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Global Research Trends on *Salvadora persica* and Periodontal Health: A Bibliometric and Visualisation Analysis

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ABSTRACT

Salvadora persica has long been used as a traditional oral hygiene tool and is increasingly investigated in periodontal research. A bibliometric study mapped research output on *Salvadora persica* (*S. persica*) and periodontal health using Scopus and Web of Science up to September 2025. After duplicate removal and exclusion of unrelated records, 185 publications were analysed using R (Bibliometrix) and VOSviewer to characterise publication trends, authorship, collaboration networks, citation impact, and keyword co-occurrence. From 1983 to 2025, the final dataset comprised 185 documents, including 147 articles and 38 reviews, with 3,423 cited references. Saudi Arabia, Malaysia, and India were the most productive countries, whereas Sweden showed the highest citation impact. The *Journal of Ethnopharmacology* and *Tropical Dental Journal* were the most productive outlets, while the *International Dental Journal* demonstrated the greatest citation impact. Co-authorship and collaboration maps showed strong collaboration, particularly between Saudi Arabia and Malaysia, but limited intercontinental partnerships. Frequently occurring keywords such as “miswak”, “*Salvadora persica*”, “oral health”, “dental plaque”, and “gingivitis” highlighted emphasis on plaque control, gingival health, and antimicrobial or periodontal outcomes. Overall, research on *S. persica* in periodontal health has expanded steadily, with Middle Eastern and Asian countries serving as hubs and Scandinavian countries contributing high-impact work. This bibliometric analysis provides an overview of the development, contributors, hotspots, and research gaps in this field, and may help guide studies on the role of *S. persica* in periodontal therapy.

Keywords: *Bibliometrics; periodontal disease; periodontal health; miswak; Salvadora persica*

INTRODUCTION

Oral health is an integral component of general well-being, and its maintenance has historically relied on both modern dentistry and traditional practices. In terms of traditional practices, *Salvadora persica* (*S. persica*), commonly known as miswak or siwak, holds a distinctive position as one of the oldest natural oral hygiene tools. Widely used in the Middle East, Africa, and South Asia, *S. persica* has been recommended in Islamic tradition and endorsed by the World Health Organization (WHO) as an effective tool for mechanical plaque control (Azizan *et al.*, 2023). Its global recognition stems not only from cultural and religious significance but also from its scientifically documented antimicrobial, anti-inflammatory, and antioxidant properties (Mekhemar *et al.*, 2021).

Periodontal diseases, including gingivitis and periodontitis, remain a major global oral health burden. Recent World Health Organization data indicate that severe periodontal disease alone affects approximately 19% of adults aged 15 years and older, representing more than 1 billion cases worldwide (World Health Organization, 2022). These conditions are primarily initiated by microbial plaque biofilms and mediated by complex host responses (Abdulkareem *et al.*, 2023). If untreated, periodontitis may lead to progressive tissue destruction and tooth loss, with significant implications for mastication, aesthetics, and quality of life. In addition, a growing body of evidence links periodontitis to systemic conditions such as diabetes mellitus, cardiovascular disease, and adverse pregnancy outcomes. Preventive and therapeutic strategies for periodontal health therefore, hold global public health importance. Within this context, *S. persica* has attracted considerable scientific interest due to its potential role as a natural adjunct in oral hygiene and periodontal therapy.

Over the past four decades, an increasing number of studies have investigated the phytochemical and pharmacological properties of *S. persica*. Experimental work has demonstrated activity against oral pathogens such as *Streptococcus mutans* and *Porphyromonas gingivalis*, reduction in dental plaque accumulation, and beneficial effects on gingival inflammation (Al-Otaibi *et al.*, 2003; Sofrata *et al.*, 2008). Clinical trials and in vivo studies have compared miswak to conventional toothbrushes, with several reports suggesting that miswak is as effective as, or even superior to, conventional toothbrushes in maintaining gingival and periodontal health (Adam *et al.*, 2021). Furthermore, reviews and narrative summaries have consolidated evidence regarding its therapeutic potential, ranging from antimicrobial activity to possible effects on caries prevention and oral biofilm modulation (Nordin *et al.*, 2020).

Despite this expanding evidence base, the scholarly landscape on *S. persica* and periodontal health has not been systematically mapped using quantitative approaches. Existing reviews tend to focus on summarising experimental and clinical findings, but do not provide a holistic overview of the research ecosystem. Key questions remain unanswered: Which countries and institutions lead in this research domain? Who are the most influential authors and journals? How have collaborations evolved over time? What are the most frequently cited works and dominant research themes? Addressing these questions requires methodologies beyond traditional literature reviews.

Bibliometric analysis offers a rigorous means to evaluate the structure, growth, and impact of scientific research (Öztürk *et al.*, 2024). It involves the statistical analysis of publication data, citation patterns, and authorship networks, enabling researchers to quantify influence, identify trends, and detect

research hotspots. Coupled with visualisation techniques, bibliometrics enables the creation of co-authorship, co-citation, and keyword co-occurrence maps that highlight both the intellectual structure and collaborative networks within a field. This approach has been widely applied in medicine, dentistry, and other scientific domains to reveal patterns of knowledge development and inform future research priorities.

For *S. persica* and periodontal health, a bibliometric approach is particularly timely. Research on this topic spans multiple disciplines, including dentistry, pharmacology, ethnomedicine, and public health, and involves contributions from diverse geographical regions. Accordingly, a quantitative mapping of the literature is needed to clarify how the field has evolved, who the major contributors are, how collaboration patterns have developed, and which thematic areas have gained prominence over time.

The rationale for this study, therefore, lies in the need to provide a comprehensive, data-driven synthesis of global research activity on *S. persica* in the context of periodontal health. Unlike narrative or systematic reviews, bibliometric and visualisation analyses can objectively capture both the quantity and quality of scholarly output, while uncovering the collaborative and thematic networks that shape the field. Such insights are crucial for identifying knowledge gaps, recognising emerging trends, and guiding future research directions.

This study aimed to conduct a bibliometric and visualisation analysis of global research on *S. persica* and periodontal health. Specifically, the objectives were to (1) assess publication output and citation trends over time; (2) identify influential authors, institutions, and countries contributing to the field; (3) map international collaboration

networks; (4) highlight the most frequently cited publications and source journals; and (5) analyse keyword co-occurrence to detect major themes and research hotspots.

By addressing these objectives, the present study seeks to provide a comprehensive overview of the research landscape on *S. persica* and its role in periodontal health, offering valuable insights for researchers, clinicians, and policymakers.

MATERIAL AND METHODS

An electronic literature search was conducted across two major bibliographic databases, Scopus (Elsevier) and Web of Science Core Collection (Clarivate Analytics), both widely used for bibliometric studies due to their broad coverage of peer-reviewed multidisciplinary literature. The search strategy was developed to capture publications addressing the relationship between *Salvadora persica* and periodontal health. Two main concept blocks were used: (1) terms related to the intervention or exposure, namely “*Salvadora persica*”, “miswak”, “siwak”, and “natural toothbrush”; and (2) terms related to periodontal and oral health outcomes, namely “periodontal health”, “periodont* health”, “gingival health”, “oral health”, “gum health”, “gingivitis”, and “periodontitis”. Within each concept block, terms were combined using the Boolean operator OR, while the two concept blocks were combined using AND to increase specificity. The truncation symbol (*) was applied to capture word variants such as “periodontal”. The final search strings were adapted to the syntax requirements of each database and were run in TITLE-ABS-KEY for Scopus and TS for Web of Science. The overall search, screening, exclusion, and final inclusion process is summarised in Fig. 1.

Scopus: TITLE-ABS-KEY ((*Salvadora persica* OR miswak OR siwak OR “natural toothbrush”) AND (“periodontal health” OR “periodont* health” OR “gingival health” OR “oral health” OR “gum health” OR gingivitis OR periodontitis))

Web of Science (WOS): TS=((*Salvadora persica* OR miswak OR siwak OR “natural toothbrush”) AND (“periodontal health” OR “periodont* health” OR “gingival health” OR “oral health” OR “gum health” OR gingivitis OR periodontitis))

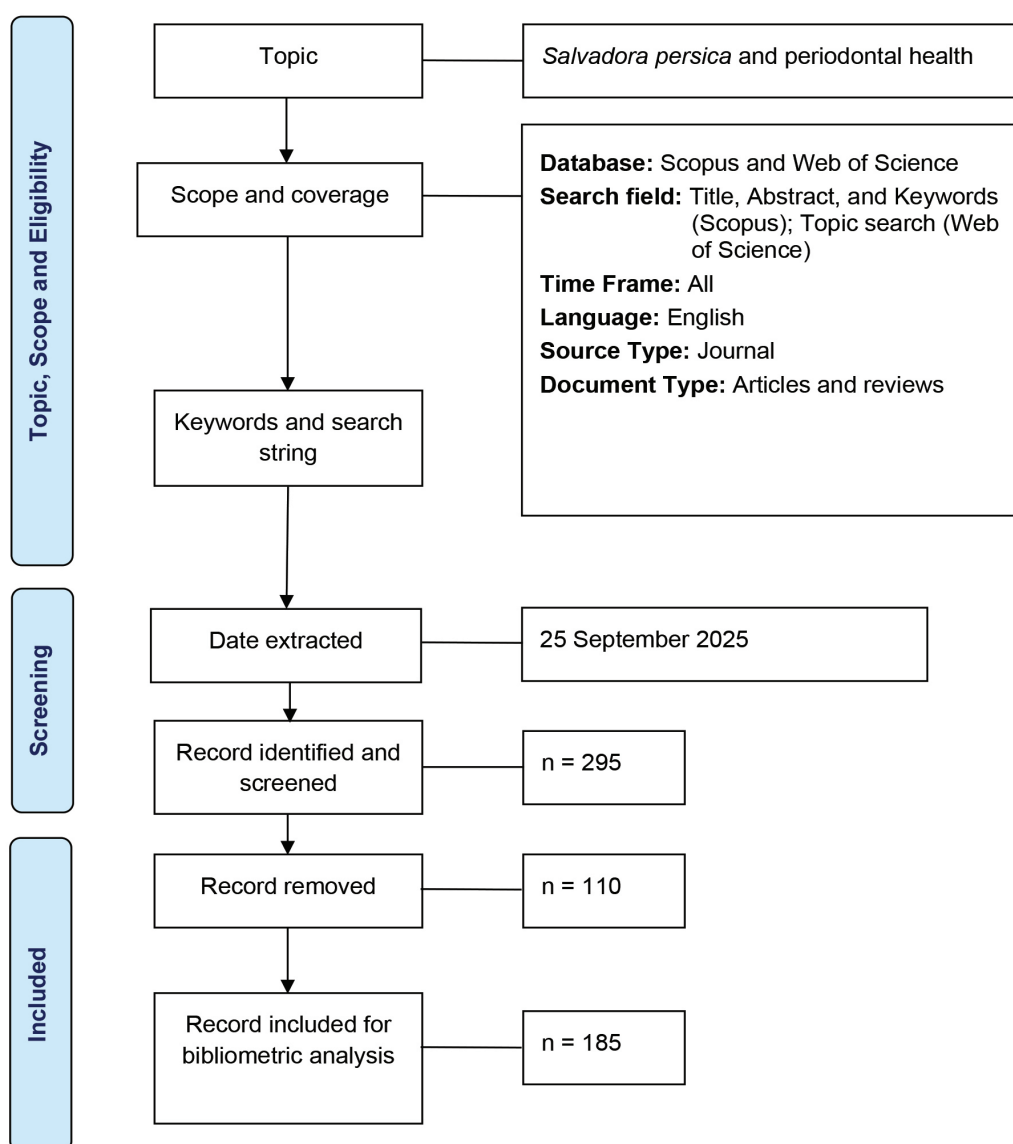


Fig. 1 Flow diagram of the search strategy (Moher *et al.*, 2009; Zakaria *et al.*, 2021).

The search was limited to English-language journal articles and reviews to capture original research and evidence synthesis publications, while excluding conference proceedings, notes, editorials, and non-relevant records. No date restriction was applied, and all records indexed up to 25 September 2025 were considered. Titles and abstracts were screened for relevance to *S. persica* and periodontal health. The final dataset was exported in BibTeX, CSV, and RIS formats, retaining essential bibliographic information including title, authorship, keywords, abstracts, and cited references for bibliometric processing.

No formal pilot testing of the search strategy was undertaken. The search syntax was developed a priori based on the study objective and relevant terminology commonly used in the *S. persica* and periodontal health literature. The strategy was then adapted to the indexing structure and search-field conventions of each database.

Bibliometric analysis was performed using RStudio (Bibliometrix package with the Biblioshiny interface) in conjunction with VOSviewer (version 1.6.20). These tools facilitated both quantitative and visual exploration of the dataset. The mapping analyses included co-citation networks, authorship collaborations, country productivity, journal distribution, and keyword co-occurrence. Three types of bibliometric visualisations were generated: Network visualisation (clustering of related items), density visualisation (highlighting concentrations of research activity), and overlay visualisation (showing temporal trends in research development).

The terms incorporated into the overlays were filtered based on study criteria to maintain contextual relevance. Collectively, this approach provided a comprehensive overview of global research trends on *S. persica* in periodontal health, identifying influential contributors, institutions, and thematic directions shaping the field.

RESULTS

Publications Evolution

The initial search identified 295 records (183 from Scopus and 112 from Web of Science). After screening for relevance and document type, 24 Scopus and 22 Web of Science records were excluded, yielding 159 records in Scopus (127 articles and 32 reviews) and 90 in Web of Science (72 articles and 18 reviews). Following the removal of 64 duplicates, a total of 185 publications (147 articles and 38 reviews) were included in the final dataset, spanning the period from 1983 to 2025. Exclusions were mainly due to duplication and documents that did not meet the inclusion criteria (such as conference abstracts, notes, and unrelated studies).

The earliest identified publication in the dataset was published in 1983 in Community Dentistry and Oral Epidemiology (El Samad Younes & El Angbawi, 1983). From 1983 to September 2025, a total of 185 publications and 3,423 references related to *S. persica* and periodontal health were indexed across the two databases.

The temporal analysis of annual publication output (Fig. 2) revealed a gradual increase across four decades, with fluctuations in the late 1990s and early 2000s. Marked peaks in publication output were observed in 2016 (16 articles), 2020 (15 articles), 2021 (16 articles), and 2023 (17 articles), reflecting rising scientific interest in the therapeutic and preventive potential of *S. persica*. Overall, the field demonstrated a positive annual growth rate, highlighting a sustained expansion of research in this area. In terms of citation dynamics (Fig. 2), variability was evident across the years. The highest average citation rates were recorded in 2008 (4.78 citations per year) and 2011 (4.03 citations per year), with additional peaks in 1995 (2.43), 2001 (2.52), and 2017 (2.62). These citation “hotspots” correspond to years when key publications on *S. persica* attracted significant scholarly attention, disproportionately shaping the field’s academic influence.

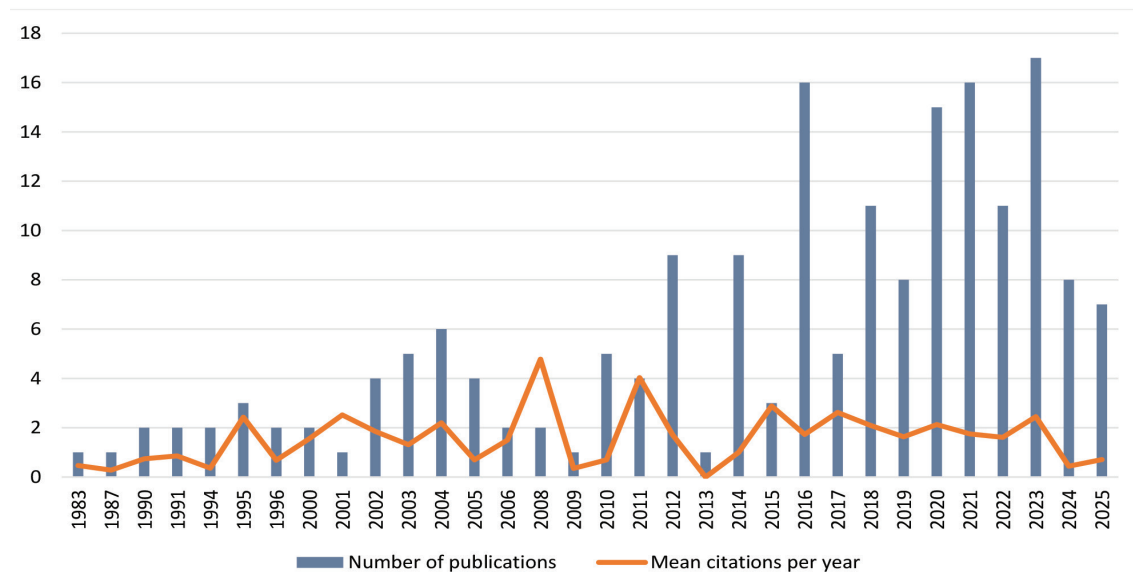


Fig. 2 Annual number of publications (bars) and mean citations per year (line) in research related to *S. persica* and periodontal health, published between 1983 and 2025.

Overall, the evidence suggests a steadily increasing recognition of *S. persica* as a relevant adjunct in periodontal health research. The observed publication and citation trends underscore its enduring importance and point to promising opportunities for further investigation into its role in periodontology.

Country and International Collaboration

A total of 185 publications on *S. persica* and periodontal health were produced by authors from 41 countries. Based on publication output, Saudi Arabia ranked first with 110 publications, followed by Malaysia (76),

India (66), Iran (33), and Sweden (22). Other contributing countries included the United States (12), Norway (9), Brazil (4), New Zealand (4), and Mauritius (1). With respect to citation impact, Saudi Arabia accumulated the highest total number of citations (758), while Sweden showed a comparatively high average article citation rate (50.4). Mauritius and New Zealand also exhibited high average article citation values, at 88.0 and 68.0 respectively; however, these values should be interpreted with caution, given their limited publication counts. Table 1 presents the leading contributing countries together with their total production, total citations, and average article citations.

Table 1 Top contributing countries in *S. persica*–periodontal health research (1983–2025)

Country	Total production	Total citation	Average article citations
Saudi Arabia	110	758	20.5
Malaysia	76	120	6.3
India	66	160	8.4
Iran	33	269	20.7
Sweden	22	403	50.4
Usa	12	90	22.5
Norway	9	144	36.0
Brazil	4	163	32.6
New Zealand	4	68	68.0
Mauritius	1	88	88.0

In terms of citation impact, Scandinavian countries showed remarkable performance despite fewer publications. For example, Sweden (22 publications, 403 citations; average 50.4 citations per article) and Norway (9 publications, 144 citations; average 36.0 citations per article) demonstrated strong scholarly influence. Conversely, countries such as India (66 publications, 160 citations; 8.4 citations per article) and Malaysia (76 publications, 120 citations; 6.3 citations per article) contributed more in volume but with lower citation averages, indicating opportunities to improve international visibility and impact. The highest citation averages were recorded by Mauritius (88 citations from a single article) and New Zealand (68 citations from 4 articles), showing how individual high-impact studies can significantly raise a country's scholarly profile.

Analysis of international collaboration patterns (Fig. 3) revealed strong networks between Middle Eastern and Southeast Asian countries, with Saudi Arabia and Malaysia frequently co-authoring research. However, the proportion

of internationally co-authored publications was relatively limited compared to global bibliometric trends, suggesting a need to expand collaborative partnerships with high-impact research hubs in Europe and North America to enhance research visibility and citation performance. Overall, while Middle Eastern and Asian countries dominate the field in terms of publication volume, Scandinavian and Western countries have contributed disproportionately to its scientific influence, reflecting a complementary but uneven global research landscape on *S. persica* in periodontology.

Journal Distribution

Regarding publication outlets, research on the relationship between *S. persica* and periodontal health has been disseminated through journals that are either directly dental-focused or that regularly publish dental-related research. The top ten most productive journals, along with their citation impact, are presented in Table 2.

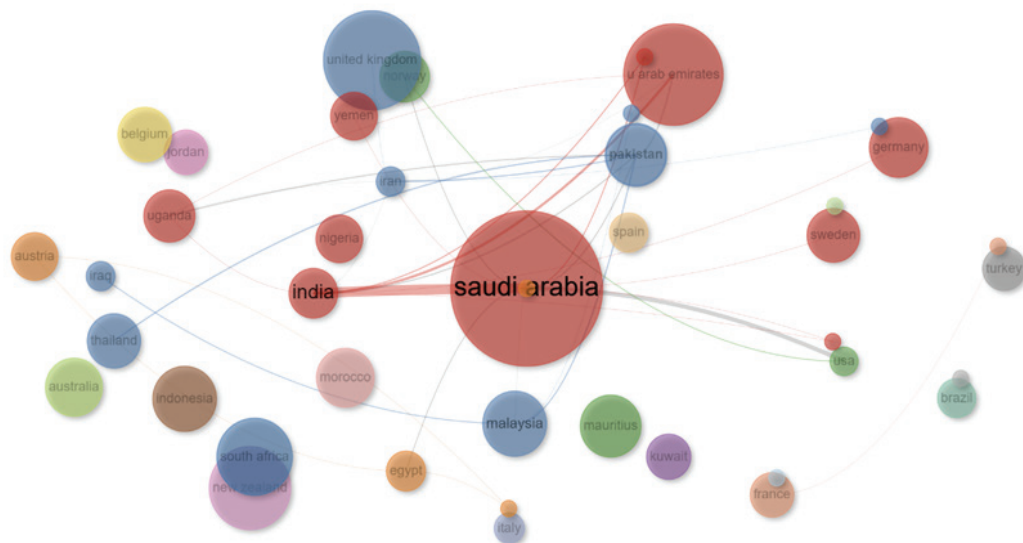


Fig. 3 International collaboration network on research exploring the relationship between *S. persica* and periodontal health.

Table 2 Top 10 journals publishing research on *S. persica* and periodontal health (1983–2025)

Journal	Number of publications	Total citations
<i>Journal of Ethnopharmacology</i>	6	188
<i>Tropical Dental Journal</i>	6	124
<i>International Dental Journal</i>	5	252
<i>International Journal of Dental Hygiene</i>	5	83
<i>Journal of Contemporary Dental Practice</i>	4	171
<i>Acta Odontologica Scandinavica Journal</i>	3	96
<i>Journal of Herbal Medicine</i>	3	5
<i>Oral Health and Preventive Dentistry Journal</i>	3	102
<i>Quintessence International Journal</i>	3	82
<i>Saudi Medical Journal</i>	3	159

The *Journal of Ethnopharmacology* and the *Tropical Dental Journal* were the most productive outlets, each publishing six papers. However, the *International Dental Journal* demonstrated the greatest citation impact with 252 citations across five publications, highlighting its strong influence in disseminating *S. persica*-related periodontal research. Similarly, the *Journal of Contemporary Dental Practice* (171 citations from four publications) and the *Saudi Medical Journal* (159 citations from three publications) ranked highly in terms of scholarly impact despite fewer publications.

The temporal pattern of journal production (Fig. 4) further illustrates these trends. Since the early 2000s, publications have

become more diversified across multiple journals, with notable growth in the *Tropical Dental Journal* and *International Journal of Dental Hygiene*. The *Journal of Contemporary Dental Practice* also maintained consistent contributions, particularly after 2003. Overall, while publications are distributed across both international and regional journals, the inclusion of highly cited papers in established outlets such as the *International Dental Journal* and *Journal of Ethnopharmacology* underscores their centrality in shaping the academic discourse on *S. persica* and periodontal health. This distribution highlights that although research visibility is increasingly global, its circulation remains firmly anchored within the dental and oral health research community.

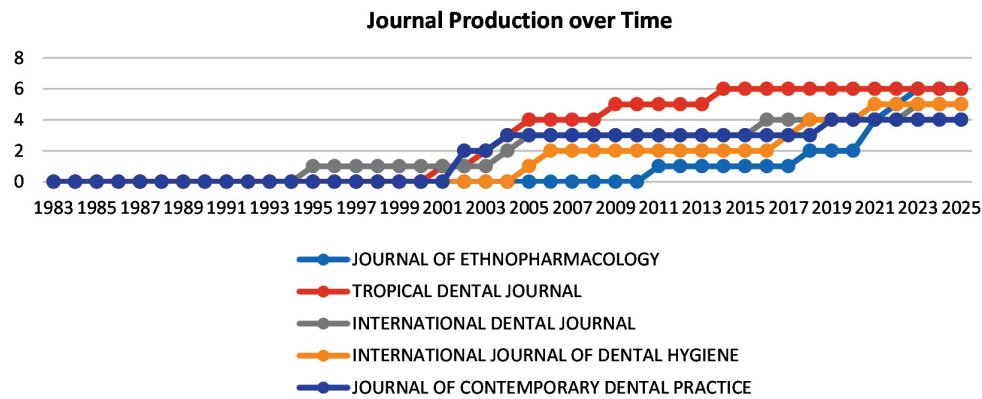


Fig. 4 Cumulative journal production over time in dental-related research on *S. persica* and periodontal health (1983–2025).

Author Contributions and Influence

Analysis of authorship patterns highlighted several key contributors driving research on *S. persica* and its role in periodontal health. Among the top 10 most productive authors (Fig. 5), Almas K led with 10 publications, followed by Al-Otaibi M with 7 publications. Gustafsson A, Ramli H and Skaug N each contributed 5 publications. Other notable contributors included Baskaradoss J, Darout I, Eid M, Mohd N and Selim H with 4 publications each.

Focusing on scholarly impact, Almas K also ranked as the most influential author with an h-index of 9 and a total of 438 citations, reflecting his long-standing role in shaping miswak research since 1995. Al-Otaibi M (h-index 6,221 citations) and Gustafsson

A (h-index 5,358 citations) also emerged as highly impactful, particularly through collaborative clinical studies conducted in the early 2000s. Scandinavian authors such as Skaug N and Gustafsson A demonstrated relatively high citation impact compared to output volume, indicating strong visibility of their publications.

More recent contributors, including Mohd N (h-index 4, m-index 0.8) and Adam F (h-index 3, m-index 0.6), represent a new wave of Malaysian scholarship on *S. persica* beginning in 2021, reflecting the regional expansion of research interest in this field. Co-authorship network mapping (Fig. 6) revealed several distinct clusters of collaboration, with Saudi Arabian and Malaysian researchers at the center of joint projects.

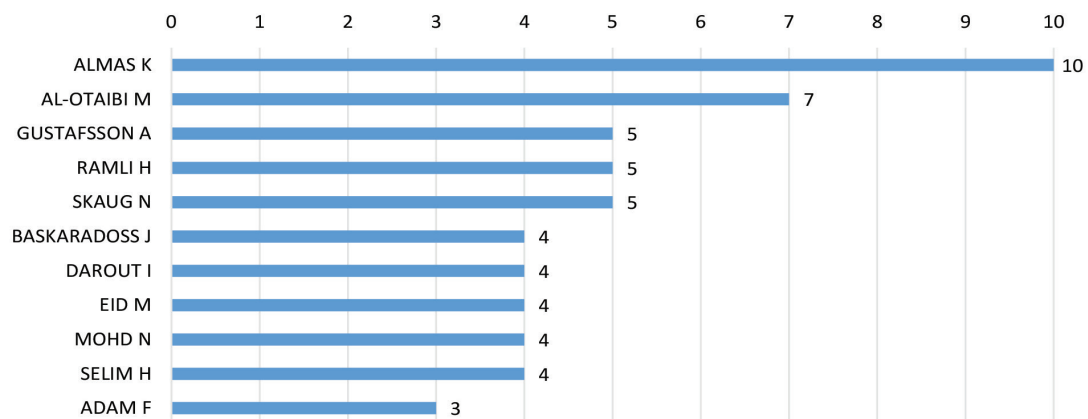


Fig. 5 Most productive authors in research on *S. persica* and periodontal health.

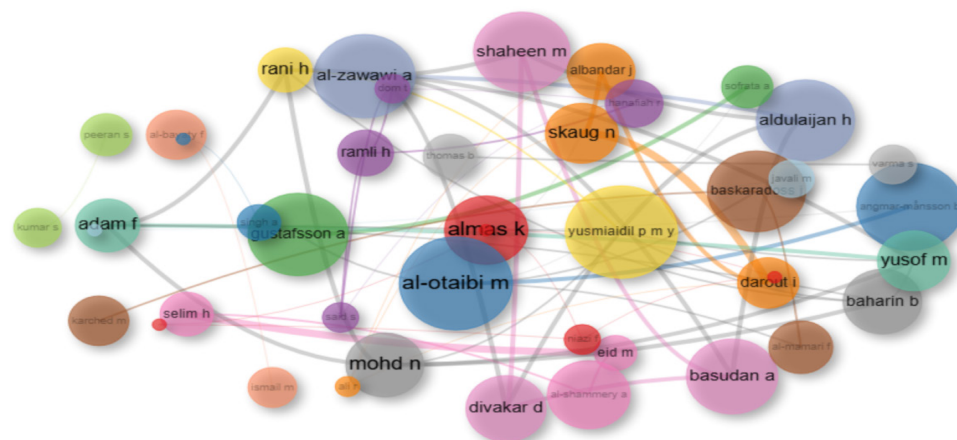


Fig. 6 Co-authorship network mapping related research on *S. persica* and periodontal health.

Most Influential Institutions/Organisations

Institutional analysis highlighted the central role of universities in advancing *S. persica* research on periodontal health. The top ten most productive institutions are shown in Table 3. Among them, Universiti Kebangsaan Malaysia emerged as the leading contributor with 27 publications, reflecting Malaysia’s growing role in this field. King Saud University (Saudi Arabia) followed with 17 publications, while King Khalid University (Saudi Arabia) ranked third with 16 publications.

Other major contributors included Universiti Teknologi MARA with 14 publications and International Islamic University Malaysia with 11 publications. Internationally, Karolinska Institute (Sweden), Kuwait University, and Ajman University (UAE) also demonstrated significant engagement, each contributing between 7 and 11 publications. From Iran, Mashhad University of Medical Sciences contributed 7 publications, while Dar Al Uloom University (Saudi Arabia) added 6 publications.

Table 3 Top 10 institutions contributing to research on *S. persica* and periodontal health

Institution/organisation	Country	Number of publications
Universiti Kebangsaan Malaysia	Malaysia	27
King Saud University	Saudi Arabia	17
King Khalid University	Saudi Arabia	16
Universiti Teknologi MARA	Malaysia	14
International Islamic University Malaysia	Malaysia	11
Karolinska Institute	Sweden	11
Kuwait University	Kuwait	11
Ajman University	UAE	7
Mashhad University of Medical Sciences	Iran	7
Dar Al Uloom University	Saudi Arabia	6

Keywords Co-occurrence Trends Analysis

The co-occurrence analysis of keywords provides an overview of the thematic landscape and conceptual focus in research on *S. persica* and periodontal health. A total of 153 distinct keywords with more than

five occurrences were identified, indicating a relatively diverse yet interconnected body of literature.

The most frequently used terms were “miswak” (59 occurrences) and “*Salvadora persica*” (47 occurrences), reflecting the dual usage of the traditional and scientific nomenclature in the field. Other dominant keywords included “oral health” (38), “dental plaque” (31), and “gingivitis” (21), underscoring the strong clinical emphasis on plaque control and gingival health. Preventive and therapeutic dimensions were also evident through recurrent terms such as “oral hygiene” (19), “caries” (17), and “toothbrush” (16), situating *S. persica* research within the broader discourse of public health and preventive dentistry (Table 4).

Table 4 Top 10 keywords in *S. persica* and periodontal health research (1983–2025)

Keyword	Occurrences
Miswak	59
<i>Salvadora persica</i>	47
Oral health	38
Dental plaque	31
Gingivitis	21
Oral hygiene	19
Caries	17
Toothbrush	16
Health	14
Extract	12

Network visualisation (Fig. 7) revealed three major clusters of research themes. The first cluster encompassed clinical terms such as *oral health*, *gingivitis*, and *periodontitis*, representing the core focus on periodontal disease prevention and management. The second cluster centered on laboratory and pharmacological dimensions, linking *extract*, *antimicrobial*, *antioxidant*, and *bioactive compounds* with *S. persica*, consistent with studies exploring benzyl isothiocyanate and other phytochemicals. The third cluster reflected preventive and adjunctive dentistry, characterised by keywords such as *toothbrush*, *caries*, and *oral hygiene*, highlighting the role of miswak as a complementary or alternative oral hygiene tool.

Temporal overlay mapping further demonstrated an evolution in research priorities. Early studies (1980s–1990s) predominantly focused on broad clinical outcomes, such as *oral health* and *gingivitis*. From the early 2000s, the thematic scope expanded to include pharmacological mechanisms, with terms such as *extract*, *antibacterial*, and *antioxidant*. In the last decade, research increasingly emphasised translational and evidence-based applications, with keywords associated with *biofilm modulation*, *periodontal therapy*, and *complementary medicine*.

The density visualisation of keyword co-occurrence (Fig. 8) further illustrates the thematic emphasis within the field. The terms “miswak” and “*Salvadora persica*” appear at the core of the map with the highest intensity, confirming their central role in driving the

literature. Closely surrounding these are clinical descriptors such as *oral health*, *dental plaque*, *gingivitis*, and *caries*, highlighting the predominant focus on preventive and periodontal outcomes. In addition, laboratory-oriented terms such as *extract*, *plaque control*, *biofilm*, *bacteria*, and *anti-inflammatory* are clustered nearby, reflecting a substantial body of pharmacological and microbiological research. Peripheral keywords, including *fluorosis*, *schoolteachers*, and *behavior*, point to emerging links with public health and community-based studies. The gradient from high-density central terms to less frequent peripheral ones demonstrates a research field that is simultaneously anchored in core clinical applications while progressively branching into experimental, behavioral, and interdisciplinary domains.

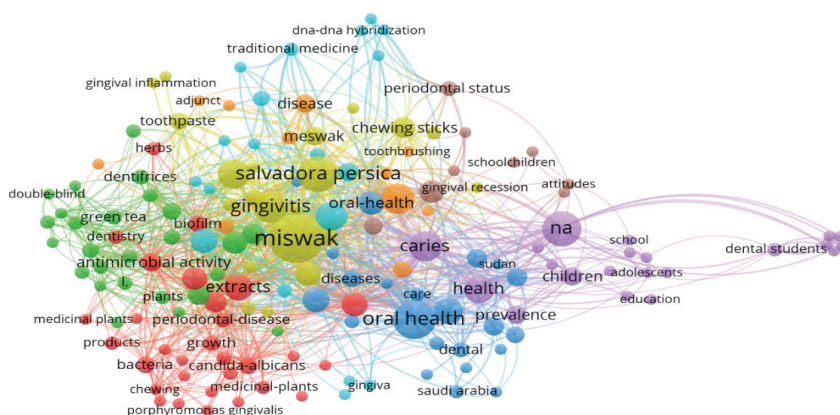


Fig. 7 Keyword co-occurrence network in research on *S. persica* and periodontal health.

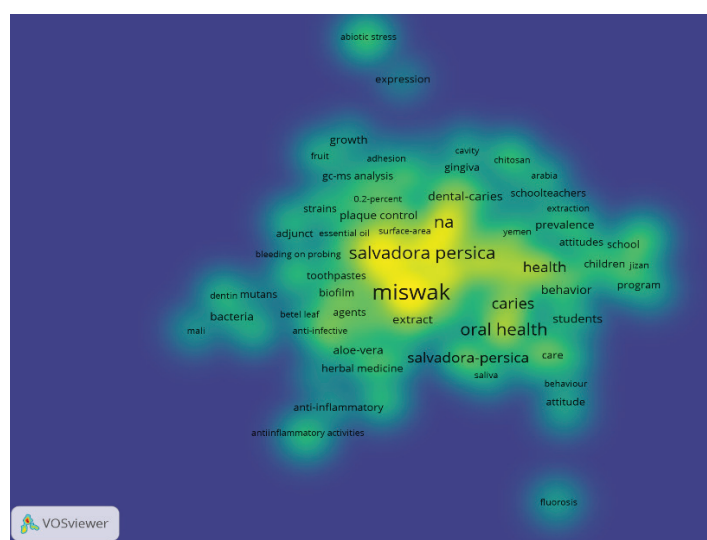


Fig. 8 Keyword density visualisation in research on *S. persica* and periodontal health.

Most Cited Documents

Citation analysis provides insights into the scholarly influence of publications on *S. persica* in the context of periodontal health. The top ten most cited documents are presented in Table 5. These papers represent a combination of laboratory studies, clinical investigations, and narrative reviews that have shaped the evidence base for miswak research. The most influential article was published by Sofrata *et al.* (2011) in *PLOS ONE*, which identified benzyl isothiocyanate as a potent antimicrobial constituent of *S. persica*. With 147 citations (10.5 average citations per year [ACPY]), it remains the highest-impact study in terms of both lifetime citations and citation velocity, reflecting its relevance across dentistry, microbiology, and pharmacology.

Early foundational work by Al-Lafi & Ababneh (1995) accumulated 134 citations (4.6 ACPY), demonstrating sustained influence despite its earlier publication date. Narrative reviews, such as Halawany (2012) and Haque & Alsareii (2015), also achieved high visibility, with ACPY values of 8.6 and 7.6, respectively, highlighting the continued importance of synthesised evidence in shaping contemporary perspectives on miswak. Notably, Aumeeruddy *et al.* (2018) achieved 88 citations (9.8 ACPY) in just seven years, indicating rapid uptake and strong visibility in ethnopharmacology and dental research. Similarly, clinical validation studies by Al-Otaibi *et al.* (2003) and Almas & Al-Zeid (2004) maintain enduring relevance, though with more modest ACPY rates (~3–3.6).

Table 5 Top 10 most cited publications on *S. persica* and periodontal health (1983–2025)

Authors (year)	Title	Journal	Total citations	Average citations/year
Sofrata <i>et al.</i> (2011)	Benzyl isothiocyanate, a major component from the roots of <i>S. persica</i> is highly active against Gram-negative bacteria	<i>PLOS ONE</i>	147	10.5
Al-Lafi & Ababneh (1995)	The effect of the extract of the miswak (chewing sticks) used in Jordan and the Middle East on oral bacteria	<i>International Dental Journal</i>	134	4.6
Halawany (2012)	A review of miswak (<i>S. persica</i>) and its effect on various aspects of oral health	<i>Saudi Dental Journal</i>	112	8.6
Haque & Alsareii (2015)	A review of the therapeutic effects of using miswak (<i>S. persica</i>) on oral health	<i>Saudi Medical Journal</i>	91	7.6
Aumeeruddy <i>et al.</i> (2018)	A review of the traditional and modern uses of <i>S. persica</i> (miswak): Toothbrush tree of Prophet Muhammad	<i>Journal of Ethnopharmacology</i>	88	9.8
Grosso <i>et al.</i> (2008)	Use of phytotherapy in dentistry	<i>Phytotherapy Research</i>	87	4.6
Sofrata <i>et al.</i> (2008)	Strong antibacterial effect of miswak against oral microorganisms associated with periodontitis and caries	<i>Journal of Periodontology</i>	85	4.5
Al-Otaibi <i>et al.</i> (2003)	Comparative effects of chewing sticks and toothbrushing on plaque removal and gingival health	<i>Oral Health & Preventive Dentistry</i>	80	3.6
Almas & Al-Zeid (2004)	The immediate antimicrobial effect of a toothbrush and miswak on cariogenic bacteria: A clinical study	<i>Journal of Contemporary Dental Practice</i>	77	3.5
Almas & Al-Lafi (1995)	The natural toothbrush	<i>World Health Forum</i>	74	2.6

Note: Average citations per year (ACPY) calculated as total citations ÷ years since publication up to 2025

DISCUSSION

This bibliometric and visualisation analysis provides a comprehensive overview of the development of research on *S. persica* in relation to periodontal health from 1983 to 2025. The findings demonstrate that the field has progressed from a relatively small body of regionally concentrated work to a broader, more multidisciplinary domain. The gradual increase in publication output over four decades, with notable peaks in 2016, 2020, 2021, and 2023, suggests sustained growth of scholarly interest. Likewise, the citation hotspots observed in selected years indicate that certain landmark studies played an important role in shaping subsequent research directions. In this respect, the present analysis not only quantifies scientific productivity but also reveals how the field's intellectual structure has evolved, a major purpose of bibliometric research (Öztürk *et al.*, 2024).

The geographical distribution of publications provides further insight into the development of this research area. Saudi Arabia, Malaysia, and India were the most productive countries, likely due to long-standing cultural familiarity with and traditional use of miswak in these regions. At the same time, countries such as Sweden and Norway achieved comparatively high average citation rates despite lower publication volume, suggesting that influence in this field is not determined solely by output quantity. A similar pattern was observed at the institutional level, where a relatively limited number of universities, including Universiti Kebangsaan Malaysia, King Saud University, King Khalid University, Universiti Teknologi MARA, and Karolinska Institute, emerged as major contributors. Collectively, these findings suggest that *S. persica* research has developed through a combination of cultural relevance, institutional continuity, and strategically visible high-impact contributions. This pattern is in keeping with the broader literature, which recognizes *S. persica* as both a traditional oral hygiene tool and an increasingly investigated adjunct in periodontal care (Nordin *et al.*, 2020; Mekhemar *et al.*, 2021).

The journal profile and citation patterns also help clarify how the field has matured. Although the *Journal of Ethnopharmacology* and *Tropical Dental Journal* were the most productive outlets in terms of publication count, the *International Dental Journal* demonstrated the greatest citation impact among the leading journals, indicating that broader visibility may be enhanced when miswak-related findings are disseminated through widely indexed and internationally read journals. The most cited documents also reflect the intellectual foundation of the field. Early influential studies focused on oral microbiology and antimicrobial activity (Al-Lafi & Ababneh, 1995), plaque control and gingival health (Al-Otaibi *et al.*, 2003), and immediate antimicrobial clinical effects (Almas & Al-Zeid, 2004). These were followed by mechanistic studies exploring antibacterial activity against oral pathogens relevant to periodontitis and caries (Sofrata *et al.*, 2008), as well as phytochemical investigations identifying benzyl isothiocyanate as a major bioactive component (Sofrata *et al.*, 2011). Highly cited review articles later consolidated this expanding body of evidence and further increased the visibility of the field (Halawany, 2012; Haque & Alsareii, 2015; Aumeeruddy *et al.*, 2018). Together, these findings suggest that the literature has advanced through a sequence of foundational laboratory work, clinical validation, and later evidence synthesis.

The keyword co-occurrence maps reinforce this interpretation. The predominance of terms such as “miswak,” “*Salvadora persica*,” “oral health,” “dental plaque,” and “gingivitis” confirms that the field remains strongly anchored in preventive and periodontal outcomes, especially plaque control and gingival health. However, the co-occurrence of terms such as “extract,” “antimicrobial,” “antioxidant,” “biofilm,” and “anti-inflammatory” indicates a clear shift toward mechanistic and translational lines of inquiry. This thematic expansion is consistent with prior reviews and meta-analytic evidence showing that *S. persica* is increasingly being evaluated not merely as a traditional chewing stick, but as a biologically active adjunct with

potential preventive and therapeutic value (Nordin *et al.*, 2020; Adam *et al.*, 2021; Mekhemar *et al.*, 2021). The emergence of terms related to biofilm modulation, complementary medicine, and periodontal therapy further suggests that the field is moving towards more clinically integrated and evidence-based applications.

An important strength of the present study is that it offers a broad, data-driven overview of a research area that has previously been discussed mainly through narrative and evidence-based reviews rather than through bibliometric mapping. By combining two major bibliographic databases with Bibliometrix/Biblioshiny and VOSviewer, this study evaluated not only publication output but also citation performance, journal distribution, country productivity, institutional leadership, collaboration networks, authorship influence, and thematic structure. This multidimensional approach is valuable because it captures both the field's productivity and the way knowledge within the field is organised and disseminated (Öztürk *et al.*, 2024). A further strength is that the analysis spans more than four decades, allowing the field to be interpreted in terms of research evolution rather than isolated findings. Accordingly, the present study helps to identify where the literature has been most active, which publications are established in the evidence base, where collaboration remains limited, and which themes appear most ready for future development.

Several limitations should nevertheless be acknowledged. First, the dataset was restricted to Scopus and the Web of Science, which means that relevant publications indexed in other databases may not have been captured. Second, only English-language articles and reviews were included; therefore, regional literature, non-English publications, conference proceedings, and other grey literature may have been underrepresented. Third, bibliometric indicators are inherently database-dependent and time-sensitive. Citation counts change over time; older publications have had a greater opportunity to

accumulate citations, and more recent studies may appear less influential because of citation lag rather than lower scientific value. This is particularly important when interpreting average citation metrics. For example, countries with very small publication output, such as Mauritius and New Zealand, may show disproportionately high average citation values because one or a few highly cited papers can markedly inflate the average. Finally, bibliometric analysis evaluates scholarly visibility, influence, and thematic structure; it does not directly determine the clinical efficacy of *S. persica*. Therefore, citation impact should not be interpreted as a direct proxy for therapeutic effectiveness.

These limitations also shape how the findings should be interpreted. The concentration of publications in culturally affiliated regions may partly reflect true research leadership, but it may also reflect database coverage and language restrictions. Similarly, the apparent dominance of certain institutions and journals should be understood within the boundaries of the selected data sources. The relatively limited intercontinental collaboration observed in this study may indicate a genuine gap in network expansion, but it may also underestimate informal or emerging collaborations not yet visible in indexed co-authorship patterns. Even so, the overall trends remain meaningful; the field has clearly moved beyond descriptive accounts of traditional use towards a more structured evidence-based approach involving microbiology, pharmacology, clinical dentistry, and complementary medicine.

The implications of this bibliometric analysis are therefore both scientific and strategic. Scientifically, the study demonstrates that research on *S. persica* and periodontal health has entered a more mature phase characterised by thematic diversification and growing translational interest. Strategically, it provides a roadmap for the next stage of development in the field. Future work should prioritise stronger international and intercontinental collaborations, broader dissemination in highly visible dental and biomedical journals,

and more robust clinical research designs, particularly multicentre randomised controlled trials with longer follow-up and clinically meaningful periodontal endpoints. Greater integration with microbiology, phytochemistry, biomaterials, and implementation of science may also help bridge the gap between traditional practice and evidence-based periodontal care. In this sense, the present bibliometric study contributes not only by summarising where the field has been, but also by clarifying where it should move next.

CONCLUSION

Overall, this study shows that research on *S. persica* in periodontal health has evolved from culturally rooted practice-based observations into an increasingly interdisciplinary scientific field. The continued growth in publications, the persistence of influential foundational studies, and the emergence of mechanistic and translational themes all indicate that miswak research is gaining broader academic relevance. By mapping the structure, strengths, and gaps of the literature, this study provides an important reference point for researchers, clinicians, and policymakers seeking to advance the evidence base on *S. persica* and its role in contemporary periodontal health care.

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