From ethnobotany to biotechnology: Research trends on *Myracrodruon urundeuva* (Anacardiaceae)

Raquel Bastos Vasconcelos, Igor Lima Soares, Lucas Pontes Leal, Willams Alves da Silva, Rebeca Bastos Vasconcelos Marinho, Édson Luiz Cetira-Filho, Ravy Jucá Farias, Francisco Assis Silva de Lima-Júnior, Paulo Goberlânio Barros Silva, Mary Anne Medeiros Bandeira

Correspondence

Raquel Bastos Vasconcelos[1,2], Igor Lima Soares[1]*, Lucas Pontes Leal[3], Willams Alves da Silva[1], Rebeca Bastos Vasconcelos Marinho[2], Édson Luiz Cetira-Filho[2], Ravy Jucá Farias[2], Francisco Assis Silva de Lima-Júnior[4], Paulo Goberlânio Barros Silva[2], Mary Anne Medeiros Bandeira[1]

[1]Graduate Program in Pharmaceutical Development and Technological Innovation, Federal University of Ceará, Fortaleza, Brazil
[2]Centro Universitário Christus (UNICHRISTUS), Fortaleza, Brazil
[3]Department of Food Technology, Federal University of Ceará, Fortaleza, Brazil
[4]Graduate Program in Biochemistry, Federal University of Ceará, Fortaleza, Brazil

*Corresponding Author: igorlima.ti@gmail.com

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Research

Abstract

Background: *Myracrodruon urundeuva* is a resilient species native to Brazil and is distinguished by its phytochemical composition, rich in tannins and chalcones, which underpin its traditional use in women's gynecological health. This intersection of ecological toughness and pharmacological relevance illustrates its strategic role in socio-biodiversity

Methods: This study applies a bibliometric approach to map the global literature on *M. urundeuva*, identifying publication trends, thematic evolution, and collaboration patterns. A total of 326 documents (1985-2023) from 172 journals were retrieved and analyzed using bibliometric tools.

Results: Publications increased at an annual rate of 5.62%, with an average document age of 10.4 years and 24.17 citations per article. Brazilian institutions dominate authorship, involving 1,149 contributors and a mean of 6.23 co-authors per publication. However, international collaboration remains low (4.9%). The high number of author keywords (933) and Keywords Plus (3612) indicates wide thematic diversity.

Conclusions: Research on *M. urundeuva* has expanded since 2010, supported by biodiversity policies and growing interest in sustainable bioproducts. This bibliometric overview provides an evidence-based foundation for guiding future research concerning this species.

Keywords: Anacardiaceae; Bibliometric analysis; Biodiversity; Pharmacology; Medicinal plants.

Background

Brazilian plant biodiversity harbors an extraordinary wealth of species with potential ecological, medicinal, and economic potential (Ranzato Filardi *et al*. 2018, Oliveira *et al*. 2024, Lambert-Moreira *et al*. 2025). Yet, many of these native resources remain underexplored or face severe threats from anthropogenic pressures and habitat loss (Zappi *et al*. 2025, Gomes *et al*. 2025, Bezerra *et al*. 2022).

The 'Farmácias Vivas' program, created by Professor Francisco José de Abreu Matos, represents a key public health strategy that bridges traditional knowledge and scientific evidence-based validation to strengthen phytotherapy within public health. Studies show that these initiatives expand access to safe, standardized herbal medicines while fostering community engagement and the valorization of local biodiversity (Camargo *et al*. 2023, Borella *et al*. 2024). Their sociobiodiverse and solidarity-driven model promotes sustainable cultivation and rational use of medicinal plants, illustrating how decentralized phytotherapy programs can democratize healthcare while also preserving culturally rooted therapeutic practices (Gamarra-Rojas *et al*. 2025).

However, the consolidation of phytotherapy in Brazil remains limited due to insufficient evidence on the safety and efficacy of herbal medicines, which reduces health professionals' confidence (Pedroso *et al.* 2021). Institutional and regulatory obstacles, including limited or fragile production infrastructure and environmental constraints, further restrict the development of medicinal plant programs (Abdala & Sena 2021). Unequal access to quality-assured herbal products also persists across regions, highlighting gaps in policy implementation (da Silva Sobrinho *et al*. 2023).

Ethnobotanical knowledge guides the selection of traditionally used plants, increasing the efficiency of identifying relevant bioactive compounds and supporting early drug discovery (Ali *et al*. 2023). This approach strengthens innovation in phytotherapy by linking cultural practices to pharmacological validation and informing the development of future medicines (Gürağaç Dereli *et al.* 2022), providing the basis for introducing different species into research settings.

Among these species, *Myracrodruon urundeuva* Allemão, commonly known as **aroeira-do-sertão**, stands out as a symbol of both resilience and vulnerability within the Caatinga biome. Native to seasonally dry tropical forests in South America, this species has been widely used in folk medicine and is highly valued for its durable timber (Silva Filha *et al*. 2025). Despite this ecological and cultural relevance, its natural distribution in Brazil is currently restricted and increasingly fragmented, and projections under future climate scenarios indicate a further reduction of suitable habitats, bringing attention to its recognized status as a threatened species (Capo *et al*. 2022). It has progressively drawn scientific and technological attention due to its pharmacological activities, ecological versatility, and potential contribution to sustainable development in semi-arid environments (Vasconcelos *et al*. 2025, Rodrigues *et al*. 2025).

Over the past decades, extensive research has explored the phytochemistry, pharmacology, and ecological role of *Myracrodruon urundeuva*. Phenolic compounds, particularly tannins and chalcones, have been identified as its main bioactive constituents, which account for its anti-inflammatory, antimicrobial, antioxidant, and wound-healing activities (Vasconcelos *et al*., 2025). As a result of this growing body of evidence, the species has been included in national and regional strategic inventories in Brazil, such as the *Brazilian Pharmacopoeia Herbal Medicines Formulary* (*Formulário de Fitoterápicos da Farmacopeia Brasileira*), the *National List of Medicinal Plants of Interest to the Brazilian Unified Health System* (*Relação Nacional de Plantas Medicinais de Interesse ao SUS*, RENISUS), and the *State List of Medicinal Plants of Ceará* (*Relação Estadual de Plantas Medicinais do Ceará, REPLAME*).

Beyond its medicinal importance, it holds exceptional ecological and economic potential. Its remarkable drought tolerance, rapid growth, and adaptability to nutrient-poor soils make it an ideal candidate for reforestation, erosion control, and restoration of degraded semi-arid lands (Nunes *et al*. 2008, Saul *et al*. 2021). In this context, the species represents a model for integrating conservation and sustainable land-use strategies within the context of climate resilience and biodiversity-based innovation.

However, despite these advances, scientific knowledge of *M. urundeuva* remains fragmented across disciplines, lacking a comprehensive synthesis that captures the evolution, connections, and emerging frontiers of research on this species. A bibliometric approach offers a powerful framework to address this gap, enabling the quantitative and qualitative mapping of scientific production, identifying key actors, thematic trends, and collaboration networks, while uncovering opportunities for interdisciplinary integration (Abdelwahab *et al*. 2025, Hassan & Duarte 2024, Izidoro *et al*. 2024).

Therefore, this study aims to perform a comprehensive bibliometric analysis of the scientific literature on *M. urundeuva*, with emphasis on thematic trends, collaborative networks, publication dynamics, and their interfaces with technological and biological applications. By consolidating dispersed information and visualizing research trajectories, this work seeks to contribute to a more integrated understanding of the species as a strategic for Brazil's sustainable development, biodiversity conservation, and biotechnological innovation.

Materials and Methods

Study area

The data analysis for this study was conducted using the Scopus, Web of Science, and PubMed databases. The keywords used were "*Myracrodruon urundeuva*", "*Myracrodruon urundeuva* Allemão", "*Astronium urundeuva*", "*Astronium gardneri*", "Aroeira-do-sertão", and "Aroeira do sertão" to encompass all research advancements related to the topic published between 1985 and 2023. Additional search criteria included document types (article, review article, conference paper, book chapter, editorial material, newspaper article, letter, meeting abstract, and proceedings paper), English language, and final publication stage. A total of 596 publications were identified across the databases for bibliometric analysis, with downloads initiated on December 21, 2024. The PRISMA flow diagram summarizing the selection criteria is presented in Figure 1.

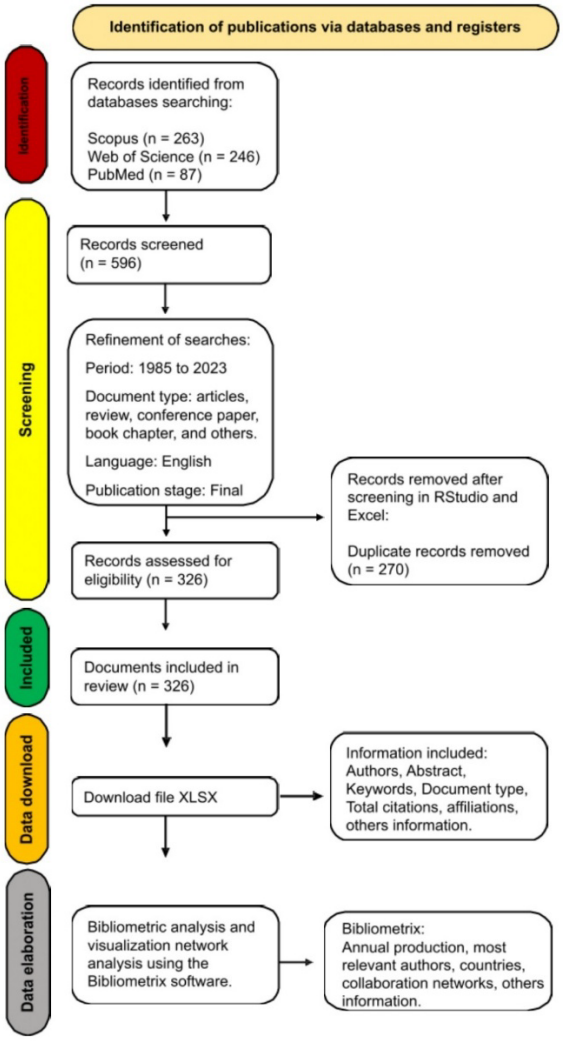

Figure 1. Flowchart of the bibliometric data collection and analysis process

The Bibliometrix, a package developed in the R statistical language for quantitative scientometric and bibliometric studies, was employed to analyze the data retrieved from scientific databases (Aria & Cuccurullo, 2017). This tool, known for its robustness and reliability, facilitated the construction of collaboration networks among journals, countries, institutions, and authors based on co-citation data and keyword mapping. Additionally, three tools were utilized for data visualization analysis

in this study: Microsoft Excel Spreadsheets (Microsoft Office Professional Plus, 2019), Minitab Free 390 software (Minitab Inc., State College, PA, USA), and Biblioshiny (version 4.1).

As this study is based on metadata analysis, no new plant material was collected, therefore the reliability of the identified trends depends on the voucher-supported data reported in the primary studies included in the analysis.

Results and Discussion

Main Information

A total of 326 scientific documents related to **aroeira-do-sertão** were retrieved for the period between 1985 and 2023, encompassing 172 different sources (Table 1). The annual growth rate of publications was 5.62%, reflecting a steady expansion of research interest in this native Brazilian species over nearly four decades. This rate is higher than those reported in bibliometric analyses of other common natural products in Brazil, such as propolis and medicinal species from *Tropaeolum* genus (Bozkuş 2025, Cé *et al*. 2025).

The average age of the documents was 10.4 years, indicating that most publications are relatively recent and that research on this topic has gained stronger momentum over the past two decades. This trend suggests a consolidation of scientific interest after 2010, possibly associated with national policies and initiatives aimed at promoting biodiversity-based innovation in Brazil, such as the *National Policy on Medicinal Plants and Herbal Medicines* (Programa Nacional de Plantas Medicinais e Fitoterápicos, PNPMF) and the *National List of Medicinal Plants of Interest to the Brazilian Unified Health System* (*Relação Nacional de Plantas Medicinais de Interesse ao SUS*, RENISUS) (Cherobin *et al*., 2022).

The mean citation rate was 24.17 citations per document, with a total of 9,516 references cited across the dataset, indicating that research on has achieved moderate to high visibility within the scientific community. This consistent citation performance underscores the growing academic relevance of the species, particularly given its niche focus as a single native taxon. In terms of content analysis, the dataset comprised 933 author's keywords (DE) and 3,612 Keywords Plus (ID), demonstrating a high thematic diversity and multidisciplinary scope, with studies ranging from phytochemistry and pharmacology to ecology, forestry, and biotechnology.

In total, 1,149 authors contributed to publications on *M. urundeuva*, among which only one was single-authored, indicating a strongly collaborative authorship pattern. The average number of co-authors per document was 6.23, and international collaborations accounted 4.9% of all documents, revealing a predominantly national research network, mainly on Brazilian institutions, with limited but growing global engagement. This limited global engagement may reflect linguistic and geographic barriers but also indicates opportunities for strengthening transnational partnerships, particularly with institutions experienced in arid-land ecology, natural product chemistry and pharmacology, and conservation biotechnology (Baker *et al*. 1995).

Table 1. Key statistics regarding the compilation of documents pertaining to aroeira-do-sertão spanning from 1985 to 2023.

Description	**Results**
Timespan	1985 - 2023
Sources (Journals)	172
Documents	326
Annual Growth Rate %	5.62
Document Average Age	10.4
Average citations per doc	24.17
References	9516
Document Contents	**Results**
Keywords Plus (ID)	3612
Author's Keywords (DE)	933
Authors	**Results**
Authors	1149
Authors of single-authored docs	1
Authors Collaboration	**Results**
Single-authored docs	1
Co-Authors per Doc	6.23
International co-authorships %	4.9
Document Types	**Results**
Original Article	294
Review	15

Regarding document types, original research articles predominated (294 documents; 90.2%), followed by reviews (15 documents; 4.6%) and a few other publication types, confirming the dominance of experimental and field-based studies over theoretical or integrative works. Notably, the review papers do not focus specifically on *Myracrodruon urundeuva*, but rather address broader topics such as the Caatinga biome, plant extracts, or general phytochemical and pharmacological studies.

Year-Based Publication Analysis

A total of 326 articles related to **aroeira-do-sertão** were identified between 1985 and 2023 (Figure 2). The annual distribution of publications illustrates a slow growth phase from the mid-1980s to the early 2000s, followed by a sharp increase starting around 2007. The most productive period occurred between 2013 and 2022, indicating a growing scientific interest and consolidation of research on the species.

The first phase (1985–1997) is characterized by very low and irregular scientific output, with only one or two publications per year. This scarcity aligns with the broader scenario of limited investment in medicinal plant research in Brazil during the 1980s and early 1990s. In the early years analyzed (the 1980s and 1990s), the number of publications was extremely low, with only one or two publications per year at irregular intervals. This scenario can be attributed to limited scientific infrastructure in Brazil and low investment in research, particularly in medicinal plants with traditional uses. The now-defunct Central de Medicamentos (CEME) of Brazil, established in 1971, played a key role in studying and promoting native medicinal plants, emphasizing the value of empirical knowledge from communities inhabiting diverse biomes across the country (Bandeira *et al*. 2024). Rather than prioritizing exotic medicinal plants, CEME shifted research priorities toward Brazil's biodiversity in 1982, aiming to identify and develop the therapeutic potential of species already used traditionally by local populations (Sant' Ana & Assad 2004). However, during this period, the exploitation of native plants, such as *Myracrodruon urundeuva*, was still far from being considered a research or conservation priority.

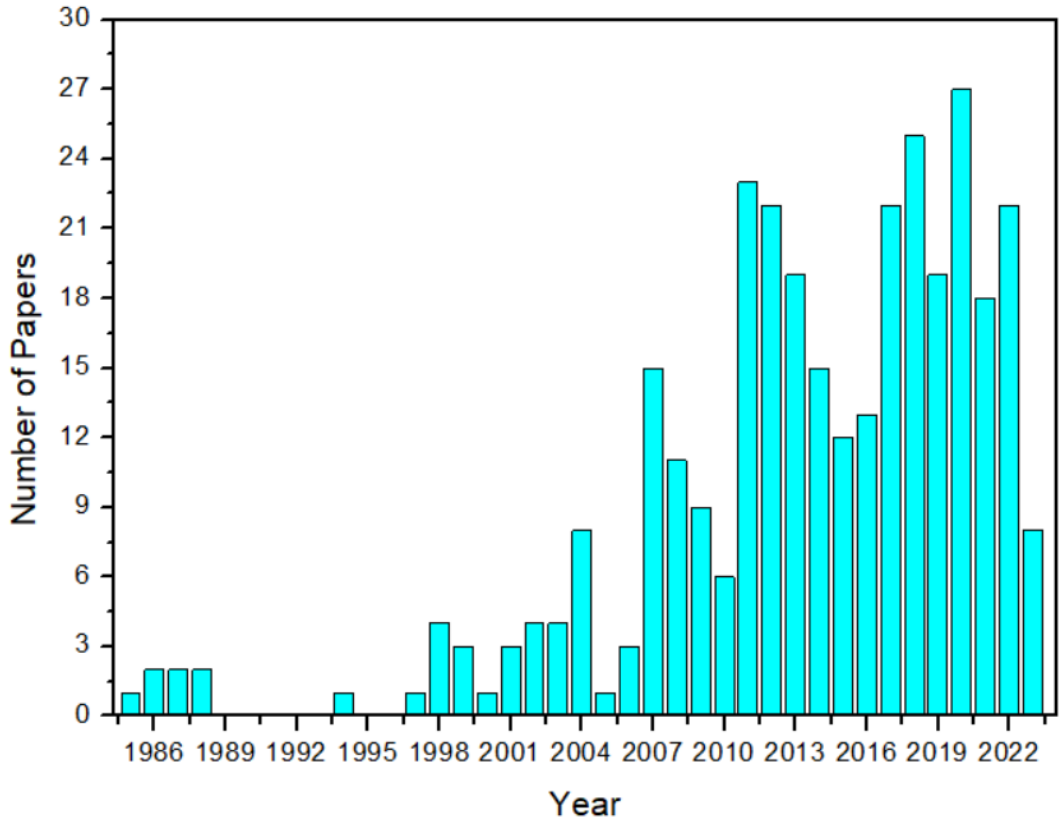

Figure 2. Annual research productivity concerning **aroeira-do-sertão** (1985–2023).

A second phase begins in 1998, marked by a gradual increase in publications, including a noticeable peak in 2004.This growth may be associated with the greater recognition of medicinal plants in Brazil, particularly from the 2000s onward, following the implementation of public policies such as the National Policy on Medicinal Plants and Herbal Medicines, officially launched in 2006. This initiative contributed to the inclusion of native plants in the Brazilian Unified Health System (SUS), promoting their medicinal use and, consequently, generating increased scientific interest, including in *Myracrodruon*

*urundeuv*a (**aroeira-do-sertão**) (Villas Bôas *et al*. 2023). Furthermore, environmental and pharmaceutical regulatory frameworks, such as the Biodiversity Law (Law No. 13.123/2015), which establishes guidelines for the sustainable use of genetic resources and associated traditional knowledge, have also stimulated research. This law was designed to regulate access to the genetic resources of native plants and ensure fair benefit-sharing with local communities (Bruno & Matos 2021).

The third phase marked a turning point, beginning around 2007 and continuing until 2013. During these years, publications increased sharply, culminating in a peak of 23 articles in 2011. This growth reflects the strengthening of universities and research centers in the Northeastern Brazil, such as the Federal University of Ceará (UFC), along with increased funding for biodiversity research (de Figueredo *et al*. 2014). In 2012, the state of Ceará, Brazil, through Ordinance No. 275, officially included *M. urundeuva* in its list of medicinal plants for public health use (Ceará 2012). This governmental recognition may have further stimulated research on the species, fostering interest in both academic investigations and industrial applications.

From 2014 onward, the field entered a phase of scientific maturity and relative stability, with consistently high publication rates and a peak of 27 articles in 2020. This stage is associated with the consolidation of research lines focusing on sustainability, environmental impact, and the technological development of herbal medicines. A milestone during this period was the implementation of RDC No. 26/2014 by ANVISA which established regulations for the quality control and production of herbal medicines in Brazil (Agência Nacional de Vigilância Sanitária 2014). This regulatory framework is crucial for the development of pharmaceuticals derived from plants, as it ensures the standardization and safety of these products. Although the numbers for 2021 (18 publications) and 2023 (8 publications) show a slight decline compared to 2020, the stability around 20 annual articles suggests sustained interest in **aroeira-do-sertão**. The decrease in publications in 2023 may be attributed to external factors such as the COVID-19 pandemic, which affected global scientific production, along with local challenges, including the scarcity of research funding and the impacts of economic crises. Despite this, the relevance of *M. urundeuva* remains evident, both nationally and internationally, with continued inclusion in public policies and advancements in the production and quality control technologies for herbal medicines.

Analysis of Scientific Publications and their Impact

The Total Citations (TC) index represents the overall number of citations accumulated by a set of publications and serves as an indicator of their broad academic influence and visibility (Yu & Meng 2018, Silva *et al*. 2015). Because it reflects the cumulative recognition of a research field, higher TC values denote greater scientific impact.

The analysis of publications on **aroeira-do-sertão** reveals a diverse panorama of scientific journals covering various aspects of the species, ranging from ethnobotanical use to pharmacological properties and ecological characteristics (Figure 3 and Figure 4). The Journal of Ethnopharmacology (JEP) stands out with the highest number of publications (20 articles) and citations (2,514), reflecting its position as one of the leading reference journals in the study of therapeutic properties and the traditional use of medicinal plants (Figure 3 and Figure 4). This focus aligns with the global interest in the scientific validation of traditional practices, ensuring international recognition.

Building upon this prominence, JEP holds a pioneering role as the first scientific journal dedicated to bringing together research on indigenous and traditional medicines within a unified platform. Since its inception, the JEP has become increasingly interdisciplinary, mirroring the diversity and complexity inherent in the field of ethnopharmacology. Furthermore, since 1997 it has served as the official journal of the International Society of Ethnopharmacology, consolidating its status as a unique and authoritative publication for disseminating and advancing knowledge on medicinal plant use and cultural pharmacological practices worldwide (Bruhn & Rivier 2019). Several other bibliometric studies in the field of medicinal plants have identified JEP as one of the journals with the highest number of publications and citations (Zhang *et al*. 2024, Mishra *et al*. 2024, El Allaoui *et al*. 2024, Wu *et al*. 2023, Luo *et al*. 2025).

Among regional journals, the Revista Brasileira de Farmacognosia (7 articles) stands out as one of the leading Brazilian publications in the field of natural products, acting as a central vehicle for the dissemination of research in pharmacognosy and in advancing graduate programs and consolidating scientific knowledge in natural product studies across Brazil (Santos 2009).

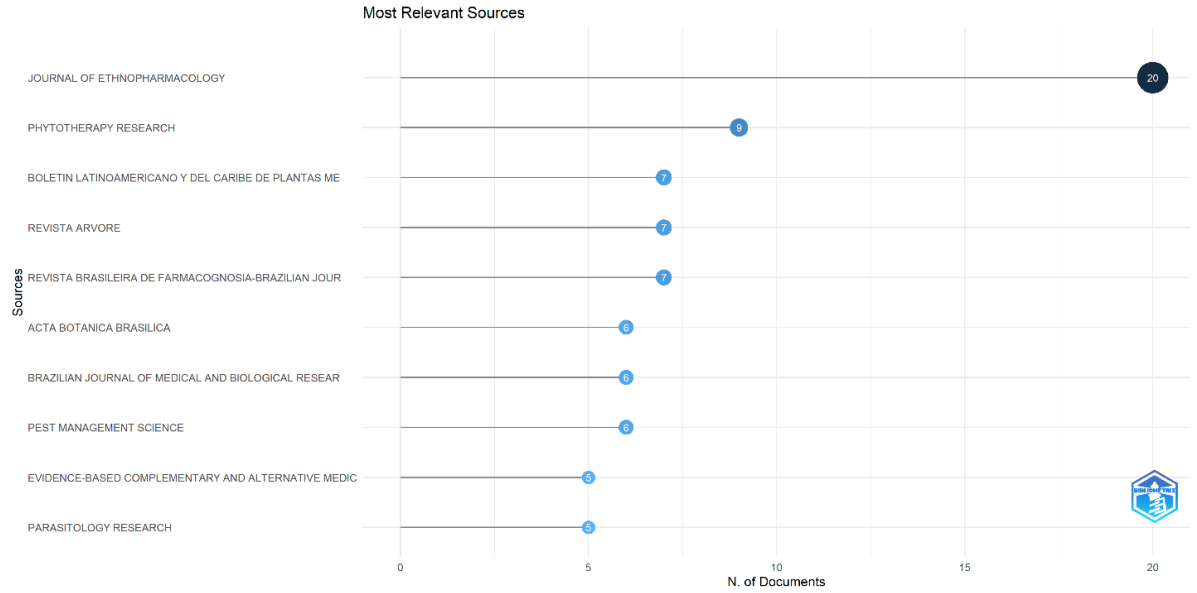

Figure 3. Journals with the highest absolute number of published articles on *M. urundeuva*.

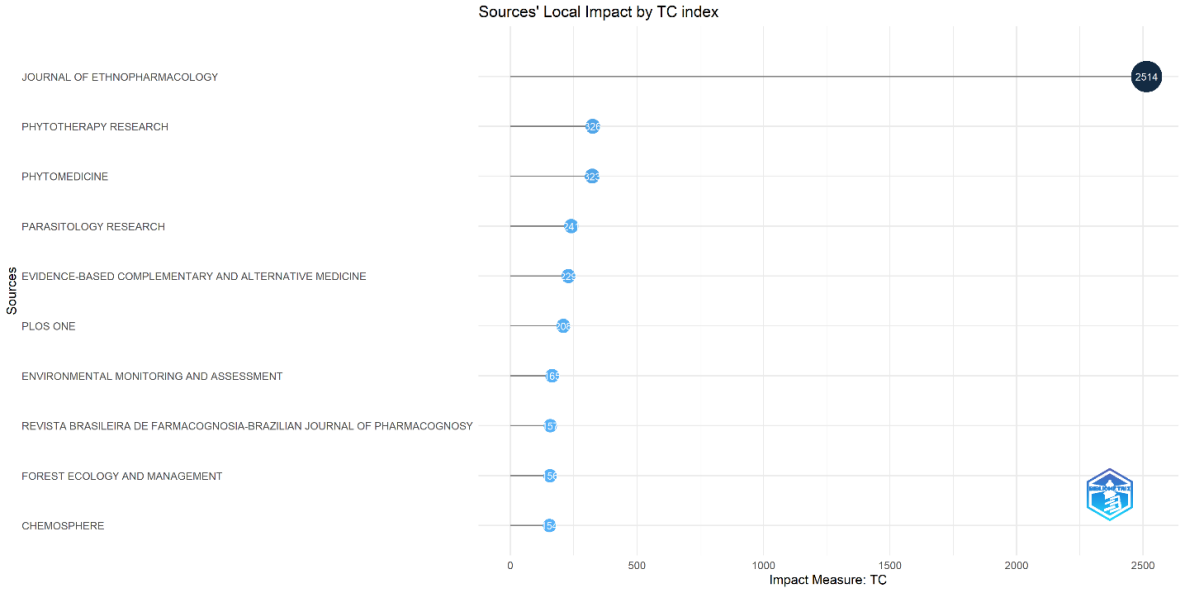

Figure 4. Journals with the most cited articles on *M. urundeuva*.

In the fields of botany and ecology, Acta Botanica Brasilica (6 articles) and Revista Árvore (7 articles) make relevant contributions, highlighting the role of *M. urundeuva* in studies on native flora and Brazilian ecosystems. Acta Botanica Brasilica, in particular, stands out for its growing importance in the dissemination of research on medicinal plants and natural products, reflecting its expanding scientific impact and increasing citation rate within ethnobotanical and pharmacognostic studies (Scarano *et al*. 2009).

Internationally recognized journals, such as Phytotherapy Research (9 articles), Pharmaceutical Biology (5 articles), PLOS ONE (4 articles), and Molecules (2 articles), cover broader topics like bioactive compounds, molecular mechanisms, and pharmacological potentials of plants. These publications extend the reach of studies on *Myracrodruon urundeuva* , fostering interest in this species beyond Brazil's borders.

The contrast between national, regional, and international journals reflects the diversity of research interests. While Brazilian and Latin American publications emphasize the conservation and valorization of natural heritage, international journals explore technological applications and medicinal potentials in global contexts. This complementarity strengthens the scientific impact of *M. urundeuva*, both as a relevant biological resource and as a subject of interdisciplinary studies.

Figure 5 shows the co-citation network of journals related to studies on **aroeira**. The size of the nodes (circles) indicates the citation frequency of each journal, while the thickness of the lines (edges) reflects the degree of co-citation, that is, how often two journals are cited together within the same references. The colors distinguish clusters of thematic areas, illustrating the interdisciplinary nature of research involving this species.

The JEP occupies a central position in the network, with the strongest connections, particularly with Phytotherapy Research, Parasitology Research, and the Annals of the Brazilian Academy of Sciences. This confirms its leading role as a major international outlet for studies on the therapeutic properties and traditional uses of medicinal plants. Its strong linkage with journals in pharmacology and ethnobotany highlights the articulation between traditional knowledge and scientific validation.

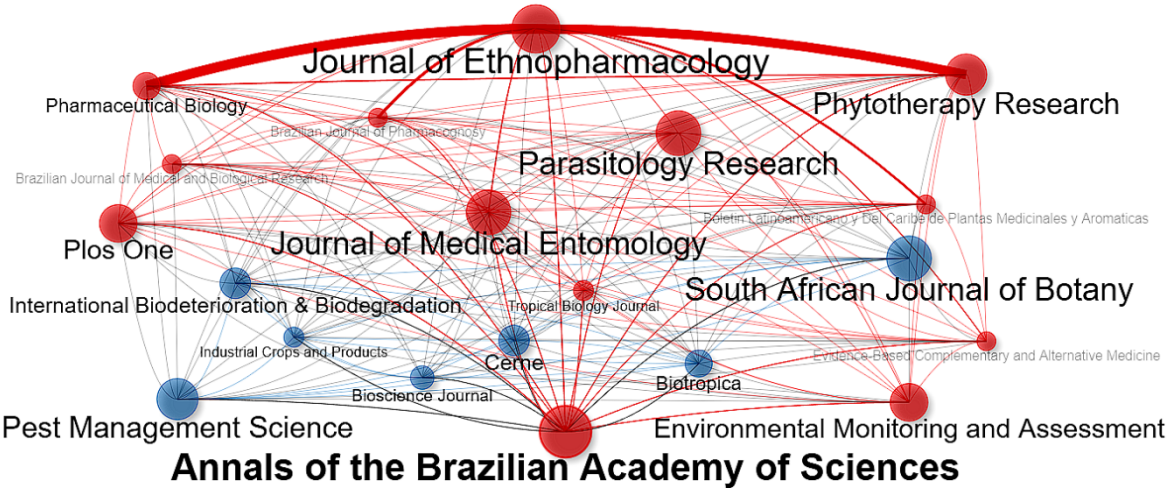

Figure 5. Network visualization of journal co-citation patterns in studies on **aroeira-do-sertão**

Another prominent cluster comprises Brazilian and Latin American journals such as the Annals of the Brazilian Academy of Sciences, Revista Brasileira de Farmacognosia, and Acta Botanica Brasilica, which form a group focused on regional botanical and pharmacognostic research. This cluster reflects the national scientific effort to value biodiversity and conserve native species, reinforcing the importance of regional journals as platforms for disseminating applied studies within the Brazilian context (Castro *et al*. 2014).

The Annals of the Brazilian Academy of Sciences is the oldest continuously published scientific journal in Brazil and is distinguished by its broad multidisciplinary scope, rigorous editorial structure, and open-access model that enhances the dissemination of scientific knowledge (Kellner 2021). Managed by the Brazilian Academy of Sciences and supported by an Editor-in-Chief, associate editors, and area editors, the journal plays a central role in national and international scientific communication (Kellner 2022).

Conversely, journals such as Pharmaceutical Biology, PLOS ONE, and Molecules form a cluster focused on biotechnology and molecular pharmacology, connecting studies on the characterization of bioactive compounds and the elucidation of mechanisms of action. This network reveals the progression of *M. urundeuva* research toward more mechanistic and technological approaches, thereby expanding its reach and international applicability.

Pharmaceutical Biology, with its long-standing tradition in pharmaceutical sciences, serves as a key platform for studies on the discovery, characterization, and biological evaluation of natural products. Its broad scope and interdisciplinary approach have strengthened its role in advancing the scientific understanding of bioactive compounds and supporting the technological development of natural-based therapeutics (Lewandowski & Pezzuto 2012). Molecules bridges chemistry and biotechnology, emphasizing the characterization and molecular diversity of natural and synthetic compounds (McPhee 2015).

The strong interconnection among ecological and botanical journals such as Biotropica, South African Journal of Botany, and Environmental Monitoring and Assessment also suggests an environmental and conservation-oriented dimension in studies

on the species, reflecting concerns for sustainable management and the ecological role of *M. urundeuva* within Brazilian biomes.

Biotropica is as a leading journal in tropical biology and conservation, emphasizing research on biodiversity, ecosystem dynamics, and environmental change in tropical regions. Its commitment to data transparency and innovative publication policies reinforces its role as a key platform for advancing ecological knowledge and sustainable management practices in biodiversity-rich areas (Bruna 2010). Complementing this ecological focus, the South African Journal of Botany has also played a pivotal role in advancing medicinal plant research, with nearly a quarter of its publications devoted to this field and a marked growth in ethnobotanical and pharmacological studies (Viljoen *et al*. 2019).

Trend Identification through Keywords

Figure 6 synthesizes the landscape of the literature on *M. urundeuva* in a word cloud, which illustrates the most frequent terms across the analyzed documents. The significance of this graphic representation lies in its ability to quickly point the dominant thematic focuses of the research, as the font size of each term is proportional to its frequency in the database. This resource enables immediate identification of the most extensively studied areas and, by inference, potential research gaps or trends concerning the **aroeira-do-sertão**.

The terms with the highest frequencies, such as Anacardiaceae (97), *Myracrodruon urundeuva* (82), and *Astronium urundeuva* (75), indicate that the study primarily focuses on the isolated use of the plant, highlighting its scientific name, synonyms, and botanical family. It is important to note that another plant species, also commonly referred to as "**aroeira**" is *Schinus terebinthifolia* Raddi.

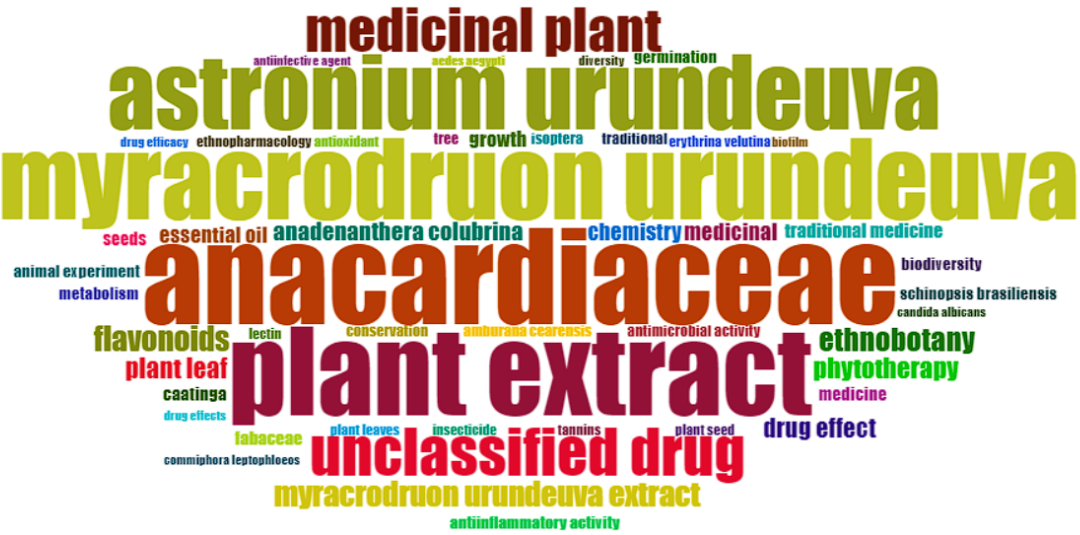

Figure 6. Word Cloud: frequent terms in *M. urundeuva* research.

The term plant extract (89) suggests that the focus of the research is on the plant's extracts, a central aspect of many studies on the medicinal properties of plant species. Additionally, terms such as flavonoids (25), tannins (11), essential oil (17), antiinflammatory activity (13), antioxidant (11), and antimicrobial activity (12) indicate that the research is exploring the phytochemicals of the plant, with an emphasis on its antioxidant, anti-inflammatory, and antimicrobial potential. Moreover, terms like animal experiment (13) and drug effect (20) suggest that the research includes animal experiments to test the effects of the plant extract. Other terms, such as drug efficacy (10) and drug effects (10), are related to evaluating the efficacy of compounds extracted from the plant, likely aiming to explore their therapeutic and medicinal applications. The presence of terms like ethnobotany (24) and traditional medicine (15) reveals an interest in the traditional use of the plant within local communities and its significance in popular medicinal practices.

Another relevant point is the inclusion of terms related to the cultivation and conservation of the plant. Terms such as growth (16), germination (13), seeds (14), conservation (12), and biodiversity (13) indicate that the research also addresses the plant's development, its germination process, and the importance of conserving the species, particularly in the context of

biodiversity (Mota *et al*. 2015, Pacheco *et al*. 2006, da Silva *et al*. 2021, Oliveira *et al*. 2019, Gaino *et al*. 2011, Monteiro *et al*. 2012).

Finally, the presence of other plant names, such as *Anadenanthera colubrina* (19), *Schinopsis brasiliensis* (13), and *Amburana cearensis* (12), suggests that the study may involve a comparison between different species of the caatinga biome, providing a broader analysis of the properties of local plants and their potential therapeutic applications. These three species are recognized for their medicinal potential and their importance in the sustainable development of herbal products, as well as for fostering integrated research on native plant resources (Souza *et al*. 2022, Ribeiro *et al*. 2014, Sá- Filho *et al*. 2021). In summary, these bibliometrics data reveal that the study of *M. urundeuva* is multifaceted, focusing on its bioactive, therapeutic, and traditional properties.

The thematic evolution of research on *M. urundeuva* between 1985 and 2023, as shown in Figure 7, reflects a maturation and diversification of scientific knowledge on this species. From a bibliometric perspective, this progression can be justified by several factors. There was an expansion in the range of topics addressed, including secondary metabolite chemistry (chalcones), antimicrobial and antioxidant activities, along with studies on growth and germination. This indicates a multidisciplinary approach, combining pharmacology, chemistry, and plant biology.

Between 2016 and 2018, there was an increase in research on the genetic diversity and the relationship of the species with specific biomes, such as the Caatinga. This trend suggests a scientific concern with the plant's adaptation and preservation in the face of environmental changes. Between 2019 and 2020, there was a strengthening of research on bioactive compounds, such as essential oils and chalcones, and their antioxidant and digestive actions. This indicates a renewed interest in the pharmaceutical valorization of the plant and its potential use in the industry. In recent years (2021-2023), studies have expanded to include the presence of the species in different biomes, such as the Atlantic Forest, as well as its potential in biotechnology, including the purification of bioactive compounds. These shifts demonstrate a more applied and translational perspective, aiming for the sustainable use of natural resources.

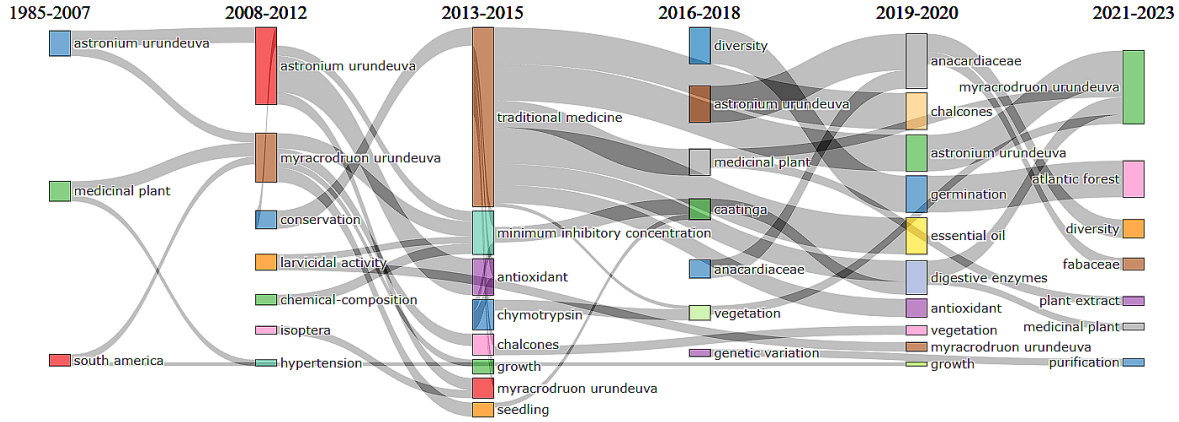

Figure 7. Thematic evolution of research topics on *M. urundeuva* (1985-2023)

Global Distribution of Scientific Production

The citation landscape related to *M. urundeuva* reflects clear bibliometric patterns, indicating both the scientific relevance of this species and the geographic distribution of academic interest in its properties. The analysis of the international collaboration network and the impact of the publications allow visualization of the main research hubs and the dissemination of knowledge about the species over time. Figure 8 presents this distribution, highlighting the countries with the highest number of publications and citations, in addition to the connections between research networks.

Brazil stands as the undisputed leader in citation count (6,524), solidifying its position as the primary producer of knowledge on the species. This prominence is expected, given that *M. urundeuva* is native to the country, where it holds significant cultural, medicinal, and economic importance (Lavôr *et al*. 2021, Andreacci & Melo Júnior 2011). However, the average number of citations per article (24.70) suggests that, although there is a large volume of publications, not all have the same level of impact on the global academic landscape. Studies from other countries are also frequently cited, though on a smaller scale, including Bolivia (155), Hungary (96.00), the Netherlands (58.00), France (49.00), the United States (46.30), and

Switzerland (34.50). This panorama illustrates that *M. urundeuva* is a subject of global scientific interest, with varying focuses and levels of impact depending on the priorities and capabilities of each country.

The analysis of scientific publications on **aroeira-do-sertão** by country reveals an interesting landscape of global contributions to research on this plant, highlighting the predominance of studies originating from Brazil, followed by more modest contributions from other countries, as illustrated in Figure 9 and Figure 10.

Brazil contributes the most to the scientific literature on **aroeira**, with a total of 264 published articles. Of these, 254 are Single Country Publications (SCP), indicating that the majority of research on this plant originates exclusively from Brazil. The dominant presence of Brazil reflects its geographic and cultural context, as *M. urundeuva* is a native plant of the northeastern semi-arid region and plays a significant role in traditional medicine in these areas (Santos *et al*. 2018, Penido *et al*. 2016). Furthermore, public policies and research incentive programs have certainly contributed to the high volume of scientific publications.

Despite the large number of articles, only 10 publications involve international collaborations, resulting in an MCP Ratio of 0.038. This suggests that, although Brazil is the largest producer of research on the species, collaboration with other countries is relatively limited. This pattern may partly reflect the concentration of studies within Brazilian institutions and the lack of greater international exchange regarding *M. urundeuva*.

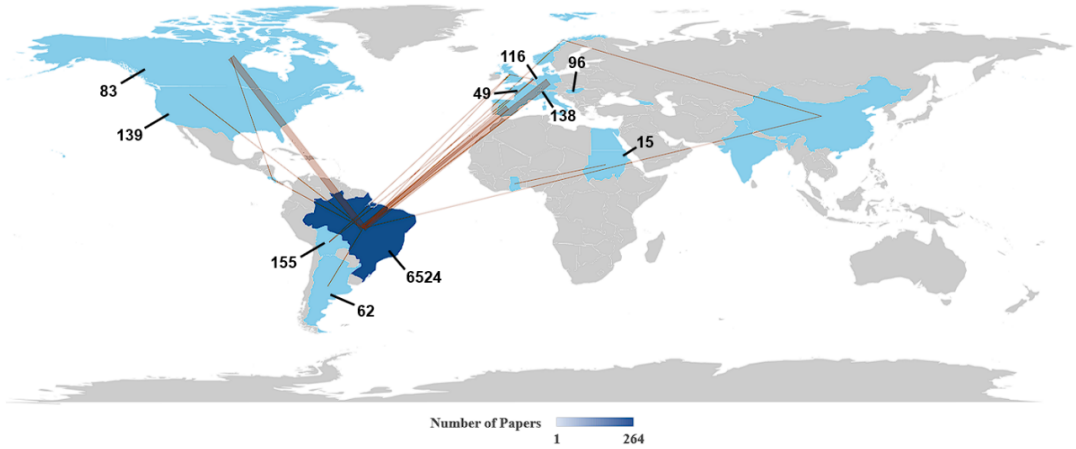

Figure 8. Global Collaboration and Citation Distribution in *M. urundeuva* research. The collaboration network is illustrated on a world map, highlighting publications and the total number of citations by country, with an emphasis on the top 10 countries. Each country is represented by a color according to the number of documents, as indicated by the scale bar, the numbers indicate the total citations, and the red lines illustrate the collaboration network.

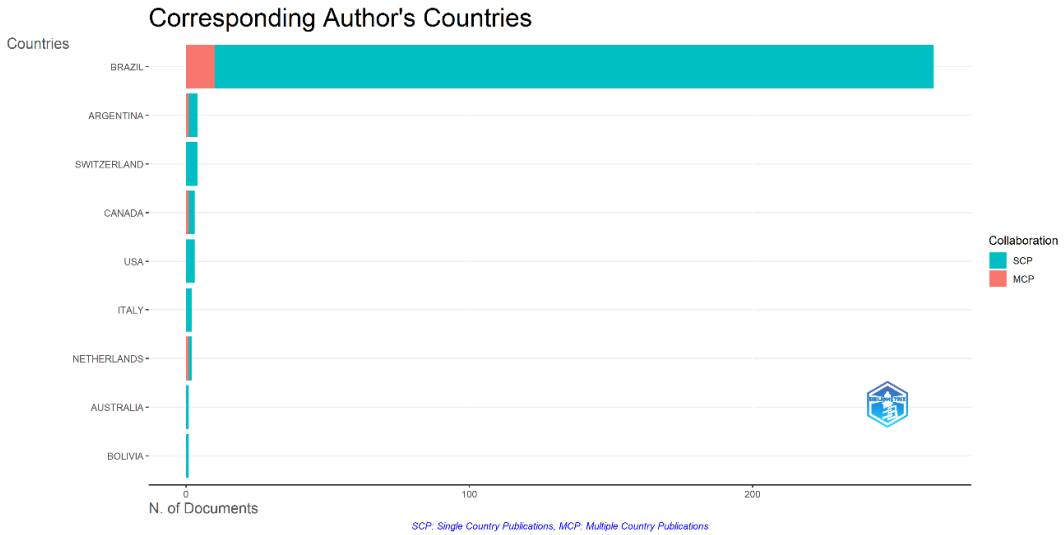

Figure 9. Publications by Country and Collaboration Type (SCP/MCP).

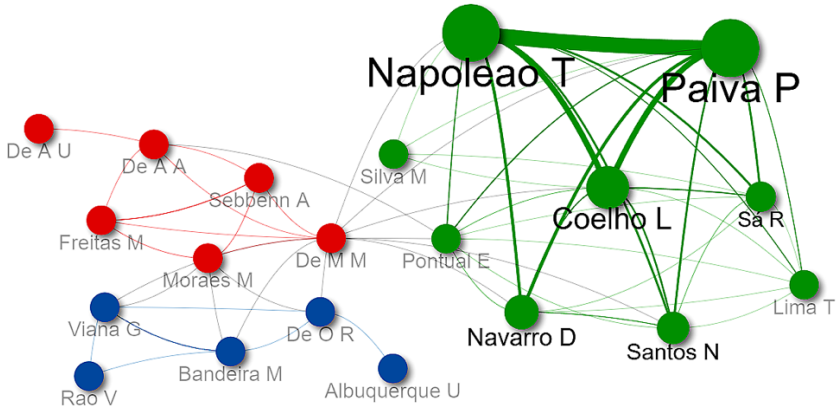

Figure 10. Intercountry collaboration network.

Key authors and their affiliations

The co-citation network analysis revealed a central core of prominent researchers in the study of *M. urundeuva* , including authors such as Napoleão T, Paiva P, and Coelho L (Figure 11). These researchers exhibit a high number of citations and strong interconnectivity, indicating intellectual leadership and establishing them as key references in the field (Figure 11 and Figure 12). In addition to their bibliometric prominence, several of these authors have contributed to studies that rely on accurate botanical identification and voucher-supported specimens, reinforcing the taxonomic reliability underlying research on this species.

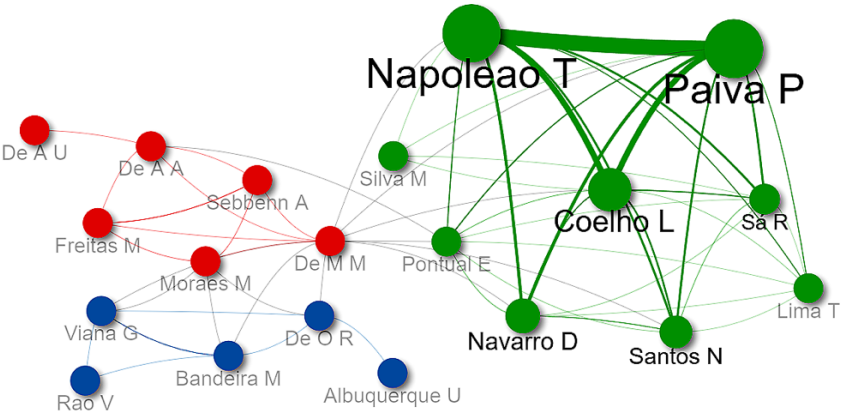

Figure 11. Co-authorship network highlighting major research clusters on *Myracrodruon urundeuva*.

Beyond the main core, secondary clusters are observed, reflecting different levels of visibility and collaboration. An intermediate group includes researchers such as De M M, Sebbenn A, and Freitas M, who show moderate co-citations, suggesting more restricted interactions or lower visibility in the literature. Secondary and peripheral clusters reflect specialized or emerging contributions, highlighting complementary research pathways. The pioneering work of Glauce Viana and Vietla Rao established the pharmacological and ethnopharmacological foundations for the study of *Myracrodruon urundeuva*, validating traditional uses and identifying bioactive compounds. Their contributions have strongly influenced the central researchers in the network, demonstrating both the continuity and historical impact of research in this field.

Professor Glauce Socorro de Barros Viana is recognized for her contributions to the pharmacological investigation of Brazilian medicinal plants. She has played a key role in advancing pharmacognosy and phytotherapy research, mentoring new researchers, and integrating her work within prominent research groups at the Federal University of Ceará. Her scientific impact has been acknowledged through multiple awards such as the Medal of Scientific Merit Prof. Abreu Matos, highlighting her prominence in the field (Bandeira *et al*. 2024).

Professor Vietla S. Rao (deceased) made significant contributions to ethnopharmacology, particularly regarding medicinal plants from Brazil's North and Northeast regions. His research on **aroeira-do-sertão** demonstrated its antiulcerogenic potential, scientifically validating traditional uses and its bioactive compounds, reinforcing the international recognition of Brazilian natural products (Santos *et al*. 2021).

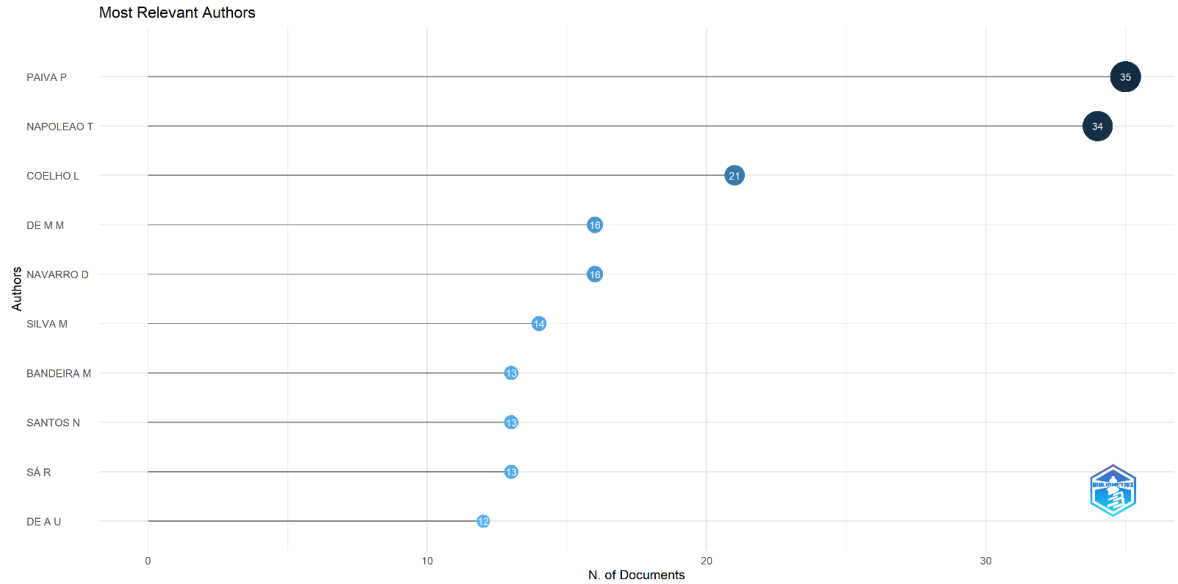

Figure 12. Author contribution in terms of number of documents.

The network graph (Figure 13) illustrates the institutional collaborations and affiliations that contribute most to the scientific production on *M. urundeuva*. The size of each node represents the number of publications, while the thickness of the connecting lines indicates the intensity of collaborative efforts between institutions. It is evident that the Federal University of Pernambuco (UFPE) and the Federal Rural University of Pernambuco (UFRPE) occupy central positions within the network, reflecting both a high volume of publications and strong collaborative ties. Other prominent institutions, such as the Federal University of Ceará (UFC) and the Federal University of Piauí (UFPI), also show considerable connectivity, highlighting the regional concentration of research on this species in northeastern Brazil. This centrality is largely driven by UFPE's robust graduate programs and long-standing research groups in ethnobotany, pharmacology and phytochemistry, which sustain high productivity and attract regional collaborations. Its strong connections with institutions such as UFPI, UFRN, and UFC further reinforce a cohesive research network that enhances the scientific output on Caatinga medicinal plants (Silva *et al*. 2025).

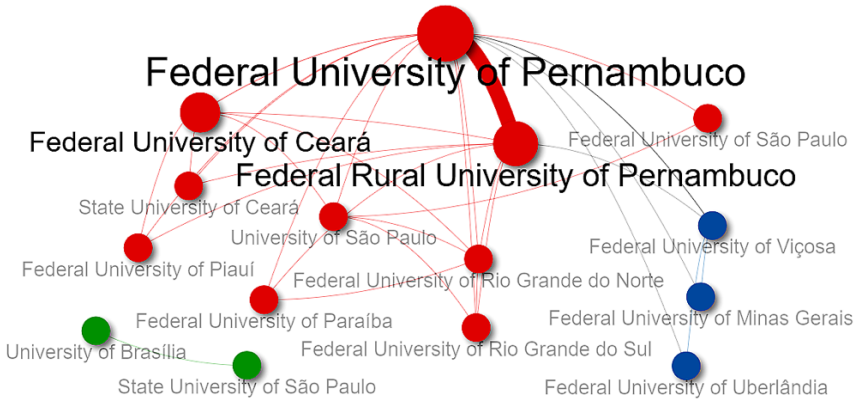

Figure 13. Institutional Collaboration Network on *Myracrodruon urundeuva*.

The network also reveals distinct clusters of collaboration. One cluster, marked in red, shows dense interactions among northeastern universities, suggesting a consolidated regional research network. Another cluster, in blue, shows collaborations among southeastern institutions, such as the Federal Universities of Minas Gerais, Viçosa, and Uberlândia, albeit with fewer links to the main network. Additionally, a smaller green cluster indicates partnerships between the University of Brasília and state universities in São Paulo, pointing to more isolated but productive research efforts. Overall, the graph highlights not only which institutions lead the research on *M. urundeuva,* but also how collaborative patterns shape knowledge dissemination. These informations can inform potential partnerships, identify gaps in the research network, and guide strategic efforts to strengthen scientific cooperation on the phytochemistry and medicinal properties of this species.

Applications in Agriculture, Health, and Biotechnology

Aroeira-do-sertão exhibits translational potential across multiple application areas, ranging from agriculture to human and animal health. In agriculture, the species can be used for sustainable management, reforestation, and conservation of the Caatinga biome, as well as for the development of natural products with repellent or antifungal activity, contributing to crop protection and reducing reliance on chemical pesticides (da Costa et al. 2025, Silva et al. 2020, Lima et al. 2017, Sousa et al. 2022). In the context of crop protection, extracts from *M. urundeuva* wood, particularly saline extracts rich in lectins, have demonstrated potent termiticidal activity and protective effects on seeds, offering an eco-friendly alternative for the management of storage pests such as Nasutitermes corniger, thereby reducing post-harvest losses and chemical pesticide use (Sá et al. 2009).

In human and animal health, bioactive compounds such as tannins, flavonoids, and sesquiterpenes display anti-inflammatory, antimicrobial, antioxidant, and wound-healing properties, highlighting their potential for the development of phytotherapeutics, cosmetics, nutraceuticals, adjuvant therapies, and functional supplements for both humans and animals (de Almeida-Apolonio *et al*. 2020, Bonifácio *et al*. 2024, Botelho *et al*. 2007, Diógenes *et al*. 2023, Krüger *et al*. 2022). The gastroprotective effects of its chalcones and tannins are well-documented, offering an alternative for treating gastric ulcers with fewer side effects than conventional drugs (Aguiar Galvão *et al*. 2018, Souza *et al*. 2007, Carlini *et al*. 2010).

The anti-inflammatory effects of the species are strongly supported by mechanistic and experimental evidence (Viana & Calou 2019). Its chalcones and tannin-rich extracts modulate key inflammatory pathways by reducing myeloperoxidase (MPO) activity and downregulating the expression of iNOS, COX-2, and TNF-α, thereby attenuating the classical cascade of inflammatory mediators. These compounds also inhibit NF-κB activation and decrease the expression of histone deacetylases (HDACs), contributing to both transcriptional and epigenetic control of inflammation (Viana & Calou 2019). In vivo studies further demonstrate significant reductions in peripheral inflammation, allergic responses, colitis, and ulcerative lesions, while isolated chalcones exhibit marked anti-inflammatory activity in ocular allergy models (Viana & Calou 2019).

Furthermore, investigations into its neuroprotective potential suggest that its antioxidant compounds may mitigate oxidative stress in neuronal cells, opening new avenues for research into neurodegenerative diseases (Calou *et al*. 2014). Specifically, chalcones isolated from the enriched fraction of *M. urundeuva* exert neuroprotective effects by neutralizing reactive oxygen species, reducing nitric oxide production, and preventing apoptosis in dopaminergic neurons, thereby preserving mitochondrial function (Nobre-Júnior *et al*. 2009).

In addition, the translational potential of *M. urundeuva* is particularly relevant to women's health. Both preclinical and clinical studies support the therapeutic potential of tannin-enriched fractions in controlling bacterial pathogens implicated in vaginosis and cervical vaginitis (Bonifácio *et al*. 2019, de Oliveira *et al*. 2017). These preparations likely act through a combined antimicrobial, astringent, and anti-inflammatory mechanisms. The antimicrobial activity inhibits pathogens such as Candida albicans, while the astringent and anti-inflammatory effects of tannins support mucosal re-epithelialization and tissue repair (Ribeiro *et al*. 2024).

In biological and applied sciences, phytochemical characterization, experimental pharmacology, and preclinical studies enable the discovery of novel bioactive compounds, validation of traditional uses, and the development of innovative technologies, including nanoformulations, controlled-release systems, and standardized bioproducts (Machado *et al*. 2021, Teixeira *et al*. 2020). In parallel, recent evidence shows that oxidative processes can markedly influence the biological performance of *M. urundeuva* extracts: while moderate oxidation may generate derivatives with enhanced antimicrobial activity at specific concentrations and time points, prolonged oxidation can lead to degradation of key phenolic constituents and a consequent reduction in efficacy (França & Marques 2024). This evidence elucidates the importance of understanding stability, storage conditions, and chemical transformation pathways to optimize extract performance in pharmacological and biotechnological applications.

The aqueous leaf extract of *M. urundeuva* exhibits strong skin-lightening potential by inhibiting tyrosinase through substrate competition and copper chelation, reaching 83.76% inhibition at 2000 µg/mL (Diógenes *et al*. 2023). It also shows relevant antioxidant activity, reducing DPPH radicals by 76.46% and limiting hydroxyl-radical formation. These properties indicate that the **aroeira-do-sertão** is a promising multifunctional ingredient for cosmetic formulations aimed at skin brightening and protection against oxidative damage (Diógenes *et al*. 2023).

Beyond cosmetic applications, the species shows particular promise for the development of phytotherapeutic products in dentistry, as dimers of chalcones (urundeuvin A-C and matosine) exhibit antimicrobial activity against oral pathogens such as Streptococcus mutans, inhibit biofilm formation, and promote tissue healing (Machado & Oliveira 2014).

In this context, the field of biotechnology further expands these opportunities through the production of extracts with enhanced bioactive content, cell culture applications, enzyme bioprospecting, and process optimization for industrial use (Silva *et al*. 2021, Riva *et al*. 2020, de Pádua *et al*. 2019, Moura *et al*. 2021, Oliveira 2012). However, due to anthropogenic pressure and the risk of species extinction, some studies have prioritized the use of adult plant leaves or extracts obtained from shoots to avoid further damage to mature trees (Rodrigues *et al*. 2025, Aguiar Galvão *et al*. 2018). In Brazil, the development of antimicrobial products based on *M. urundeuva* presents translational potential, yet remains largely underexplored at the industrial level. Despite extensive pharmacological evidence supporting its antibacterial, anti-inflammatory, and wound-healing properties, few patents and commercial initiatives have been reported nationally (Sousa *et al*. 2021).

In food technology, plant extracts and bioactive compounds can be incorporated into functional foods, natural preservatives, or nutraceutical ingredients, leveraging their antioxidant and antimicrobial properties to promote innovation in sustainable, value-added products (Montanari *et al*. 2012, Santos-Filho *et al*. 2025, Eliane *et al*. 2018, Lopes Gomes *et al*. 2013, Moreira *et al*. 2018).

Overall, the integration of ethnopharmacological, chemical, and experimental knowledge of **aroeira-do-sertão** underscores its scientific translational potential, product development opportunities, and applicability across multiple biotechnological and pharmaceutical sectors.

Conclusion

This bibliometric study provides a comprehensive, integrative overview of nearly four decades of scientific research on *Myracrodruon urundeuva*, revealing a progressive expansion and diversification of knowledge surrounding this native Brazilian species. The analysis demonstrates a clear evolution from early ethnobotanical and ecological investigations toward more complex experimental, pharmacological, and biotechnological approaches, reflecting the maturation of the field and its increasing scientific relevance.

The results highlight Brazil as the central hub of scientific production focusing on **aroeira-do-sertão**, a pattern strongly linked to the species' geographic distribution, traditional use, and inclusion in national public health and biodiversity policies. Despite the high volume of national publications, international collaboration remains limited, indicating a significant opportunity to strengthen transnational research networks, particularly in areas related to natural product chemistry, biotechnology, conservation science, and translational pharmacology.

Thematic analyses reveal that research on **aroeira** is inherently multidisciplinary, encompassing phytochemistry, pharmacology, ecology, forestry, and biotechnology. The prominence of keywords related to bioactive compounds, antimicrobial and anti-inflammatory activities, and traditional medicine underscores the strong translational potential of the species, while the growing emphasis on conservation, genetic diversity, and sustainable use reflects increasing environmental awareness and regulatory alignment.

Journal co-citation and collaboration network analyses further demonstrate the strategic role of both international journals and regional Brazilian publications in disseminating research on the species. Together, these outlets form a complementary ecosystem that enhances scientific visibility, consolidates knowledge, and applied research linked to biodiversity valorization.

From an applied perspective, the accumulated scientific evidence positions as a promising biological resource for agriculture, health, food technology, and biotechnology. However, the relatively low number of industrial applications, patents, and large-scale technological developments highlights a persistent gap between academic research and innovation-driven applications. Bridging this gap will require coordinated efforts involving academia, industry, and regulatory agencies, alongside sustainable management strategies that mitigate anthropogenic pressures on natural populations.

Overall, this bibliometric analysis not only consolidates dispersed scientific knowledge on the species but also identifies research trends, gaps, and opportunities. By mapping the intellectual structure and evolution of the field, this study

contributes to a more strategic understanding of **aroeira-do-sertão** as a key species for biodiversity-based innovation, conservation planning, and sustainable development in Brazil.

Declarations

List of abbreviations: ANVISA - Brazilian Health Regulatory Agency; CEME - Central Agency for Medicines; COVID-19 - Coronavirus Disease 2019; COX-2 – Cyclooxygenase-2; DE - Author's Keywords; ID - Keywords Plus; DPPH - 2,2-diphenyl-1-picrylhydrazyl; HDACs - Histone Deacetylases; iNOS - inducible Nitric Oxide Synthase; JEP - Journal of Ethnopharmacology; MCP - Multiple Country Publication; MPO - Myeloperoxidase; NF-κB - Nuclear Factor kappa B; PNPMF - National Policy on Medicinal Plants and Herbal Medicines; RDC - Collegiate Board Resolution; RENISUS - National List of Medicinal Plants of Interest to the Brazilian Unified Health System; REPLAME - State List of Medicinal Plants of Ceará; SCP - Single Country Publication. SUS - Brazilian Unified Health System; TC - Total Citations; TNF-α - Tumor Necrosis Factor-alpha; UFC - Federal University of Ceará; UFPE - Federal University of Pernambuco; UFRPE - Federal Rural University of Pernambuco; UFPI - Federal University of Piauí; UFRN - Federal University of Rio Grande do Norte.

Ethics approval and consent to participate: Not applicable.

Consent for publication: Not applicable

Availability of data and materials: The bibliometric dataset generated and analyzed during the current study is available as a Supplementary File in CSV format, containing the raw data.

Competing interests: Not applicable.

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Author contributions: R.B.V. conceptualized the study, curated the data, performed formal analysis, and wrote the original draft. I.L.S. designed the methodology, conducted formal analysis, created visualizations, and wrote the original draft. L.P.L. curated the data, performed formal analysis, and wrote the original draft. W.A.S. created visualizations, wrote the original draft, and reviewed and edited the manuscript. R.B.V.M. wrote the original draft and reviewed and edited the manuscript. É.L.C.-F. designed the methodology, created visualizations, and curated the data. R.J.F. performed formal analysis and created visualizations. F.A.S.L.-J. designed the methodology and reviewed and edited the manuscript. P.G.B.S. supervised the study, wrote the original draft, and reviewed and edited the manuscript. M.A.M.B. supervised the study, conceptualized the project, provided resources, and reviewed and edited the manuscript.

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