021/jf011476k	458
Marchese A, 2017, Crit Rev Microbiol (22)	https://doi.org/10.1080/1040841X.2017.1295225	455
Delamare APL, 2007, Food Chem (23)	https://doi.org/10.1016/j.foodchem.2005.09.078	392
Gang DR, 2001, Plant Physiol (24)	https://doi.org/10.1104/pp.125.2.539	382
KachurA K, 2020, Crit Rev Food Sci (25)	https://doi.org/10.1080/10408398.2019.1675585	368
Salehi B, 2018, Phytother Res (26)	https://doi.org/10.1002/ptr.6109	362
Zhao TT, 2019, J Pharm Pharmacol (27)	https://doi.org/10.1111/jphp.13129	349
Lukhoba CW, 2006, J Ethnopharmacol (28)	1 https://doi.org/0.1016/j.jep.2005.09.011	333
Shang XF, 2010, J Ethnopharmacol (29)	https://doi.org/10.1016/j.jep.2010.01.006	317
Ivanova D, 2005, J Ethnopharmacol (30)	https://doi.org/10.1016/j.jep.2004.08.033	311
Vitalini S, 2013, J Ethnopharmacol (31)	https://doi.org/10.1016/j.jep.2012.11.024	302
Wang ZL, 2018, Pharm Biol (32)	https://doi.org/10.1080/13880209.2018.1492620	286
Sharififar F, 2009, Food Chem (33)	https://doi.org/10.1016/j.foodchem.2008.06.064	281
Qian J, 2013, PLOS ONE (34)	https://doi.org/10.1371/journal.pone.0057607	279
Tan BKH, 2004, Curr Med Chem (35)	https://doi.org/10.2174/0929867043365161	271
Birtic S, 2015, Phytochemistry (36)	https://doi.org/10.1016/j.phytochem.2014.12.026	270
Grayer RJ, 1996, Phytochemistry (37)	https://doi.org/10.1016/S0031-9422(96)00429-3	267
Fachini-Queiroz FC, 2012, Evid-Based Compl Alt (38)	https://doi.org/10.1155/2012/657026	247
Tundis R, 2008, Mini-Rev Med Chem (39)	https://doi.org/10.2174/138955708783955926	238
Uritu CM, 2018, Pain Res Manag (3)	https://doi.org/10.1155/2018/7801543	235
Conforti F, 2008, J Ethnopharmacol (40)	https://doi.org/10.1016/j.jep.2007.11.015	231
Cakilcioglu U, 2010, J Ethnopharmacol (41)	https://doi.org/10.1016/j.jep.2010.08.017	230
Neves JM, 2009, J Ethnopharmacol (42)	https://doi.org/10.1016/j.jep.2009.04.041	226
Luo CX, 2020, Front Pharmacol (43)	https://doi.org/10.3389/fphar.2020.00153	219
Kamatou GPP, 2008, J Ethnopharmacol (44)	https://doi.org/10.1016/j.jep.2008.06.030	217
Cakilcioglu U, 2011, J Ethnopharmacol (45)	https://doi.org/10.1016/j.jep.2011.05.046	214
Jamila F, 2014, J Ethnopharmacol (46)	https://doi.org/10.1016/j.jep.2014.03.016	213
Mosaddegh M, 2012, J Ethnopharmacol (47)	https://doi.org/10.1016/j.jep.2012.02.004	211
Borges RS, 2019, J Ethnopharmacol (48)	https://doi.org/10.1016/j.jep.2018.09.038	205
Sajed H, 2013, J Ethnopharmacol (49)	https://doi.org/10.1016/j.jep.2012.12.018	205
Polat R, 2012, J Ethnopharmacol (50)	https://doi.org/10.1016/j.jep.2011.12.004	203
Ribeiro-Santos R, 2015, Trends Food Sci Tech (51)	https://doi.org/10.1016/j.tifs.2015.07.015	198
Ahmed HM, 2019, Molecules (52)	https://doi.org/10.3390/molecules24010102	196
Nadeem M, 2019, Appl Sci-BaselA (53)	https://doi.org/10.3390/app9153139	195
Ugulu I, 2009, J Med Plants Res (54)	NA	192
Giao MS, 2007, J Sci Food Agr (55)	https://doi.org/10.1002/jsfa.3023	192
Kala CP, 2005, J Ethnobiol Ethnomed (56)	https://doi.org/10.1186/1746-4269-1-11	186
Tetik F, 2013, J Ethnopharmacol (57)	https://doi.org/10.1016/j.jep.2012.12.054	186
Baher ZF, 2002, Flavour Frag J (58)	https://doi.org/10.1002/ffj.1097	180
Gurdal B, 2013, J Ethnopharmacol (59)	https://doi.org/10.1016/j.jep.2012.12.012	176
Borras-Linares I, 2014, Int J Mol Sci (60)	https://doi.org/10.3390/ijms151120585	172
Menkovic N, 2011, J Ethnopharmacol (61)	https://doi.org/10.1016/j.jep.2010.09.008	170
Savikin K, 2013, J Ethnopharmacol (62)	https://doi.org/10.1016/j.jep.2013.02.006	170
Hajhashemi V, 2000, J Ethnopharmacol(63)	https://doi.org/10.1016/S0378-8741(99)00209-3	170
Vladimir-Knezevic S, 2014, Molecules (64)	https://doi.org/10.3390/molecules19010767	169

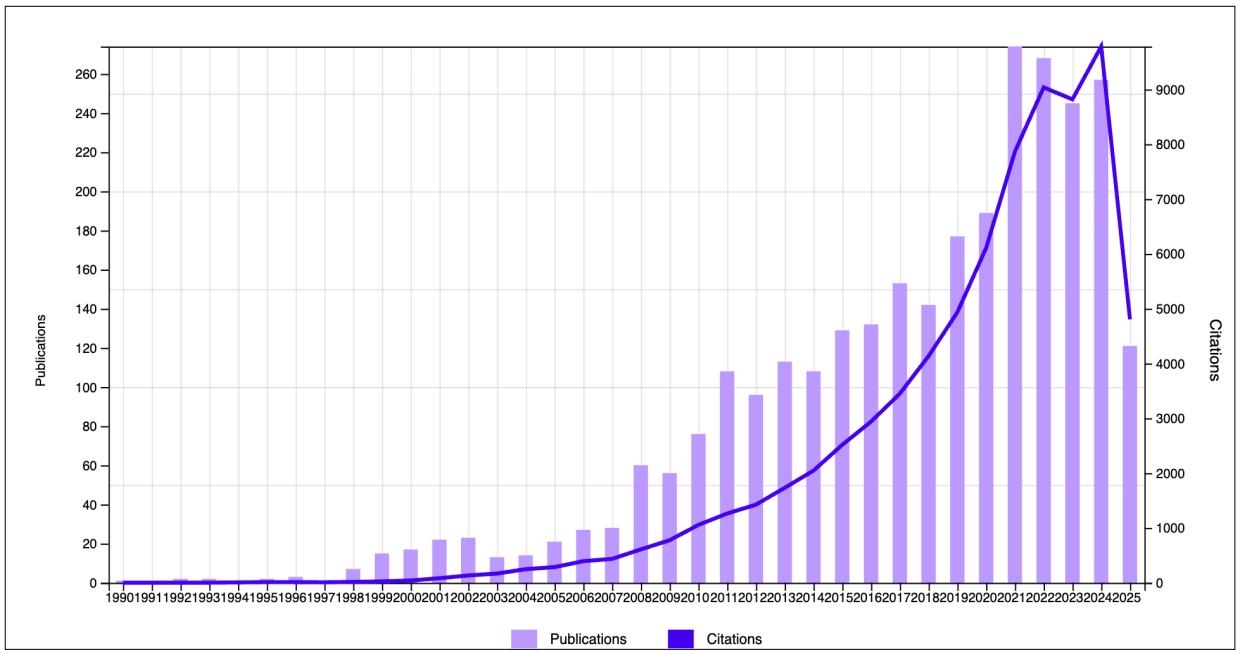

Fig. 1. Most globally cited documents in Lamiaceae.

Annual scientific production and growth trajectory

The bibliometric analysis of the family Lamiaceae (1954–2025) reveals a dynamic and evolving research landscape. Although specific annual production data for the entire family were not directly available in the provided material, the bibliometric study on *O. stamineus*, a prominent species within the Lamiaceae , offers a strong indication of broader patterns (11). Research on *O. stamineus* demonstrated a notable surge in publication activity during 2006 and 2012 (11) and according to the graph below highest number of articles were published in 2022. This specific trend for a representative species of Lamiaceae suggests that the broader family research likely experienced similar periods of accelerated growth.

The occurrence of distinct surges in publication volume, as observed for *O. stamineus*, is rarely coincidental. Alternatively, given *O. stamineus's* emphasis, a spike could be triggered by the allocation of significant new funding that focuses on natural products, medicinal plants, or health issues like diabetes. These substantial increases frequently show the impact of important findings or major changes in the scientific landscape. These might include the release of fundamental research papers or highly influential review articles that pave the way for new lines of inquiry and inspire a wave of follow-up studies (65). Advancements in research methodologies, such as improved phytochemical analysis techniques, the advent of *in silico* modelling tools for drug discovery (2) and enhanced *in vitro* and *in vivo* assay capabilities, may also stimulate increased research output. Furthermore, growing global health concerns and a renewed interest in traditional medicine may prompt intensified scientific inquiry into natural remedies. This pattern reflects a research field that is highly responsive to scientific breakthroughs, societal needs and technological advancements, reflecting its adaptability and continued relevance.

Fig. 2. provides an immediate and intuitive understanding of the temporal evolution of research interest and output in the Lamiaceae family. It allows for quick identification of periods of high or low research activity, serving as a critical starting point for deeper investigation into the factors influencing these trends and the overall dynamism of the field.

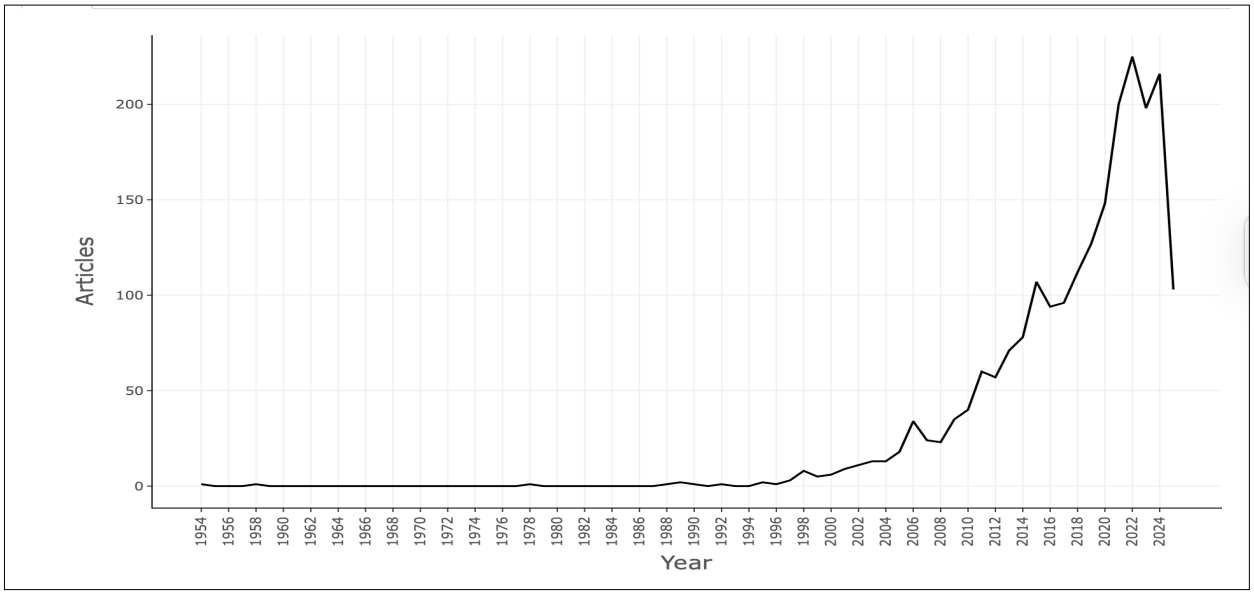

Fig. 2. Annual scientific production of Lamiaceae research (1954–2025).

Most influential sources and authors

The analysis of publication sources and authors provides crucial insights into the key dissemination channels and intellectual leaders within Lamiaceae research (Fig. 3, 4). While comparative bibliometric studies on related topics, like chamomile, have successfully identified leading publication sources like the Journal of Ethnopharmacology, the provided material notes a "diverse distribution across journals" for *O. stamineus* research (11), indicating a broad publication landscape (66). This implies that publications are probably going to become important venues for the larger Lamiaceae family.

The identification of leading journals and prolific authors serves as a powerful indicator of the intellectual "gatekeepers" and "thought leaders" within the Lamiaceae research domain. Journals that consistently publish a high volume of Lamiaceae-related research are likely preferred outlets due to their specific scope, established reputation, or high impact factor. These platforms play a vital role in disseminating influential research and shaping the discourse within the field. Similarly, prolific and highly cited authors are not merely productive; they often play a pivotal role in shaping research agendas, attracting funding and influencing the direction of future studies. Their sustained contributions, mentorship and extensive collaborative networks (which will be further explored in Section 4.6) are instrumental in advancing the field. Analysing their affiliations and co-authorship patterns can further reveal institutional strengths and the formation of key collaborative hubs. This information is invaluable for emerging researchers seeking relevant literature and potential mentors, for academic institutions benchmarking their research output and for funding agencies

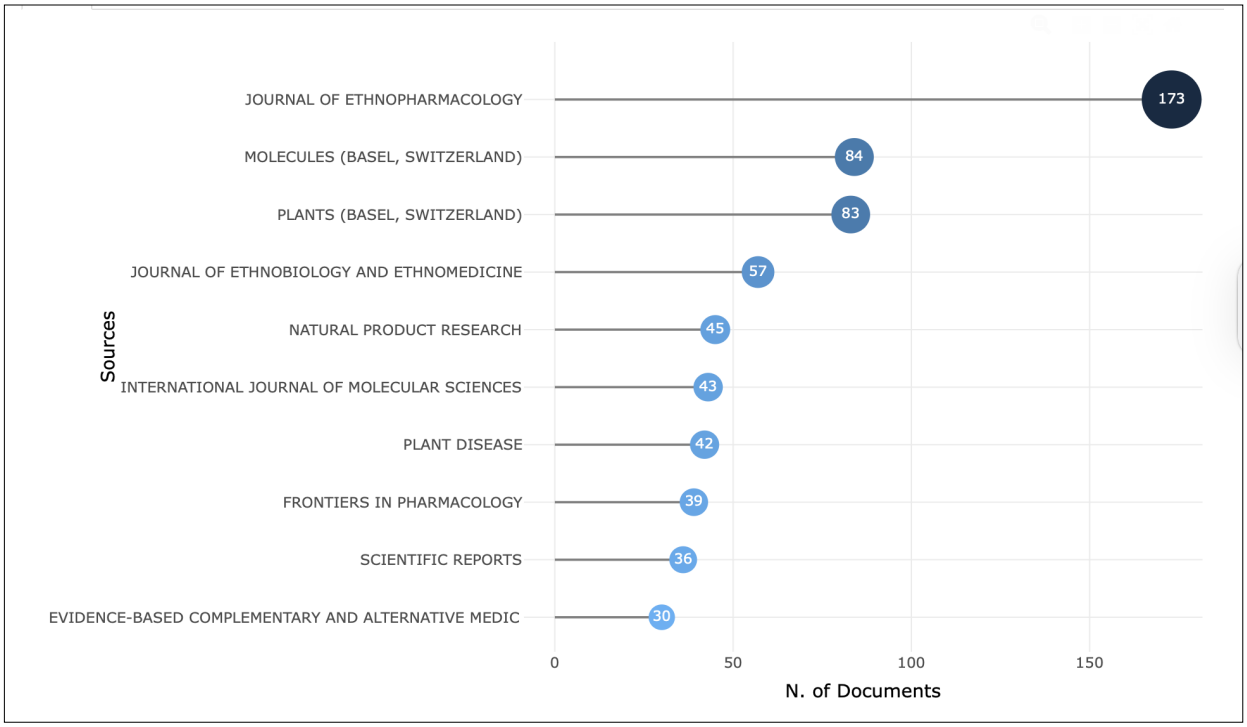

Fig. 3. Top 10 Most relevant sources (Journals) publishing on Lamiaceae.

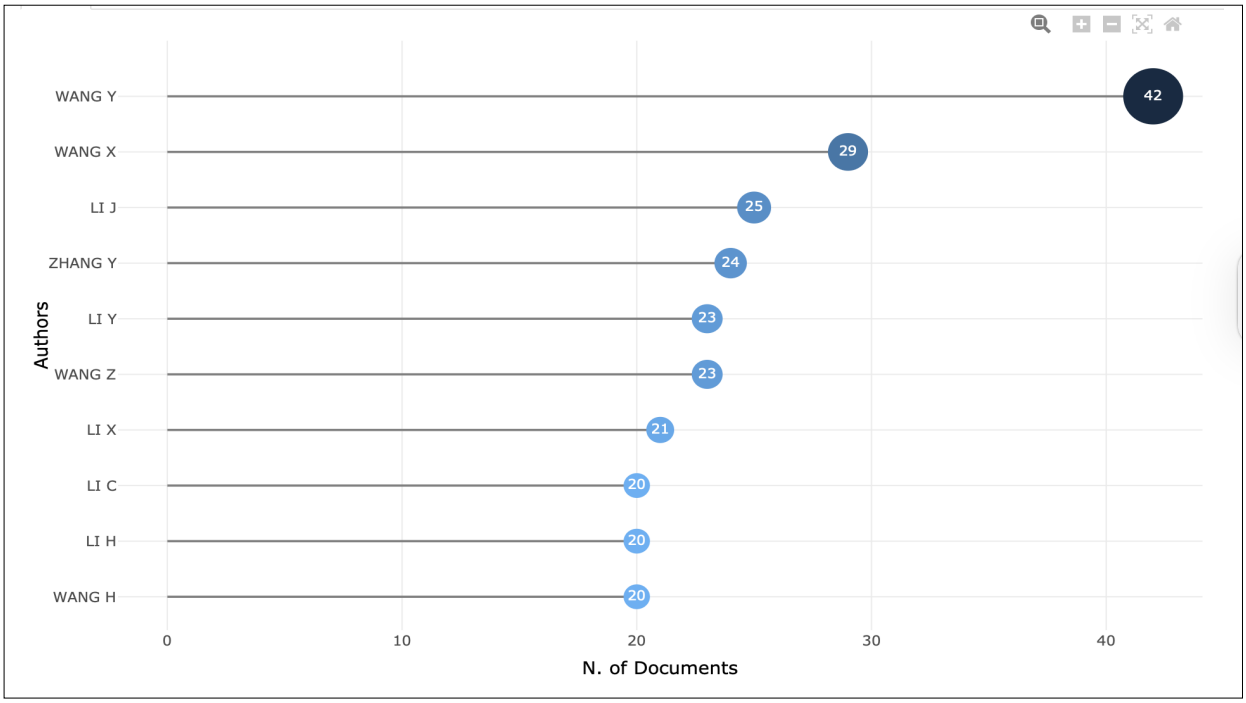

Fig. 4. Top 10 most relevant authors in Lamiaceae research.

aiming to identify areas of excellence and potential investment. Fig. 3 provides a clear, quantitative overview of the most active and impactful publication channels, guiding researchers on where to disseminate their findings and where to access cutting-edge research. Fig. 4 quantitatively recognises the leading individual contributors to Lamiaceae research, making it easier to identify key experts, assess their influence and facilitate potential collaborations.

Geographical distribution and international collaboration

The global landscape of Lamiaceae research exhibits a varied geographical distribution, reflecting varying regional strengths and research priorities. The bibliometric analysis of *O. stamineus* explicitly noted "international contributions"(11), indicating a global interest in this Lamiaceae species. Furthermore, in a separate bibliometric study on chamomile, Iran was identified as a highly productive country (66, 67), suggesting that certain nations may lead in specific areas of medicinal plant research. This section maps the leading countries based on their publication output and the affiliations of corresponding authors and explores the extent and patterns of international collaborations.

The geographical distribution of research output is rarely arbitrary; it often reflects a confluence of regional factors. If certain countries demonstrate a disproportionately high research output on Lamiaceae, it could be attributed to the native abundance and diversity appears 4 times in the paper and diverse 8 times. Need to change within their borders, as exemplified by the detailed study of Lamiaceae in Sumatra, Indonesia (11). Deeply embedded traditional medicine practices that utilize these plants also play a significant role in driving research, as scientists seek to validate traditional knowledge through modern scientific methods. Additionally, substantial government investment in natural product research and development can bolster a nation's research output in this field. The presence and strength of international collaborations, conversely, indicate shared scientific interests, the pooling of resources and complementary expertise. Such collaborations often lead to more impactful and globally relevant research outcomes by leveraging diverse perspectives and capabilities. The absence of cooperation in specific geographical or topical areas may highlight missed opportunities for information sharing and collaborative development. This understanding is crucial for informing strategies aimed at fostering international research partnerships, identifying emerging research hubs and directing resources to regions with high potential for Lamiaceae-related discoveries. Fig. 5 visually demonstrates the global spread and intensity of Lamiaceae research, clearly highlighting major contributing countries and their collaborative relationships. It provides a quick visual assessment of scientific diplomacy and knowledge transfer patterns across different regions.

Key research themes and concepts

A detailed examination of keywords and thematic clusters provides a comprehensive understanding of the conceptual structure underpinning Lamiaceae research. Keyword analysis for *O. stamineus* specifically highlights "chemical characterisation, diabetes management and ethnobotanical aspects" as prominent research areas. Frequently occurring terms include 'article', 'Orthosiphon', 'plant extract', 'diabetes mellitus', 'antidiabetic activity' and 'antidiabetic agent' (11). More broadly, the Lamiaceae family is recognised for its richness in bioactive secondary metabolites, such as alkaloids, terpenoids and polyphenols (2) Research applications extend to neuroprotective agents (12), the pesticidal efficiency of essential oils (67) and therapeutic uses in cardiovascular diseases (3).

The consistent co-occurrence of terms like "chemical characterisation" alongside "antidiabetic activity" and "ethnobotanical aspects" signifies a robust and increasingly sophisticated translational research focus within the Lamiaceae domain. This pattern indicates a systematic progression where traditional uses of Lamiaceae plants, deeply rooted in ethnobotany, are being rigorously validated through modern scientific methods. This validation often involves detailed phytochemical analysis to identify active compounds, followed by comprehensive biological activity assays to confirm their efficacy. The remarkable range of documented uses, from pesticidal to neuroprotective and cardiovascular health, highlights the chemical adaptability of

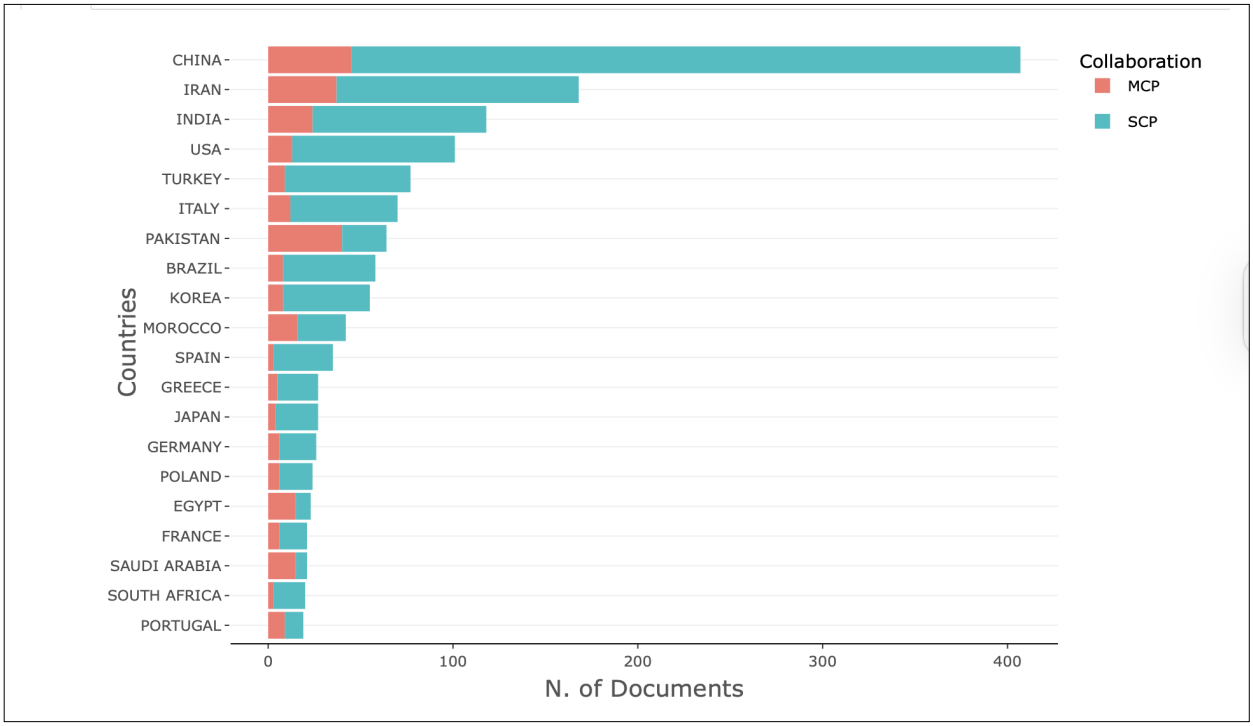

Fig. 5. Corresponding author's countries network map.

Lamiaceae and the wide range of pharmacological possibilities of its secondary metabolites. The emergence of specific compound names, such as rosmarinic acid, sinensetin and eupatorine, as prominent keywords suggest a maturation of the field (66) . This indicates a shift beyond studies of crude extracts to investigations focused on specific active principles and their underlying mechanisms of action. Because of this comprehensive thematic understanding, the Lamiaceae family is positioned as a highly significant source for novel drug discovery, the development of functional foods and sustainable agricultural solutions. Fig. 6 provides an immediate and intuitive visual summary of the dominant research concepts and areas of intense focus within the Lamiaceae literature. Fig. 7 presents a structured and proportional view of the intellectual landscape, showing how different themes are nested or related and their overall representation within the body of research.

Evolution of research trends (Trend topics)

Changes in the most popular study topics are not random; rather, they are a reflection of the dynamic character of scientific investigation, which is frequently impacted by a complex interaction between discoveries, technological breakthroughs and shifting worldwide priorities for instance, the increasing adoption of *in silico* methods, such as molecular docking and systems pharmacology for discovering neuroprotective agents from Lamiaceae compounds (2), would likely appear as a significant emerging methodological trend over time. This signifies a move towards more efficient and targeted drug discovery approaches. Conversely, a decline in certain traditional or less sophisticated research areas might signal their saturation or a shift towards more advanced techniques. The emergence of research explicitly linking Lamiaceae species to specific health challenges, such as neurodegenerative diseases or cardiovascular diseases, or to novel applications like biopesticides, indicates the field's responsiveness to pressing societal health and

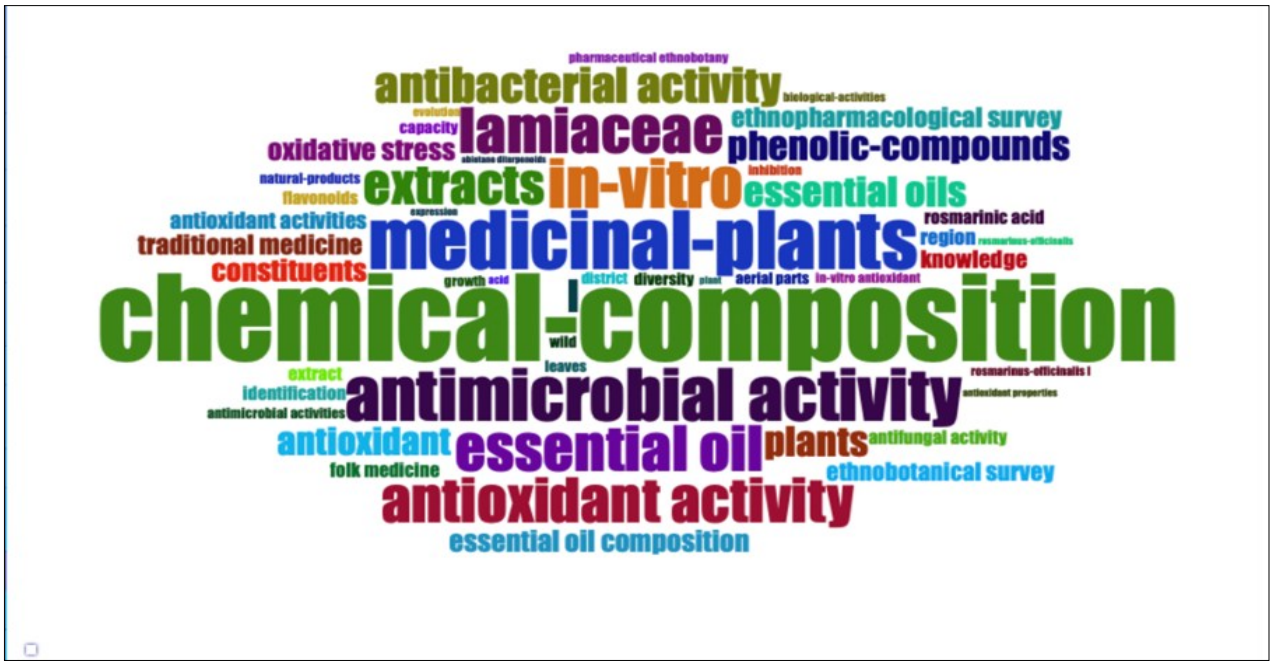

Fig. 6. Word cloud of most frequent keywords in Lamiaceae research.

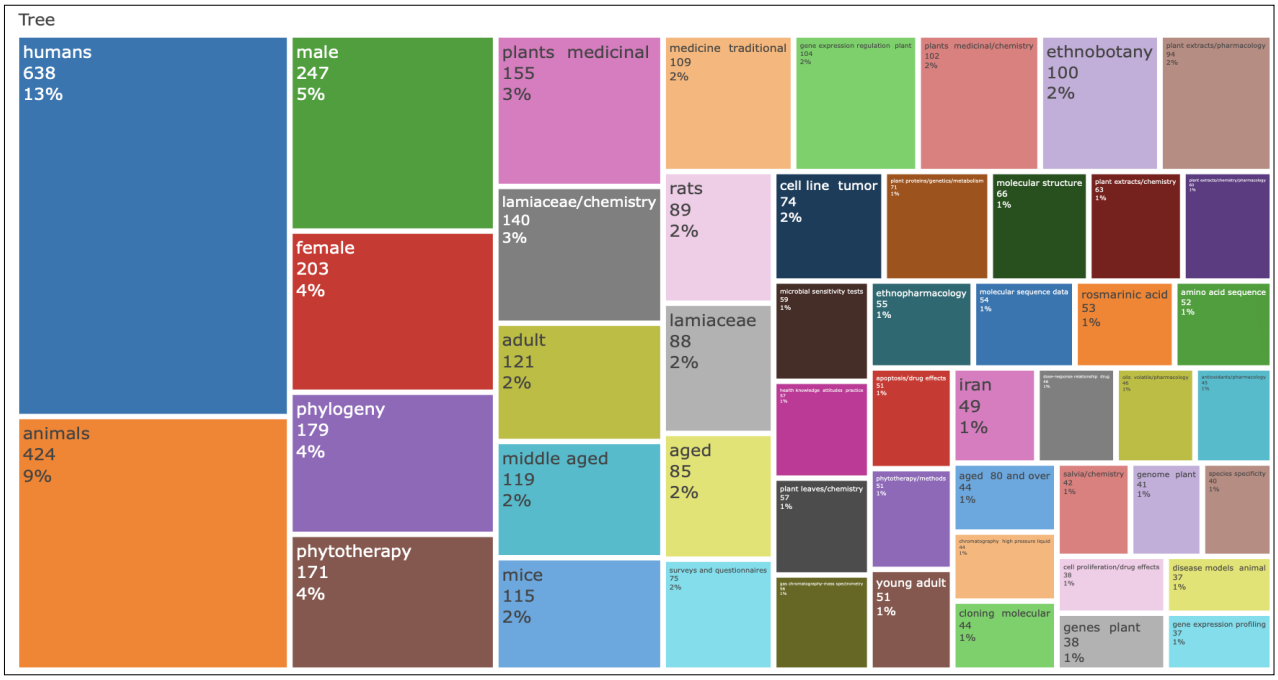

Fig. 7. Tree map of key research themes.

environmental concerns (8). This section provides crucial foresight for researchers, indicating promising new areas for investigation, potential funding opportunities and avenues for interdisciplinary collaboration. It helps identify "hot" topics and areas that are maturing or fading in prominence. Fig. 8 visualisation effectively illustrates the temporal dynamics of research themes, allowing for the clear identification of "hot" topics, established areas and those that have matured or become less prominent, providing a historical context to the current research landscape.

Collaboration, co-occurrence and co-citation networks

Bibliometric software like VOSviewer and Bibliometrix R is specifically designed to generate and visualise these networks, including co-authorship and keyword co-occurrence networks (7–10, 12–15)

The analysis of collaboration networks reveals the social structure of the Lamiaceae research community. A highly interconnected network with numerous strong links suggests robust collaboration, efficient knowledge sharing and potentially more impactful research outcomes due to the synergistic efforts of multiple researchers and institutions. Conversely, isolated clusters might indicate specialised sub-fields with limited cross-pollination or missed opportunities for broader conceptual integration. Identifying the central nodes-highly collaborative authors or institutions-reveals key players who facilitate knowledge flow and foster interdisciplinary connections. This analysis is crucial for identifying key collaborative hubs, potential partners for future research and highlighting existing interdisciplinary connections or areas where greater scientific cooperation is needed.

Similarly, keyword co-occurrence networks map the intellectual structure of the field, showing which concepts are frequently discussed together within the literature. For example, strong links between "antioxidant" and "diabetes" keywords would reinforce the mechanistic understanding that antioxidant properties contribute to Lamiaceae's antidiabetic effects (1). This analysis goes beyond individual metrics to reveal systemic relationships and intellectual cohesion, illustrating how different research concepts are interconnected and forming distinct thematic clusters. Fig. 9 effectively represents the conceptual structure of the research field, revealing how different topics are interconnected and forming distinct thematic clusters, thereby illustrating the intellectual landscape. Fig. 10 illustrates the social structure of research, identifying key collaborators, influential institutions and potential areas for fostering new partnerships and strengthening existing ones. Fig. 11 illustrates the co-citation network across the countries demonstrating intellectual cohesion.

Thematic mapping and clustering by coupling

The coupling map function in bibliometrix is specifically designed to perform coupling network analysis and plot community detection results on a bi-dimensional map, where axes measure cluster centrality and impact (9). Because bibliographic coupling makes it easier for researchers to locate similar prior research, it can be helpful in a wide range of subjects. However, if two documents are independently cited by one or more additional documents, they are said to be co-cited. Bibliographic coupling gauges how similar two papers are by counting the number of references they have in common, which suggests a shared (10, 12–14).

Thematic maps derived from advanced clustering techniques provide a strategic, high-level overview of the research field, allowing for the categorisation of themes into distinct types based on their intellectual centrality (importance and influence) and density (level of development and internal cohesion). For example, research on *O. stamineus*'s antidiabetic properties, given its significant and sustained attention, would likely emerge as a "motor theme" (11) . Motor themes are characterised by high centrality and strong internal development, representing the core and most dynamic areas of the field. Conversely, nascent research into the

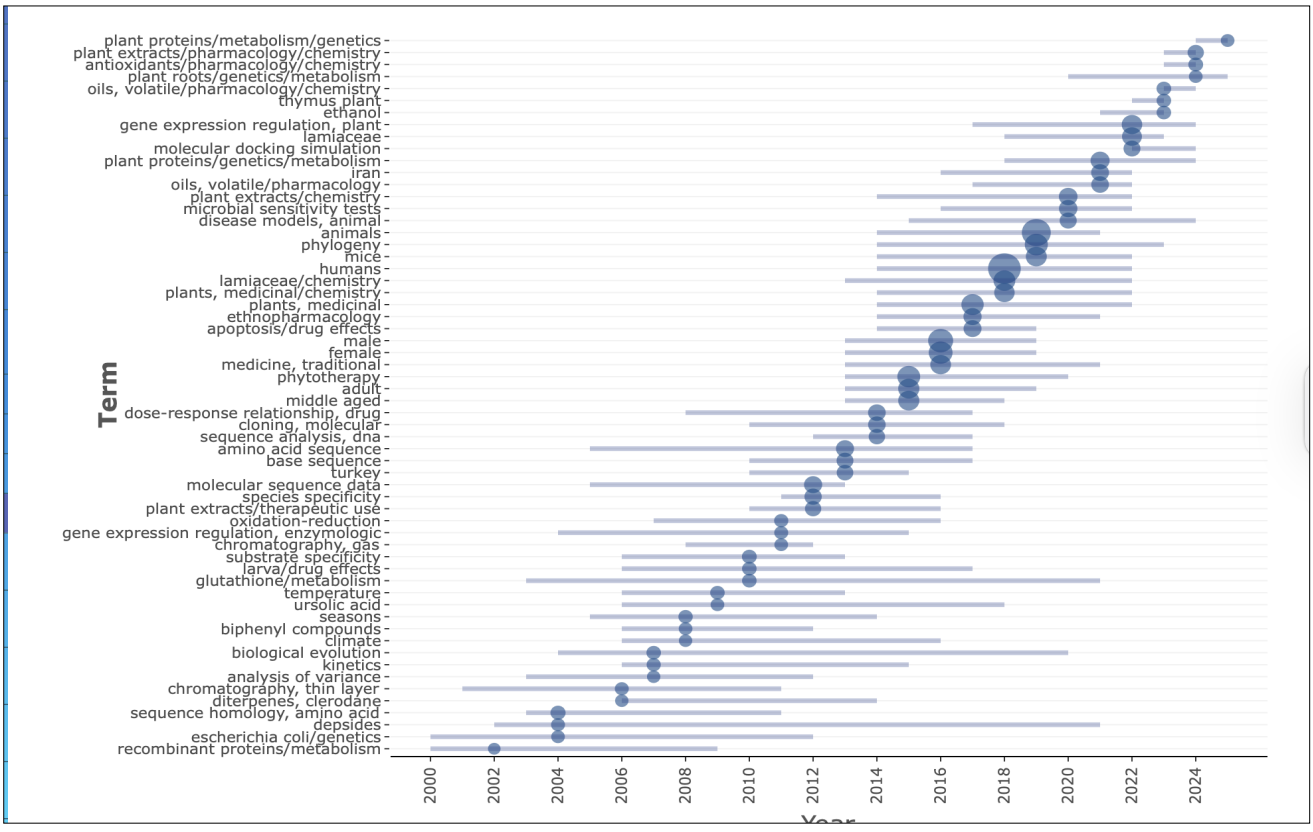

Fig. 8. Timeline visualisation of emerging and declining research topics.

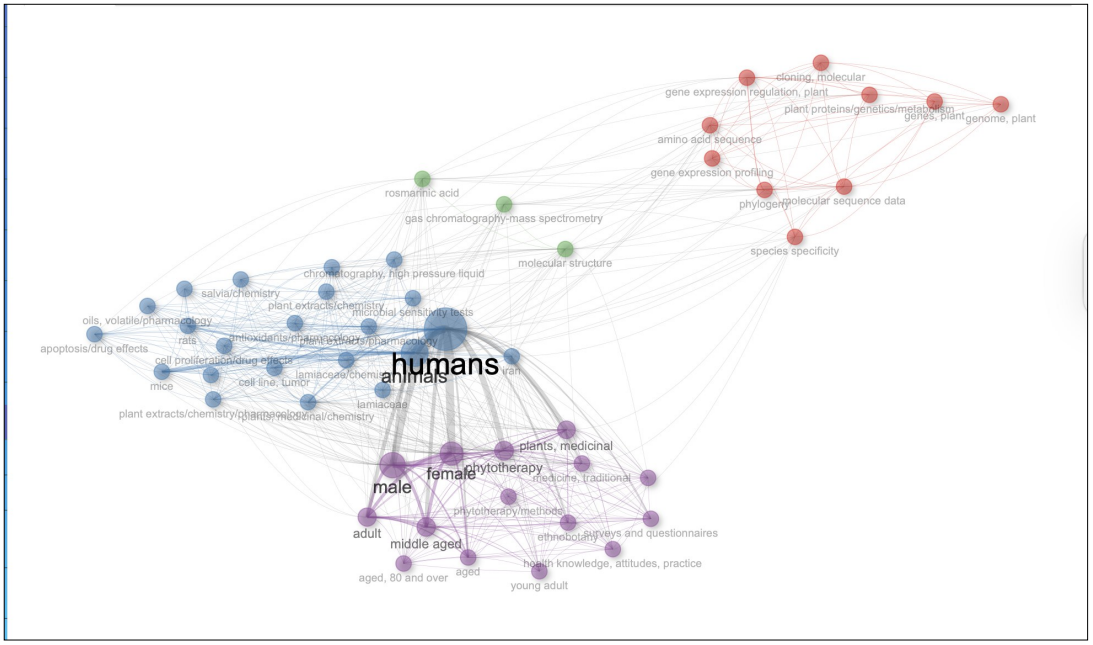

Fig. 9. Co-occurrence network of keywords.

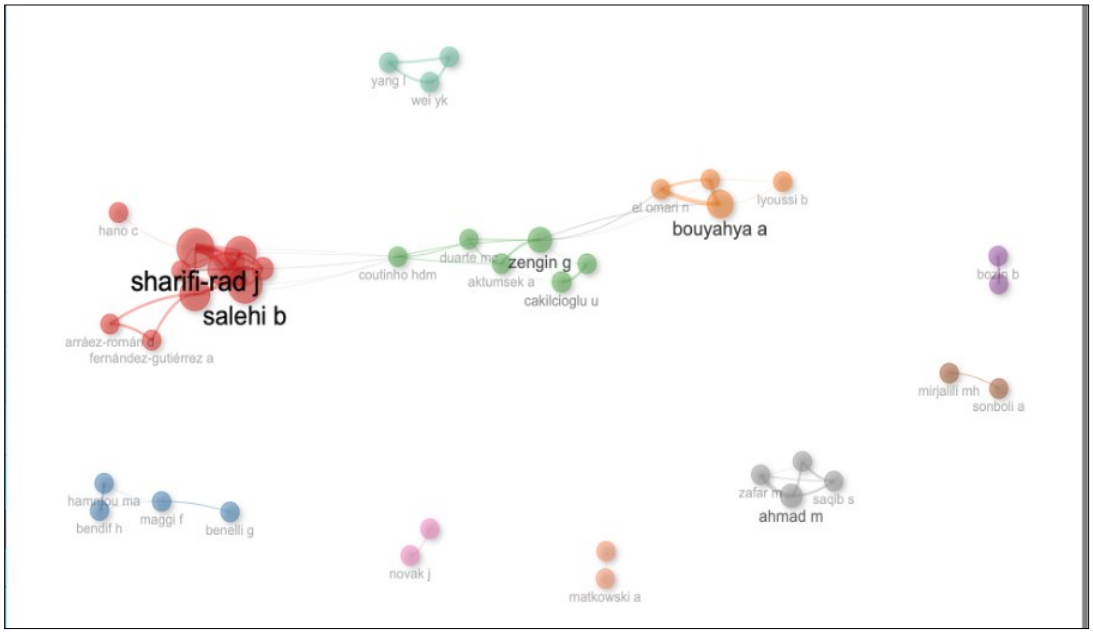

Fig. 10. Collaboration network of authors/institutions.

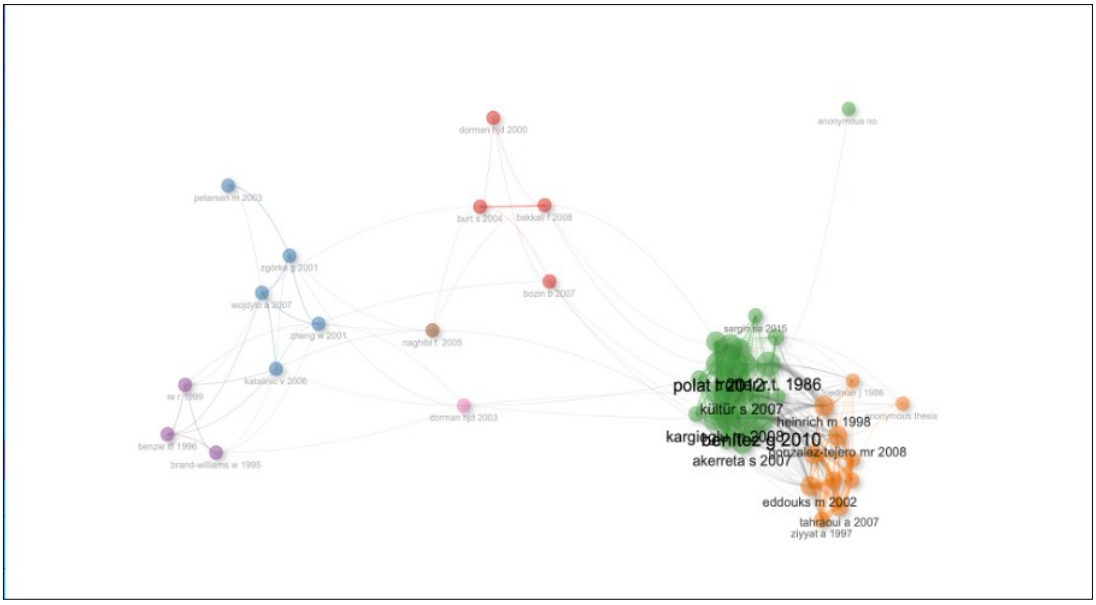

Fig. 11. Co-citation network.

conservation of Lamiaceae species (1–3, 5–7), if less developed but showing nascent interest, might appear as an "emerging theme." Other categories include "niche themes" (well-developed but peripheral, indicating specialised areas) and "basic themes" (central but less developed, representing foundational but perhaps underexplored areas). This categorisation is crucial for understanding the maturity, strategic importance and potential for growth of different research fronts within the Lamiaceae domain. This analysis is invaluable for strategic planning in research, guiding resource allocation and identifying areas ripe for innovation, consolidation, or diversification. It helps pinpoint both established strengths and promising frontiers. Fig. 12 offers a unique, high-level strategic view of the research domain, categorising themes based on their intellectual importance and maturity. It is an invaluable tool for identifying research gaps, potential areas for interdisciplinary integration and future research directions.

Three-field plot analysis

The three fields plot function in bibliometrix is specifically designed to visualise relationships between three distinct bibliometric entities, such as authors, their frequently used keywords and the sources (journals) in which they publish, using a Sankey diagram (68).

A 3-field plot offers a uniquely integrated and holistic view of how different elements of the research ecosystem are interconnected and influence each other. For instance, if a specific author consistently employs a particular set of keywords and primarily publishes in certain specialised journals, this visualisation powerfully highlights their research specialisation and their influence within a defined thematic area and publication channel. It can reveal unexpected or subtle connections between authors and specific themes or demonstrate how certain journals serve as pivotal platforms for research fronts. This goes beyond individual metric analysis to show the systemic relationships that shape the intellectual landscape. This visualisation helps to understand the intricate flow of knowledge, influence and specialisation within the Lamiaceae research community, identifying key players and their multifaceted contributions across different dimensions of the scientific endeavour. Fig. 13 presents a unique, integrated perspective on the relationships between different bibliometric entities, providing a comprehensive and holistic understanding of the research landscape and the interplay between its components.

Major applications and research areas of Lamiaceae: A synthesis

Synthesising the findings from the preceding bibliometric analyses provides a comprehensive overview of the major applications and research areas on the family Lamiaceae , moving beyond metrics to discuss substantive scientific significance. The existing research provides an in-depth examination of the diverse properties and applications of Lamiaceae. Its essential oils exhibit a wide range of activities, including antioxidant, antitumor, anti-inflammatory, antiviral, analgesic, antimicrobial, antifungal and insecticidal properties (1-3, 5–6, 69). The family holds significant importance in various industries such as perfumery, pharmaceutics, cosmetics, food and fragrance (16, 21). Specific bioactive compounds like rosmarinic acid, eupatorine and sinensetin are highlighted for their therapeutic potential (67). Research specifically focuses on neuroprotective agents derived from Lamiaceae compounds (2), the antidiabetic properties of *O. stamineus* (11) and the potential for developing herbal medicines with larvicidal, insecticidal and repellent properties, for instance, against *Aedes aegypti* (1).

The broad spectrum of reported bioactivities and applications, ranging from traditional medicinal uses to modern pharmacological interventions, agricultural applications and even cosmetic formulations, powerfully underscores the unparalleled chemical variety and pharmacological richness inherent in the Lamiaceae family. The continuous discovery of new applications, such as neuroprotection (2), or the scientific validation of long-standing traditional uses, like the antidiabetic properties of *O. stamineus* (11), points to a vibrant and continuously expanding frontier of research. The increasing focus on specific essential oils and isolated polyphenolic compounds, such as rosmarinic acid (67), indicates a maturation of the field, moving beyond studies of crude plant extracts to a more refined understanding of the active constituents and their precise mechanisms. Furthermore, the

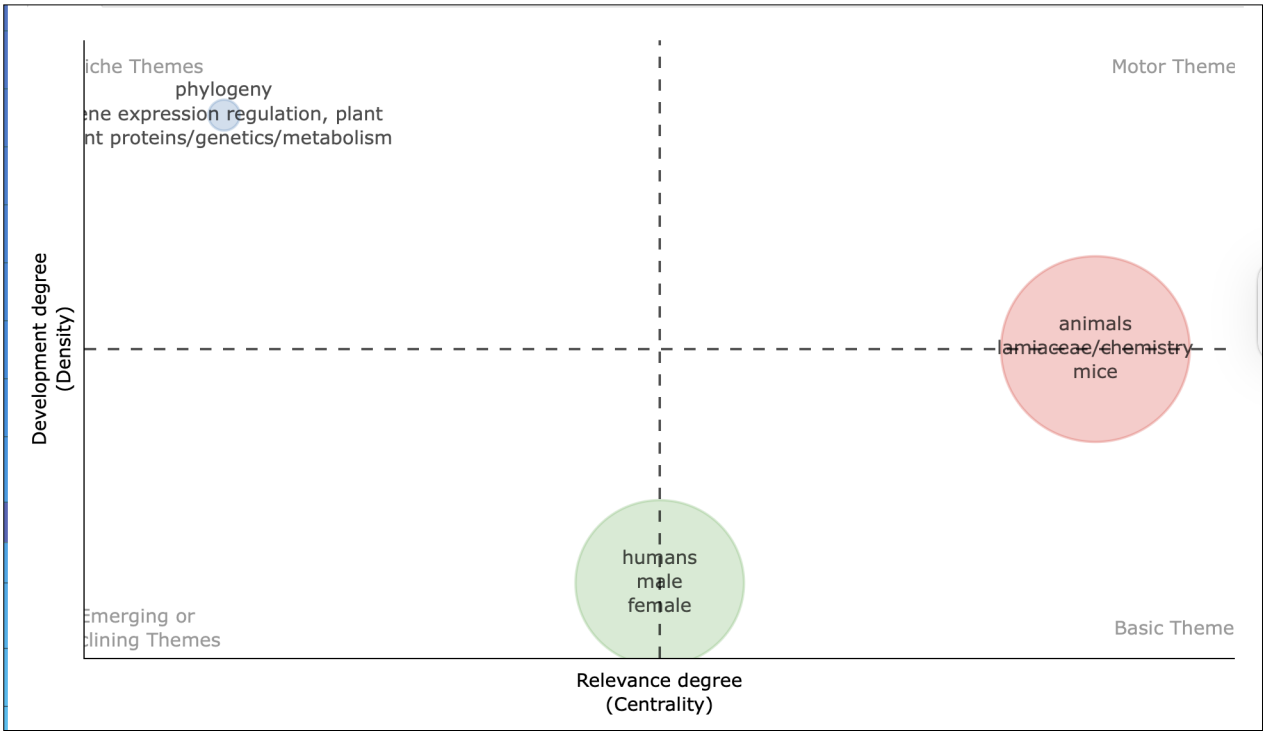

Fig. 12. Thematic map.

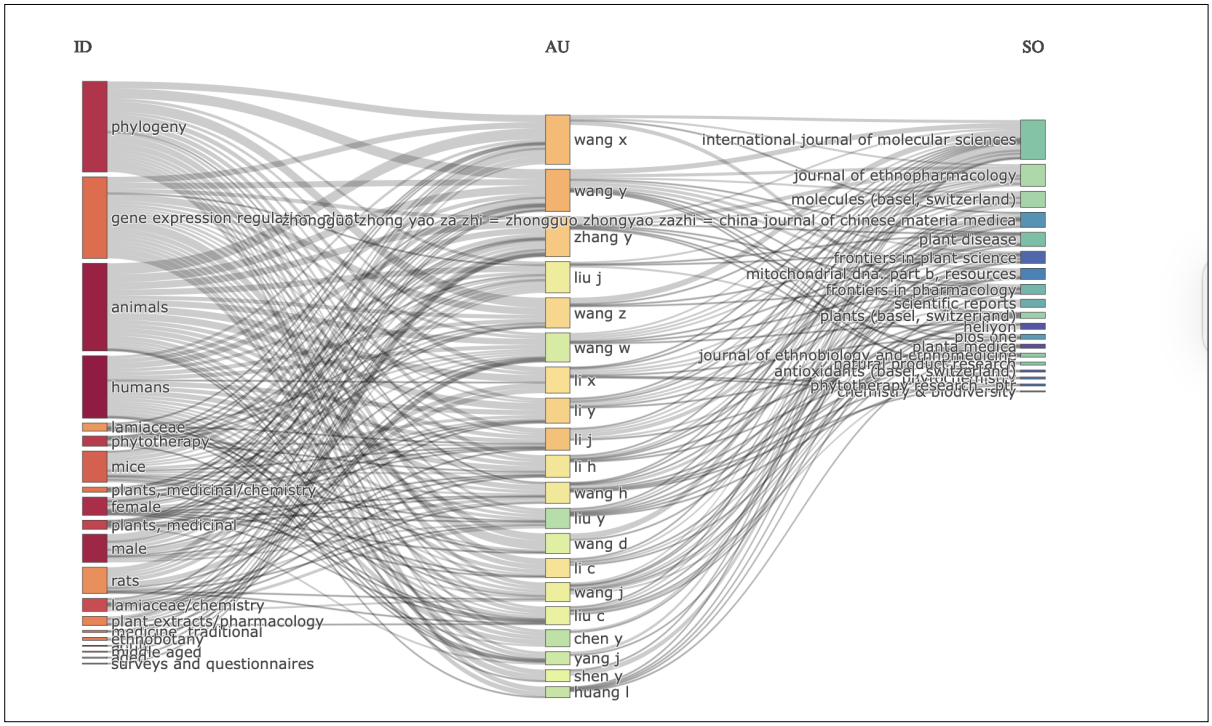

Fig. 13. Three-field plot (Authors-keywords-sources).

Three fields plot analysis (AU=authors, CR=references, DE=authors keywords).

significant application in pest control (67) highlights a crucial ecological and agricultural dimension of Lamiaceae research that is often distinct from human health-focused studies, demonstrating the family's multifaceted utility. This section reinforces the substantial potential of Lamiaceae as a sustainable source for novel therapeutics, functional foods and eco-friendly biopesticides, thereby highlighting its profound relevance across multiple industries and diverse scientific disciplines.

Research gaps and emerging areas

Despite the extensive research on the Lamiaceae family, particularly concerning its pharmacological applications, specific knowledge gaps persist. A notable example is the explicit mention that the antidiabetic mechanism of *O. stamineus* "remains not fully understood" (11), despite numerous reports on its antidiabetic properties. This suggests that although the efficacy of *O. stamineus* in diabetes management has been demonstrated through *in vitro* and *in vivo* studies, the precise molecular pathways, cellular targets, or synergistic effects of its complex compounds are still elusive. This represents a critical and fundamental knowledge gap that, if addressed, could unlock the full therapeutic potential of *O. stamineus* and other Lamiaceae species.

Furthermore, while pharmacological applications are robust, certain ecological roles or specific conservation efforts for Lamiaceae species may be less explored in the current literature, despite the family's ecological significance and threats like habitat destruction and overexploitation (1). The increasing adoption of *in silico* methods in drug discovery, as highlighted for neuroprotective agents from Lamiaceae (65), suggests an emerging area that could be further leveraged for targeted compound identification and mechanistic prediction across a broader range of applications.

Conclusion

Summary of key findings

This comprehensive bibliometric analysis of Lamiaceae research landscape from 1954 to 2025 reveals a dynamic and globally engaged scientific field. The annual scientific production demonstrates periods of significant growth, exemplified by surges in research on *O. stamineus* in 2006 and 2012, indicating a field responsive to discoveries and societal needs. Influential entities, including leading journals and leading authors, play a crucial role in shaping research agendas and disseminating knowledge. The geographical distribution of research highlights key contributing countries and the increasing prevalence of international collaborations, signifying shared scientific interests and resource pooling.

Core research themes predominantly revolve around the pharmacological properties of Lamiaceae species, including their antidiabetic, antioxidant, anti-inflammatory, neuroprotective and pesticidal activities, alongside intensive phytochemical characterisation and ethnobotanical explorations. The co-occurrence networks illustrate the strong conceptual links between traditional knowledge, chemical analysis and therapeutic applications. Collaboration networks reveal a progressively interconnected research community, fostering knowledge exchange and synergistic advancements. Thematic mapping further categorises these research areas, identifying "motor themes" that drive the field and "emerging themes" that represent new frontiers. The three-field plot provides an integrated view of author-keyword-source relationships, showcasing specialised contributions and knowledge flow. Collectively, these findings underscore the immense medicinal, economic and ecological potential of the Lamiaceae family.

Recommendations for future research and policy

Based on the analysis, several recommendations for future research and policy emerge:

- **Deeper mechanistic investigations:** Future research should prioritise elucidating the precise molecular mechanisms underlying the observed bioactivities of Lamiaceae compounds, particularly for well-studied species like *O. stamineus,* where the full antidiabetic mechanism remains unclear (11). This could involve utilising advanced omics technologies (e.g., genomics, proteomics, metabolomics) and sophisticated computational modelling to identify specific cellular targets and pathways.
- **Clinical validation:** While preclinical studies are abundant, more rigorous clinical trials are needed to validate the efficacy and safety of promising Lamiaceae-derived therapeutics in human populations. This will bridge the gap between traditional use, laboratory findings and clinical application.
- **Sustainable cultivation and bioprospecting:** Given the increasing demand for natural products, developing sustainable cultivation and harvesting practices is crucial to ensure the long-term availability of Lamiaceae resources and prevent overexploitation of wild populations (2). Emphasis should also be placed on bioprospecting underutilised or less-studied Lamiaceae species to discover novel bioactive compounds.
- **Interdisciplinary collaborations:** Fostering interdisciplinary collaborations, for instance, linking conservation biology with pharmacology, ethnobotany and agricultural sciences, is essential to ensure sustainable bioresource utilisation and a holistic understanding of the family's potential.
- **Policy support:** Governments and institutions should be encouraged to increase funding and support for natural product research, particularly for families like Lamiaceae with proven pharmacological significance. Additionally, clear regulatory frameworks for herbal medicines and robust conservation strategies for endangered Lamiaceae species are vital to protect their genetic variations and ecological roles.

Acknowledgements

The authors are thankful to their institution for providing the necessary facilities and support and to Prof. P. V. Arya and Dr. Jyoti Paul for their guidance on the methodology of bibliometric analysis.

Authors' contributions

JK contributed to the conception and design of the study. Material preparation, data collection and analysis were performed by JK, RK, SG, CDR and MAP. The first draft of the manuscript was written by JK and RK and all authors commented on previous versions of the manuscript. All authors have read and approved the final manuscript.

Compliance with ethical standards

Conflict of interest: Authors do not have any conflict of interest to declare.

Ethical issues: None

References

1. Raja RR. Medicinally potential plants of Lamiaceae family: an. Res J Med Plant. 2012;6:203-13. https://doi.org/10.3923/rjmp.2012.203.213
2. Ramos da Silva LR, Ferreira OO, Cruz JN, de Jesus Pereira Franco C, Oliveira dos Anjos T, Cascaes MM, et al. Lamiaceae essential oils, phytochemical profile, antioxidant and biological activities. Evid Based Complement Alternat Med. 2021;2021:6748052. https://doi.org/10.1155/2021/6748052
3. Uritu CM, Mihai CT, Stanciu GD, Dodi G, Alexa-Stratulat T, Luca A, et al. Medicinal plants of the family Lamiaceae in pain therapy: a review. Pain Res Manag. 2018;2018:7801543. https://doi.org/10.1155/2018/7801543
4. Keator G, Steunenberg M. Lamiaceae (mint family). In: Keator G, Steunenberg M, editors. California plant families: west of the Sierran Crest and deserts. Berkeley: University of California Press; 2009. p.98-100. https://doi.org/10.1525/9780520943247-041
5. Yavuz C, Kılıç DD, Ayar A, Yıldırım T. Antibacterial effects of methanol extracts of some plant species belonging to Lamiaceae family. Int J Second Metab. 2017;4:429-33. https://doi.org/10.21448/ijsm.376691
6. Jordamovic N, Niksic H, Muratovic S, Gusic I, Koric E, Alagic L, et al. Phytochemical investigation and antioxidative capacity of triterpenes present in plant species belonging to Lamiaceae family. Bull Chem Technol Bosnia Herzegovina. 2020;54.
7. Moral-Muñoz JA, Herrera-Viedma E, Santisteban-Espejo A, Cobo MJ. Software tools for conducting bibliometric analysis in science: an up-to-date review. Prof Inf. 2020;29:1-13. https://doi.org/10.3145/epi.2020.ene.03
8. Passas I. Bibliometric analysis: the main steps. Encyclopedia. 2024;4:604-14. https://doi.org/10.3390/encyclopedia4020065
9. Aria M, Cuccurullo C. Bibliometrix: an R-tool for comprehensive science mapping analysis. J Informetr. 2017;11:959-75. https://doi.org/10.1016/j.joi.2017.08.007
10. Kumar R. Bibliometric analysis: comprehensive insights into tools, techniques, applications and solutions for research excellence. Spectr Eng Manag Sci. 2025;3:45-62. https://doi.org/10.31181/sems31202535k
11. Akwu NA, Banji-Onisile F, Adeoye JK, Rambau U, Mendez M, Nnadozie I, et al. *Orthosiphon stamineus* Benth. (Lamiaceae): a bibliometric analysis of its antidiabetic properties. Acta Sci Biol Sci. 2025;47:e72905. https://doi.org/10.4025/actascibiolsci.v47i1.72905
12. Lim WM, Kumar S. Guidelines for interpreting the results of bibliometric analysis: a sensemaking approach. Glob Bus Organ Excell. 2024;43:17-26. https://doi.org/10.1002/joe.22229
13. Boyack KW, Klavans R. Co-citation analysis, bibliographic coupling and direct citation: which citation approach represents the research front most accurately? J Am Soc Inf Sci Technol. 2010;61:2389-404. https://doi.org/10.1002/asi.21419
14. Bales ME, Wright DN, Oxley PR, Wheeler TR. Bibliometric visualization and analysis software: state of the art, workflows and best practices.
15. Mulay P, Joshi R, Chaudhari A. Distributed incremental clustering algorithms: a bibliometric and word-cloud review analysis. Sci Technol Libr. 2020;39:289-306. https://doi.org/10.1080/0194262X.2020.1775163
16. Dorman HD, Deans SG. Antimicrobial agents from plants: antibacterial activity of plant volatile oils. J Appl Microbiol. 2000;88:308-16. https://doi.org/10.1046/j.1365-2672.2000.00969.x
17. Petersen M, Simmonds MS. Rosmarinic acid. Phytochemistry. 2003;62:121-5. https://doi.org/10.1016/S0031-9422(02)00513-7
18. Krishnaiah D, Sarbatly R, Nithyanandam R. A review of the antioxidant potential of medicinal plant species. Food Bioprod Process. 2011;89:217-33. https://doi.org/10.1016/j.fbp.2010.04.008

19. Marchese A, Orhan IE, Daglia M, Barbieri R, Di Lorenzo A, Nabavi SF, et al. Antibacterial and antifungal activities of thymol: a brief review of the literature. Food Chem. 2016;210:402-14. https://doi.org/10.1016/j.foodchem.2016.04.111

20. Pratap R, Ram VJ. Natural and synthetic chromenes, fused chromenes and versatility of dihydrobenzo[h]chromenes in organic synthesis. Chem Rev. 2014;114:10476-526. https://doi.org/10.1021/cr500075s

21. İşcan G, Kırımer N, Kürkcüoğlu M, Başer HC, Demirci F. Antimicrobial screening of Mentha piperita essential oils. J Agric Food Chem. 2002;50:3943-6. https://doi.org/10.1021/jf011476k

22. Marchese A, Barbieri R, Coppo E, Orhan IE, Daglia M, Nabavi SF, et al. Antimicrobial activity of eugenol and essential oils containing eugenol: a mechanistic viewpoint. Crit Rev Microbiol. 2017;43:668-89. https://doi.org/10.1080/1040841X.2017.1295225

23. Delamare AP, Moschen-Pistorello IT, Artico L, Atti-Serafini L, Echeverrigaray S. Antibacterial activity of the essential oils of *Salvia officinalis* L. and *Salvia triloba* L. Food Chem. 2007;100:603-8. https://doi.org/10.1016/j.foodchem.2005.09.078

24. Gang DR, Wang J, Dudareva N, Nam KH, Simon JE, Lewinsohn E, et al. An investigation of the storage and biosynthesis of phenylpropenes in sweet basil. Plant Physiol. 2001;125:539-55. https://doi.org/10.1104/pp.125.2.539

25. Kachur K, Suntres Z. The antibacterial properties of phenolic isomers, carvacrol and thymol. Crit Rev Food Sci Nutr. 2020;60:3042-53. https://doi.org/10.1080/10408398.2019.1675585

26. Salehi B, Mishra AP, Shukla I, Sharifi-Rad M, Contreras MD, Segura-Carretero A, et al. Thymol, thyme and other plant sources: health and potential uses. Phytother Res. 2018;32:1688-706. https://doi.org/10.1002/ptr.6109

27. Zhao T, Tang H, Xie L, Zheng Y, Ma Z, Sun Q, et al. *Scutellaria baicalensis* Georgi. (*Lamiaceae*): a review of its traditional uses, botany, phytochemistry, pharmacology and toxicology. J Pharm Pharmacol. 2019;71:1353-69. https://doi.org/10.1111/jphp.13129

28. Lukhoba CW, Simmonds MS, Paton AJ. *Plectranthus*: a review of ethnobotanical uses. J Ethnopharmacol. 2006;103:1-24. https://doi.org/10.1016/j.jep.2005.09.011

29. Shang X, He X, He X, Li M, Zhang R, Fan P, et al. The genus *Scutellaria*: an ethnopharmacological and phytochemical review. J Ethnopharmacol. 2010;128:279-313. https://doi.org/10.1016/j.jep.2010.01.006

30. Ivanova D, Gerova D, Chervenkov T, Yankova T. Polyphenols and antioxidant capacity of Bulgarian medicinal plants. J Ethnopharmacol. 2005;96:145-50. https://doi.org/10.1016/j.jep.2004.08.033

31. Vitalini S, Iriti M, Puricelli C, Ciuchi D, Segale A, Fico G. Traditional knowledge on medicinal and food plants used in Val San Giacomo (Sondrio, Italy)-an alpine ethnobotanical study. J Ethnopharmacol. 2013;145:517-29. https://doi.org/10.1016/j.jep.2012.11.024

32. Wang ZL, Wang S, Kuang Y, Hu ZM, Qiao X, Ye M. A comprehensive review on phytochemistry, pharmacology and flavonoid biosynthesis of *Scutellaria baicalensis*. Pharm Biol. 2018;56:465-84. https://doi.org/10.1080/13880209.2018.1492620

33. Sharififar F, Dehghn-Nudeh G, Mirtajaldini M. Major flavonoids with antioxidant activity from *Teucrium polium* L. Food Chem. 2009;112:885-8. https://doi.org/10.1016/j.foodchem.2008.06.064

34. Qian J, Song J, Gao H, Zhu Y, Xu J, Pang X, et al. The complete chloroplast genome sequence of the medicinal plant *Salvia miltiorrhiza*. PLoS One. 2013;8:e57607. https://doi.org/10.1371/journal.pone.0057607

35. Tan BK, Vanitha J. Immunomodulatory and antimicrobial effects of some traditional Chinese medicinal herbs: a review. Curr Med Chem. 2004;11:1423-30. https://doi.org/10.2174/0929867043365161

36. Birtić S, Dussort P, Pierre FX, Bily AC, Roller M. Carnosic acid. Phytochemistry. 2015;115:9-19. https://doi.org/10.1016/j.phytochem.2014.12.026

37. Grayer RJ, Kite GC, Goldstone FJ, Bryan SE, Paton A, Putievsky E. Infraspecific taxonomy and essential oil chemotypes in sweet basil, *Ocimum basilicum*. Phytochemistry. 1996;43:1033-9. https://doi.org/10.1016/S0031-9422(96)00429-3

38. Fachini-Queiroz FC, Kummer R, Estevao-Silva CF, Carvalho MD, Cunha JM, Grespan R, et al. Effects of thymol and carvacrol, constituents of *Thymus vulgaris* L. essential oil, on the inflammatory response. Evid Based Complement Alternat Med. 2012;2012:657026. https://doi.org/10.1155/2012/657026

39. Tundis R, Loizzo MR, Menichini F, Statti GA, Menichini F. Biological and pharmacological activities of iridoids: recent developments. Mini Rev Med Chem. 2008;8:399-420. https://doi.org/10.2174/138955708783955926

40. Conforti F, Sosa S, Marrelli M, Menichini F, Statti GA, Uzunov D, et al. In vivo anti-inflammatory and *in vitro* antioxidant activities of Mediterranean dietary plants. J Ethnopharmacol. 2008;116:144-51. https://doi.org/10.1016/j.jep.2007.11.015

41. Cakilcioglu U, Turkoglu I. An ethnobotanical survey of medicinal plants in Sivrice (Elazığ–Turkey). J Ethnopharmacol. 2010;132:165-75. https://doi.org/10.1016/j.jep.2010.08.017

42. Neves JM, Matos C, Moutinho C, Queiroz G, Gomes LR. Ethnopharmacological notes about ancient uses of medicinal plants in Trás-os-Montes (northern Portugal). J Ethnopharmacol. 2009;124:270-83. https://doi.org/10.1016/j.jep.2009.04.041

43. Luo C, Zou L, Sun H, Peng J, Gao C, Bao L, et al. A review of the anti-inflammatory effects of rosmarinic acid on inflammatory diseases. Front Pharmacol. 2020;11:153. https://doi.org/10.3389/fphar.2020.00153

44. Kamatou GP, Makunga NP, Ramogola WP, Viljoen AM. South African *Salvia* species: a review of biological activities and phytochemistry. J Ethnopharmacol. 2008;119:664-72. https://doi.org/10.1016/j.jep.2008.06.030

45. Çakılcıoğlu U, Khatun S, Türkoğlu İ, Hayta S. Ethnopharmacological survey of medicinal plants in Maden (Elazığ–Turkey). J Ethnopharmacol. 2011;137:469-86. https://doi.org/10.1016/j.jep.2011.05.046

46. Jamila F, Mostafa E. Ethnobotanical survey of medicinal plants used by people in Oriental Morocco to manage various ailments. J Ethnopharmacol. 2014;154:76-87. https://doi.org/10.1016/j.jep.2014.03.016

47. Mosaddegh M, Naghibi F, Moazzeni H, Pirani A, Esmaeili S. Ethnobotanical survey of herbal remedies traditionally used in Kohghiluyeh va Boyer Ahmad province of Iran. J Ethnopharmacol. 2012;141:80-95. https://doi.org/10.1016/j.jep.2012.02.004

48. Borges RS, Ortiz BL, Pereira AC, Keita H, Carvalho JC. *Rosmarinus officinalis* essential oil: a review of its phytochemistry, anti-inflammatory activity and mechanisms of action involved. J Ethnopharmacol. 2019;229:29-45. https://doi.org/10.1016/j.jep.2018.09.038

49. Sajed H, Sahebkar A, Iranshahi M. *Zataria multiflora* Boiss. (Shirazi thyme)-an ancient condiment with modern pharmaceutical uses. J Ethnopharmacol. 2013;145:686-98. https://doi.org/10.1016/j.jep.2012.12.018

50. Polat R, Satıl F. An ethnobotanical survey of medicinal plants in Edremit Gulf (Balıkesir-Turkey). J Ethnopharmacol. 2012;139:626-41. https://doi.org/10.1016/j.jep.2011.12.004

51. Ribeiro-Santos R, Carvalho-Costa D, Cavaleiro C, Costa HS, Albuquerque TG, Castilho MC, et al. A novel insight on an ancient aromatic plant: the rosemary (*Rosmarinus officinalis* L.). Trends Food Sci Technol. 2015;45:355-68. https://doi.org/10.1016/j.tifs.2015.07.015

52. Ahmed HM. Ethnomedicinal, phytochemical and pharmacological investigations of *Perilla frutescens* (L.) Britt. Molecules. 2018;24:102. https://doi.org/10.3390/molecules24010102

53. Nadeem M, Imran M, Gondal TA, Imran A, Shahbaz M, Amir RM, et al. Therapeutic potential of rosmarinic acid: a comprehensive review. Appl Sci. 2019;9:3139. https://doi.org/10.3390/app9153139

54. Ugulu I, Baslar S, Yorek N, Dogan Y. The investigation and quantitative ethnobotanical evaluation of medicinal plants used around Izmir province, Turkey. J Med Plants Res. 2009;3:345-67.

55. Gião MS, González-Sanjosé ML, Rivero-Pérez MD, Pereira CI, Pintado ME, Malcata FX. Infusions of Portuguese medicinal plants: dependence of final antioxidant capacity and phenol content on extraction features. J Sci Food Agric. 2007;87:2638-47. https://doi.org/10.1002/jsfa.3023

56. Kala CP. Ethnomedicinal botany of the Apatani in the Eastern Himalayan region of India. J Ethnobiol Ethnomed. 2005;1:11. https://doi.org/10.1186/1746-4269-1-11

57. Tetik F, Civelek S, Cakilcioglu U. Traditional uses of some medicinal plants in Malatya (Turkey). J Ethnopharmacol. 2013;146:331-46. https://doi.org/10.1016/j.jep.2012.12.054

58. Baher ZF, Mirza M, Ghorbanli M, Rezaii MB. The influence of water stress on plant height, herbal and essential oil yield and composition in *Satureja hortensis* L. Flavour Fragr J. 2002;17:275-7. https://doi.org/10.1002/ffj.1097

59. Gürdal B, Kültür Ş. An ethnobotanical study of medicinal plants in Marmaris (Muğla, Turkey). J Ethnopharmacol. 2013;146:113-26. https://doi.org/10.1016/j.jep.2012.12.012

60. Borrás-Linares I, Stojanović Z, Quirantes-Piné R, Arráez-Román D, Švarc-Gajić J, Fernández-Gutiérrez A, et al. *Rosmarinus officinalis* leaves as a natural source of bioactive compounds. Int J Mol Sci. 2014;15:20585-606. https://doi.org/10.3390/ijms151120585

61. Menković N, Šavikin K, Tasić S, Zdunić G, Stešević D, Milosavljević S, et al. Ethnobotanical study on traditional uses of wild medicinal plants in Prokletije Mountains (Montenegro). J Ethnopharmacol. 2011;133:97-107. https://doi.org/10.1016/j.jep.2010.09.008

62. Šavikin K, Zdunić G, Menković N, Živković J, Ćujić N, Tereščenko M, et al. Ethnobotanical study on traditional use of medicinal plants in South-Western Serbia, Zlatibor district. J Ethnopharmacol. 2013;146:803-10. https://doi.org/10.1016/j.jep.2013.02.006

63. Hajhashemi V, Sadraei H, Ghannadi AR, Mohseni M. Antispasmodic and anti-diarrhoeal effect of *Satureja hortensis* L. essential oil. J Ethnopharmacol. 2000;71:187-92. https://doi.org/10.1016/S0378-8741(99)00209-3

64. Vladimir-Knežević S, Blažeković B, Kindl M, Vladić J, Lower-Nedza AD, Brantner AH. Acetylcholinesterase inhibitory, antioxidant and phytochemical properties of selected medicinal plants of the Lamiaceae family. Molecules. 2014;19:767-82. https://doi.org/10.3390/molecules19010767

65. Bhattacharya S, Gupta N, Dutta A, Khanra PK, Dutta R, Žiarovská J, et al. Repurposing major metabolites of Lamiaceae family as potential inhibitors of α-synuclein aggregation to alleviate neurodegenerative diseases: an *in silico* approach. Front Pharmacol. 2025;16:1519145. https://doi.org/10.3389/fphar.2025.1519145

66. Khazaneha M, Zandrahimi F, Sadatmoosavi A, Salarpour S, Karegar-Borzi H, Tajedini O, et al. An overview of scientific publication of the chamomile (*Matricaria chamomilla*) research: a bibliometric analysis. J Scientometr Res. 2024;13:604-14. https://doi.org/10.5530/jscires.13.2.47

67. Ebadollahi A, Ziaee M, Palla F. Essential oils extracted from different species of the Lamiaceae plant family as prospective bioagents against several detrimental pests. Molecules. 2020;25:1556. https://doi.org/10.3390/molecules25071556

68. Nuryana Z, Xu W, Lu S, Tasir Z, Suyadi S. Mapping global research on shadow education: trends and future agenda. Int J Eval Res Educ. 2023;12:1105-13. https://doi.org/10.11591/ijere.v12i2.24667

69. Chakrabartty I, Mohanta YK, Nongbet A, Mohanta TK, Mahanta S, Das N, et al. Exploration of Lamiaceae in cardiovascular diseases and functional foods: medicine as food and food as medicine. Front Pharmacol. 2022;13:894814. https://doi.org/10.3389/fphar.2022.894814

Additional information

Peer review: Publisher thanks Sectional Editor and the other anonymous reviewers for their contribution to the peer review of this work.

Reprints & permissions information is available at https://horizonepublishing.com/journals/index.php/PST/open_access_policy

Publisher's Note: Horizon e-Publishing Group remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Indexing: Plant Science Today, published by Horizon e-Publishing Group, is covered by Scopus, Web of Science, BIOSIS Previews, Clarivate Analytics, NAAS, UGC Care, etc
See https://horizonepublishing.com/journals/index.php/PST/indexing_abstracting

Publisher information: Plant Science Today is published by HORIZON e-Publishing Group with support from Empirion Publishers Private Limited, Thiruvananthapuram, India.