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Research Article

South Africa's Highly Cited Research on Medicinal Plants: A Scientometric Exploration of Impact and Innovation

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ABSTRACT

Background and Aim: This bibliometric study investigated High-impact Publications (HCPs) in South Africa's Medicinal Plants research from 2021 to 2025. The primary aim is to map the scholarly landscape by identifying influential works, key authors, institutions, and emerging trends in the literature, highlighting medicinal plants. **Methodology:** This bibliometric analysis, a systematic search was extracted on Elsevier's Scopus database, on 13, March 2025, to retrieve relevant data from 2021 to 2025. A total of 5,386 publication records were related to research on medicinal plants in Africa. These publications were sorted by the citations they received since their publication. Out of 5386 publications by Africa, only 62 publications were found to have received 100 to 2034 citations per paper. These 62 publications are presumed as HCs for this study. The data so collected was documented, tabulated, and analyzed using Microsoft Excel. VOSviewer and R Studio software were utilized for network visualization. **Results:** These publications were sorted by the citations they received since their publication. Out of 5386 publications by Africa, only 62 publications were found to have received 100 to 2034 citations per paper. These 62 publications are presumed as HCs for this study. This study reveals that high-impact publications, extensive international collaboration, and a strong preference for review articles characterize South African research on medicinal plants. **Conclusion:** This research provides a comprehensive overview of influential works and their contributions to the understanding of medicinal plants. It establishes a foundation for future study and underscores the critical need for ongoing investigation in this area to improve patient management and outcomes.

Keywords: Medicinal Plants, Bibliometrics study, VOSviewer, South Africa, Highly cited publications.

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INTRODUCTION

Medicinal plants have been an integral part of traditional healthcare systems across the globe, and South Africa is recognized as one of the most biodiverse regions contributing significantly to ethnomedicine and phytotherapy (Iwu 2014). The country's rich flora, comprising approximately 30,000 plant species, has been extensively studied for its pharmacological properties, leading to numerous scientific publications. In recent years, research on South African medicinal plants has gained global recognition, with several studies achieving high citation counts, reflecting their impact on the scientific community. Highly cited papers serve as indicators of influential research, showcasing key discoveries, methodologies, and advancements in the field (Gupta, Mueen Ahmed, and Gupta 2018; Senthamilselvi *et al.*, 2021). The present study aims to conduct a scientometric analysis of South Africa's highly cited papers on medicinal plants, examining their research trends, growth patterns, and academic influence. By employing bibliometric techniques, this study identifies the most impactful publications, prolific authors, leading institutions, and dominant research themes. Citation analysis provides insights into the intellectual structure of the field, revealing collaborative networks, interdisciplinary approaches, and the evolution of research topics over time. Moreover, the study explores the contribution of South African researchers to global medicinal plant research, highlighting their role in drug discovery, phytochemical analysis, and therapeutic applications (Alarcon-Ruiz *et al.*, 2023; Gupta *et al.*, 2018; Senthamilselvi *et al.*, 2021). Understanding the landscape of highly cited publications in this domain is crucial for researchers, policymakers, and funding agencies. It helps in recognizing key research gaps, fostering international collaborations, and directing future research efforts toward high-impact areas such as novel drug development, sustainable harvesting practices, and the conservation of medicinal plant biodiversity (Córdoba-Tovar *et al.*, 2023; Sivasekaran, 2021; Iwu 2014; Rohit 2022; Williams, Victor, and Crouch 2013). Additionally, this study contributes to

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the broader discourse on knowledge dissemination and scientific influence, providing valuable insights into how South Africa's medicinal plant research has shaped global pharmacological advancements. By shedding light on the bibliometric characteristics of highly cited papers, this study paves the way for future research trajectories. It strengthens the role of South African scholars in the global scientific landscape.

Reviews of related literature

Here are some relevant literature reviews and studies on South Africa's highly cited research on medicinal plants, focusing on scientometric analyses of impact and innovation:

(Bolshakov 2021) conducted a bibliometric analysis of the top 100 most cited articles on African medicinal plants. It identified prolific authors, leading journals, and active institutions, highlighting South Africa's significant contribution to this research field. The analysis also emphasized the need for increased international collaboration to enhance research impact.

(Masondo and Makunga 2019) review discusses the advancements in analytical technologies used for standardizing and authenticating commercialized natural products derived from South African medicinal plants. It underscores the importance of high-throughput analytical techniques in ensuring the safety and efficacy of herbal medicines and highlights the role of these methods in drug discovery and development.

(Madonsela *et al.*, 2024) scientometric analysis examines the trends, productivity, and collaboration patterns in South African medical research over three decades. It provides insights into the growth of scientific publications in medicine, including medicinal plant research, and emphasizes the importance of partnerships in enhancing research output and impact.

These studies offer comprehensive insights into the impact and innovation of South Africa's research on medicinal plants through scientometric analyses (Sooryamoorthy 2010).

Objectives of the Study

To analyze the publication trends of highly cited research on medicinal plants in South Africa over a specific period.

To identify the most prolific authors, institutions, and countries collaborating in this field.

To evaluate the impact of research outputs by assessing citation patterns, *h*-index, and other bibliometric indicators.

To determine the leading journals and publishers contributing to South Africa's highly cited medicinal plant research.

To map research collaborations and co-authorship networks at national and international levels.

To assess keyword trends and thematic evolution in South Africa's medicinal plant research.

To explore the role of funding agencies and their contributions to the advancement of this field.

To analyze the influence of medicinal plant research on innovation, patents, and commercialization.

To compare South Africa's research output and impact with other leading countries in medicinal plant studies.

To provide recommendations for future research directions and policy implications based on scientometric findings.

These objectives will help comprehensively assess South Africa's contribution to global medicinal plant research and its influence on scientific and industrial innovations. Analysis:

METHODOLOGY

This bibliometric analysis, a systematic search was extracted on Elsevier's Scopus database, on 13, March 2025, to retrieve relevant data from 2021 to 2025. The research strategy employed the keyword for Medicinal plants-related keywords co-joined with the TITLE-ABS-KEY tag, coupled with affiliation tag (for limiting the country search only to Africa), and data range tag limited to 2021 to 2025. The Scopus database retrieved a total of 5386 publication records related to Medicinal Plants research in Africa. These publications were sorted by the citations they received since their publication. Out of 5386 publications by Africa, only 62 publications were found to have received 100 to 2034 citations per paper. These 62 publications are presumed as HCPs for this study. Their meta-data records were organized and all information related to contributing authors, organizations, subject categories, research collaboration, funding, and keywords was downloaded. Furthermore, these 62 HCPs were sorted by document type, source type, affiliating, organizations, research authors and their affiliations, source journals for research publication, and keywords. No restrictions were applied to loading records by document type, publication source, and language. The data so collected was documented, tabulated, and analyzed using Microsoft Excel. VOSviewer and R Studio software were utilized for network visualization of participating countries, organizations, authors, and keywords used. The study applied select bibliometric indicates for measuring the publication performance of African Medicinal Plants research. The search strategy of this study was as follows: TITLE-ABS-KEY ("medicinal AND plants AND (LIMIT-TO (PUBYEAR, 2021) OR LIMIT-TO (PUBYEAR, 2022) OR LIMIT-TO (PUBYEAR, 2023) OR LIMIT-TO (PUBYEAR, 2024) OR LIMIT-TO (PUBYEAR, 2025)) AND (LIMIT-TO (AFFILCOUNTRY, "South Africa")).

RESULTS

This analysis reveals that high-impact publications, extensive international collaboration, and a strong preference for review articles characterize South African research on medicinal plants. The decline in publication growth requires further investigation

Table 1: Main information about the collection of the 100 most cited articles on African medicinal plant research between 2021 and 2024.

Description	Results
Main Information about Data	
Timespan	2021:2024
Sources (Journals, Books, etc.,)	54
Documents	62
Annual Growth Rate %	-48.33
Document Average Age	3.18
Average citations per doc	246.3
References	0
Document Contents	
Keywords Plus (ID)	1448
Author's Keywords (DE)	229
Authors	
Authors	6201
Authors of single-authored docs	2
Authors Collaboration	
Single-authored docs	2
Co-Authors per Doc	138
International co-authorships %	82.26
Document Types	
Article	21
Book chapter	1
Review	40

to understand potential challenges in research output. However, the high citation count per document reflects the significance of this research in the global scientific community. Future studies could explore the evolution of research themes, key contributing institutions, and the practical applications of these highly cited papers in medicine, pharmaceuticals, and conservation efforts.

Main Information about the data collection

Table 1 illustrates that South Africa's highly cited papers on medicinal plants (2021-2024) reveal 62 documents across 54 sources, with a high impact (246.3 citations per document) but a declining annual growth rate (-48.33%). The research is highly collaborative, with 6201 authors and 82.26% international co-authorship. Review articles (40) dominate, indicating knowledge consolidation, while research articles (21) and a book chapter (1) are less frequent. The high citation rate underscores the field's global influence, though the decline in publication growth suggests challenges that require further investigation.

Top 25 highly cited publications

Table 2 presents a bibliometric analysis of highly cited papers across various journals. ZHOU B (2021, Lancet) leads with 2036 citations, the highest total, followed by KLIONSKY DJ (2021, Autophagy) with 1700. WELSH JA (2024, J Extracell Vesicles) has the highest TC per year (442.00), indicating recent high-impact research. The Normalized TC metric, which adjusts for citation distribution, is highest for ZHOU B (7.09) and WILKINSON JL (4.41, 2022, PNAS), showing strong relative influence.

Highly impactful Journals

Figure 1 shows that the Highly Cited Papers in high-impact journals like Lancet, Nature Biotechnology, and PNAS dominate the list, suggesting a focus on medical and biological sciences. International collaboration is evident, with articles spanning disciplines such as nanomedicine, food science, environmental research, and molecular sciences.

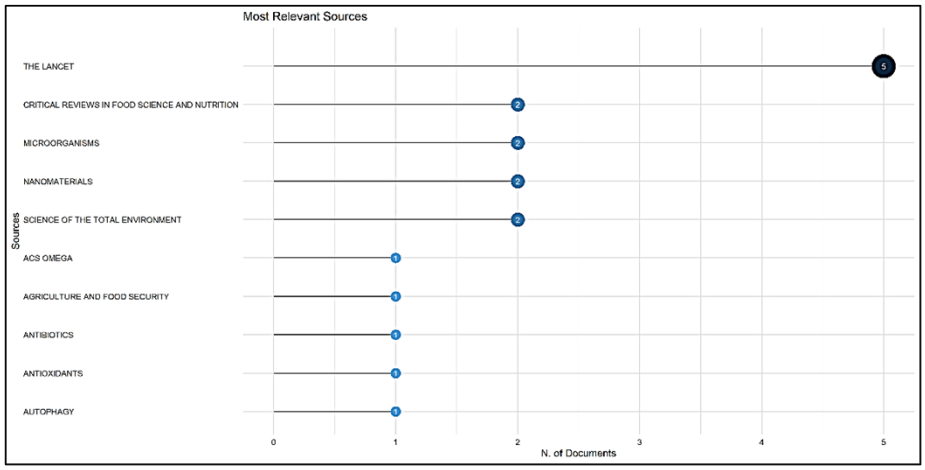

Figure 1: Highly impactful journals.

Table 2: Details of highly cited publications.

Paper	DOI	Total Citations	TC per Year	Normalized TC
ZHOU B, 2021, LANCET	10.1016/S0140-6736(21)01330-1	2036	407.20	7.09
KLIONSKY DJ, 2021, AUTOPHAGY	10.1080/15548627.2020.1797280	1700	340.00	5.92
WELSH JA, 2024, J EXTRACELL VESICLES	10.1002/jev2.12404	884	442.00	2.21
WILKINSON JL, 2022, PROC NATL ACAD SCI U S A	10.1073/pnas.2113947119	845	211.25	4.41
NAYFACH S, 2021, NAT BIOTECHNOL	10.1038/s41587-020-0718-6	443	88.60	1.54
NAGHAVI M, 2024, LANCET	10.1016/S0140-6736(24)00367-2	405	202.50	1.01
SEKHOACHA M, 2022, MOLECULES	10.3390/molecules27175730	366	91.50	1.91
MENSAH GA, 2023, J AM COLL CARDIOL	10.1016/j.jacc.2023.11.007	362	120.67	2.12
SABE VT, 2021, EUR J MED CHEM	10.1016/j.ejmech.2021.113705	352	70.40	1.23
BRYAZKA D, 2022, LANCET	10.1016/S0140-6736(22)00847-9	291	72.75	1.52
TRISOS CH, 2021, NAT ECOL EVOL	10.1038/s41559-021-01460-w	282	56.40	0.98
VERMA C, 2021, MATER ADV	10.1039/d0ma00681e	251	50.20	0.87
BITWELL C, 2023, SCI AFRICAN	10.1016/j.sciaf.2023.e01585	250	83.33	1.46
PICOT-ALLAIN C, 2021, CURR OPIN FOOD SCI	10.1016/j.cofs.2021.02.009	234	46.80	0.82
ZARE H, 2021, INT J NANOMED	10.2147/IJN.S299448	215	43.00	0.75
HAJ-AMOR Z, 2022, SCI TOTAL ENVIRON	10.1016/j.scitotenv.2022.156946	206	51.50	1.08
SCHUMACHER AE, 2024, LANCET	10.1016/S0140-6736(24)00476-8	206	103.00	0.52
EL-SABER BATIHA G, 2021, FOOD CONTROL	10.1016/j.foodcont.2021.108066	204	40.80	0.71
TERLOUW BR, 2023, NUCLEIC ACIDS RES	10.1093/nar/gkac1049	198	66.00	1.16
BHATWALKAR SB, 2021, FRONT MICROBIOL	10.3389/fmicb.2021.613077	197	39.40	0.69
JIDEANI AIO, 2021, INT J FOOD PROP	10.1080/10942912.2020.1866597	180	36.00	0.63
HASSAN ZM, 2021, AGRIC FOOD SECUR	10.1186/s40066-020-00282-6	178	35.60	0.62
GEORGE BP, 2021, ANTIOXIDANTS	10.3390/antiox10091455	176	35.20	0.61
LEYANE TS, 2022, INT J MOL SCI	10.3390/ijms23137273	175	43.75	0.91
DESNEUX N, 2022, J PEST SCI	10.1007/s10340-021-01442-8	172	43.00	0.90

The distribution of TC per year reveals that recent publications (e.g., 2024 papers) receive citations more quickly, reflecting trending research areas. Some papers, despite high total citations, have lower normalized TC values, implying field-dependent citation variations.

This data highlights key contributors, influential research areas, and citation dynamics, offering valuable insights for future research focus and scholarly impact.

Top most highly productive institutions

The figure represents a collaborative network visualization of research institutions using VOSviewer. Each node in the network corresponds to a university or research institution, and the size of the node represents the prominence of the institution in terms of collaborative research output. The connections (edges) between nodes indicate collaborative relationships between institutions, with the thickness of the edges reflecting the strength of these collaborations. The color-coding groups' institutions into clusters based on their research collaborations.

Figure 2 represents the most relevant affiliations based on the number of published articles. Tehran University of Medical Sciences leads with 32 articles, followed closely by the University of Washington with 31 articles, indicating their significant contributions to research in this domain. Other major contributors include the DOE Joint Genome Institute and the University of California, each with 25 articles, reflecting their strong research output. Wageningen University (21 articles) and Imperial College London (20 articles) also show notable contributions, emphasizing their engagement in high-impact research. Further down the list, the University of Oxford (16 articles), University of Johannesburg (14 articles), All India Institute of Medical Sciences (13 articles), and Bahir Dar University (13 articles) have made considerable contributions, indicating a diverse geographical representation in research activities. This distribution highlights the dominance

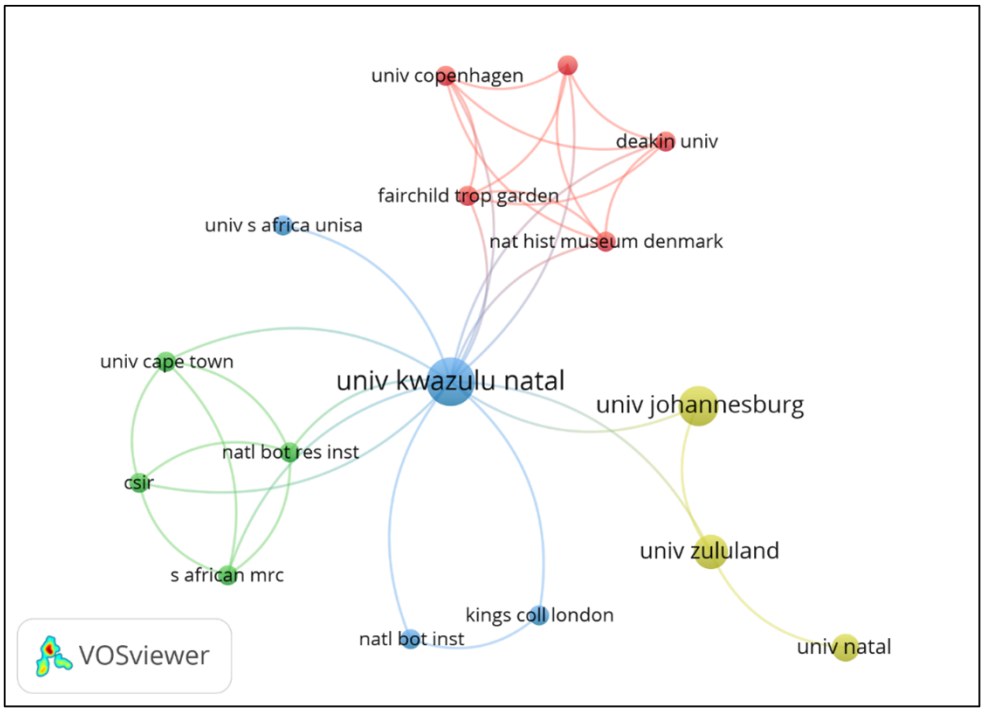

Figure 2: Visualization of highly productive institutions.

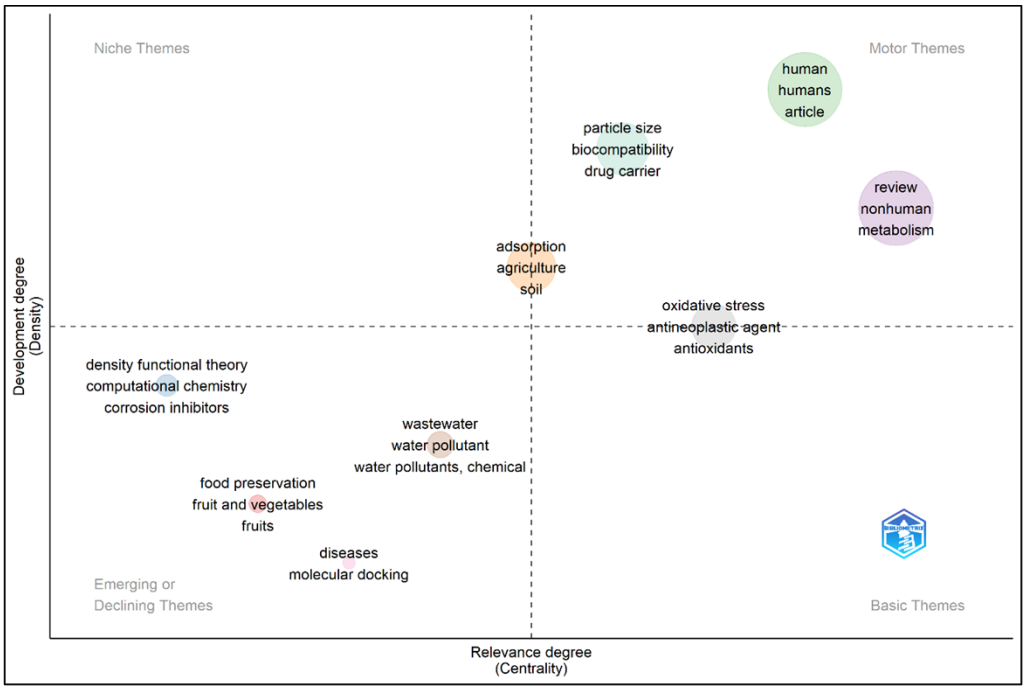

Figure 3: Thematic map of South Africa's medicinal plants.

of medical, genomic, and multidisciplinary research institutions while also showcasing international participation. The variation in article counts suggests different levels of research engagement and specialization among these institutions.

Thematic Keyword sources

Figure 3, Thematic map provides a bibliometric analysis of research trends by categorizing topics based on their relevance (centrality) and development (density). The upper-right quadrant (Motor Themes) contains well-developed and highly relevant topics, such as "human," "humans," "article," "review," "nonhuman," and "metabolism", indicating their critical role in the research field. Additionally, terms like "particle size," "biocompatibility," and "drug carrier" suggest significant advancements in biomedical and pharmaceutical studies. The lower-right quadrant (Basic Themes) includes foundational research topics with high

Figure 4: World cloud.

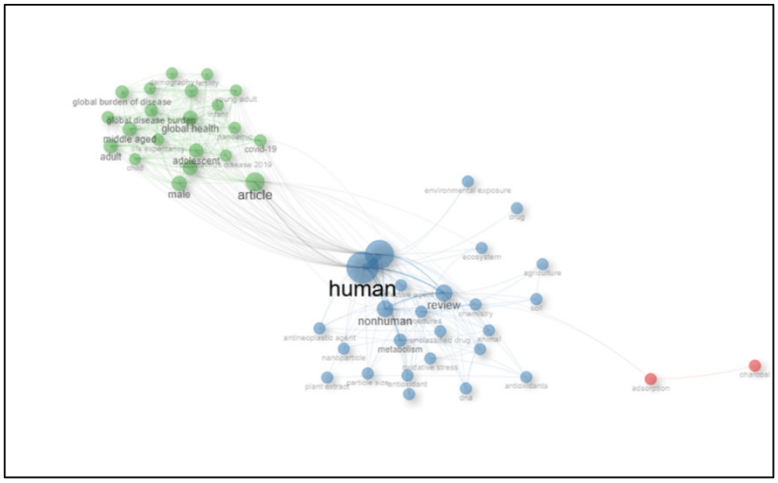

Figure 5: Keyword clusters.

relevance but lower development, such as "oxidative stress," "antineoplastic agent," and "antioxidants," which are crucial in medical and biochemical research. The upper-left quadrant (Niche Themes) consists of highly specialized topics with strong internal development but lower centrality, including "adsorption," "agriculture," and "soil," implying focused studies in environmental science and sustainable agriculture. Lastly, the lower-left quadrant (Emerging or Declining Themes) features less-developed and less central topics like "density functional theory," "computational chemistry," "corrosion inhibitors," and "molecular docking," which may be emerging trends or areas losing research momentum. Overall, the thematic map effectively highlights the structure of research within the field, showing dominant, emerging, and peripheral themes.

Significant keywords

Figures 4 and 5 show the word cloud and keyword cluster visually represent the most frequently occurring terms in a research dataset, highlighting key themes and trends. The most prominent words, such as "human," "humans," "nonhuman," "global health," "review," and "article," suggest a strong emphasis on health-related studies, particularly those involving human and nonhuman subjects. Other significant terms like "metabolism," "oxidative stress," "antioxidant," and "antineoplastic agent" indicate a focus on biochemical and medical research, possibly in areas related to disease treatment and prevention. The presence of terms such as "pandemic," "COVID-19," "global burden of disease," and "mortality" points to public health concerns and epidemiological studies. Additionally, words like "particle size," "nanoparticle," "adsorption," and "agriculture" suggest research in environmental science, materials science, and their applications in health. The inclusion of demographic terms such as "female," "male," "middle-aged," "adolescent," "child," and "young adult" indicates that studies often focus on different population groups. Overall, the word cloud illustrates a multidisciplinary research landscape, with major themes in human health, disease prevention, environmental exposure, and material science applications.

The network visualization presented in Figure 6, generated using VOSviewer, illustrates the co-occurrence relationships among

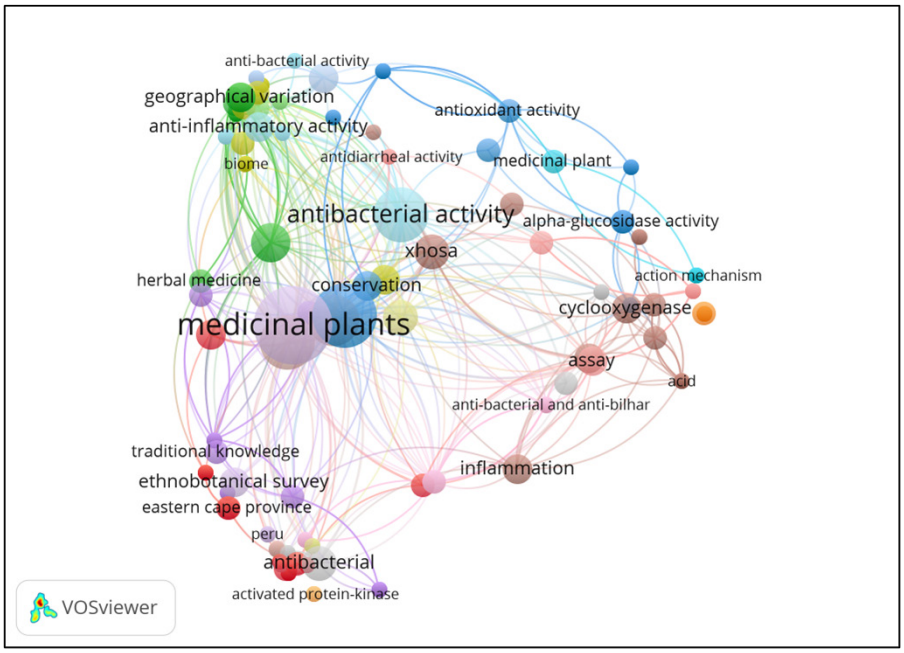

Figure 6: Visualization of highly significant keywords.

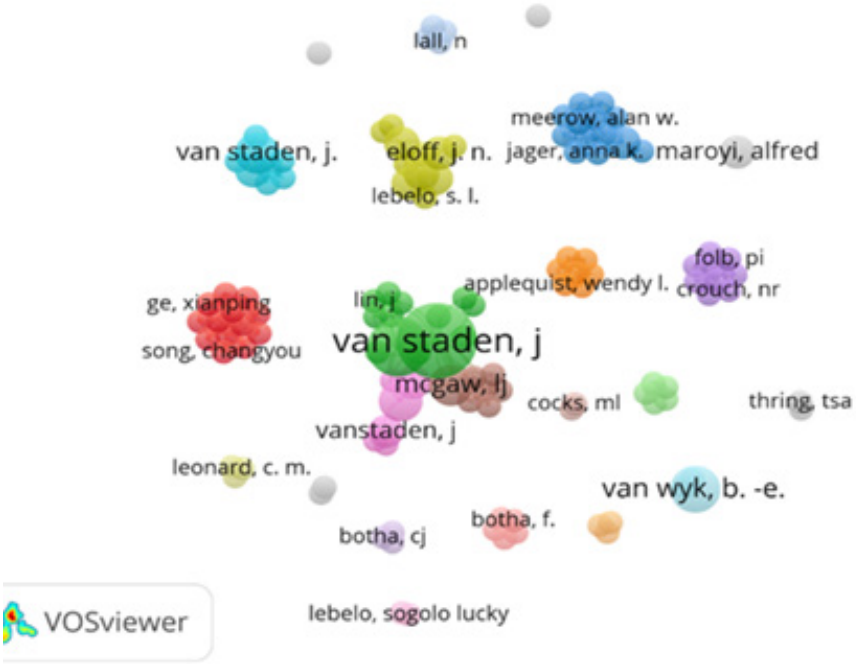

Figure 7: Visualization network of co-authorship map.

key terms in the research domain of medicinal plants. The largest and most central cluster revolves around "medicinal plants," "antibacterial activity," and "antioxidant activity," indicating a strong focus on the biological properties and therapeutic potential of these plants. Various interconnected clusters highlight different aspects of medicinal plant research, such as "ethnobotanical survey," "herbal medicine," and "traditional knowledge," suggesting a significant interest in indigenous and traditional medicinal practices.

Additionally, the terms "anti-inflammatory activity," "cyclooxygenase," and "action mechanism" indicate pharmacological studies exploring the biochemical pathways involved in medicinal plant efficacy. The presence of keywords such as "geographical variation," "conservation," and "biome" suggests an ecological and sustainability perspective, emphasizing the importance of preserving medicinal plant diversity. The "assay" and "alpha-glucosidase activity" terms reflect experimental approaches and potential applications in

drug discovery, particularly for conditions like diabetes and inflammation-related disorders.

Overall, this visualization underscores the interdisciplinary nature of medicinal plant research, integrating pharmacology, ethnobotany, environmental science, and biotechnology. The intricate connections between terms reveal a well-developed research landscape, with a primary emphasis on antibacterial, antioxidant, and anti-inflammatory properties, alongside efforts to document and conserve traditional knowledge and biodiversity.

Top Most Productive Authors

Figure 7 is co-authorship network visualization generated using VOSviewer, illustrating the collaborative relationships between researchers in a particular academic field. The network consists of clusters of authors represented by nodes, where the size of each node indicates the number of publications or citations associated with that author. The lines (or edges) between nodes represent co-authorship links, and clusters are color-coded to indicate groups of researchers who frequently collaborate.

At the centre of the network, "van Staden, J." appears as the most prominent author, indicating a leading researcher in the field with extensive collaborations. The large node size suggests a high number of publications or citations. Another significant author is "van Wyk, B.-E.", who is also well-connected but forms a separate cluster. This suggests that both authors are key figures in the field but may work in somewhat distinct research groups.

Several other authors, such as "Eloff, J.N.," "McGaw, L.J.," and "Ge, Xianping," form smaller but well-connected clusters, indicating regional or topic-specific collaborations. The presence of multiple smaller clusters around these main nodes suggests a diverse research community where different groups contribute to the broader field, possibly focusing on different subtopics.

The visualization also reveals isolated or loosely connected authors, such as "Lall, N." and "Thring, TSA," suggesting that while they contribute to the field, their collaborations are limited or focused on niche topics.

DISCUSSION

Discussions contain 62 records of research articles indexed in SCOPUS, covering multiple disciplines. The study aims to analyze the most productive sources of research output, including journal contributions, citation impact, and open-access trends. Below is a detailed discussion based on the dataset: Several high-impact journals have significant research contributions to the dataset. Notably: The Lancet appears multiple times, highlighting its role as a major contributor, particularly in medical and public health research. Science of the Total Environment is another frequently occurring source, reflecting the growing importance of environmental and sustainability research. Other high-impact sources include the Journal of the American College of Cardiology, Microorganisms, Nature Ecology and Evolution, and Critical Reviews in Food Science and Nutrition.

The dataset spans multiple years, with research articles published between 2021 and 2023. The year 2022 has a significant number of research outputs, suggesting an increase in publications post-pandemic. The publication trends indicate a focus on contemporary research topics such as cardiovascular diseases, microbiology, environmental science, and food safety. The "Cited by" column indicates the number of times each article has been cited. High citation counts suggest a strong impact in the academic community. Many journals provide open access options, including Gold and Green Open Access, making research widely accessible.

The study highlights research in diverse fields: Medical and Health Sciences (The Lancet, Journal of the American College of Cardiology) Environmental Science (Science of the Total Environment, Environmental Research) Microbiology and Biotechnology (Microorganisms, Frontiers in Cellular and Infection Microbiology) Food Science and Nutrition (Critical Reviews in Food Science and Nutrition, Food and Chemical Toxicology).

The dataset includes author affiliations, showing global collaboration patterns. Authors are affiliated with top institutions, indicating strong research partnerships. This study provides a comprehensive analysis of research trends in SCOPUS-indexed sources. The dominance of medical, environmental, and food science journals suggests a focus on public health, sustainability, and food safety. The presence of high citation counts and open-access publications highlights the impact and accessibility of these studies. Future research can explore deeper insights into citation dynamics and institutional collaborations.

CONCLUSION

South Africa's highly cited research on medicinal plants has significantly contributed to ethnopharmacology, phytochemistry, and drug discovery. The country's research impact is driven by strong institutional collaborations, particularly among universities and global partners. Key studies focus on the pharmacological properties and bioactive compounds of indigenous plants, with leading journals like the Journal of Ethnopharmacology disseminating findings. Despite challenges such as funding limitations and conservation concerns, the research continues to influence global medicinal plant studies. Future efforts should emphasize biotechnological innovations, sustainable practices, and commercialization to maximize impact.

CONFLICT OF INTEREST

The authors declared no potential conflicts of interest concerning the research, authorship, and/or publication of this article.

ABBREVIATIONS

TP: Total publications; **TC:** Total Citations; **CPP:** Citations per Paper; **IF:** Impact Factor; **TLS:** Total Link Strength; **ACP:** Average citation paper.

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