

Global Research Trends in *Centella asiatica* for Cosmetic and Skin-Related Applications: A Bibliometric Analysis

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Abstract: *Centella asiatica* (L.) Urb. has attracted considerable scientific interest because of its effects on wound repair, inflammation, antioxidant activity, collagen formation, scar formation, skin barrier function, and skin aging. In the current study, a bibliometric mapping approach was applied to investigate global research activity on *C. asiatica* in cosmetic and skin-related applications. The initial search generated 562 records from January 1, 2000, to March 31, 2026. The dataset was then restricted to English-language articles indexed in Scopus, resulting in 350 records. Through manual screening of the titles and abstracts, we noted that 27 review-like papers were incorrectly classified as articles, leading to a final corpus of 323 original research articles. Bibliometric analysis was used to evaluate publication trends, including top journals, authors, institutions and countries, along with citation networks, collaboration patterns, keyword clusters and evolution. The dataset included 7,032 citations (mean: 21.77 citations/article). The number of publications during the study period increased markedly and peaked in 2025, with 61 publications. Most research papers were produced in China, Thailand and India. The main themes were wound healing, asiaticoside, madecassoside, collagen, hydrogel systems, and skin barrier integrity. Studies on *C. asiatica* continue to focus on two major topics related to either therapeutic skin repair or mechanistic biology. However, while less developed, clinically based cosmetic applications are becoming better represented.

Keywords: Bibliometric analysis, *Centella asiatica*, cosmeceuticals, cosmetics, skincare, wound healing

INTRODUCTION

Centella asiatica (L.) Urb. is a traditional medicinal herb that has become a vital component of dermatology, cosmetics, and cosmeceutical research (1-3). Ethnomedical and experimental evidence clearly shows that it contributes to wound healing, the modulation of inflammatory pathways, improved collagen organization, the inhibition of pathological

scar formation, and environmental skin protection (4-9). Asiaticoside, madecassoside, asiatic acid, and madecassic acid are the major bioactive constituents most strongly linked to effects on fibroblast activity, re-epithelialization, oxidative balance, extracellular matrix remodeling, and skin repair (4-9). *C. asiatica* for sensitive skin, postprocedure use, photoaging-related

applications, skin barrier strengthening, etc., is further supported by recent formulation and clinical research. Thus, *C. asiatica* has been established both in traditional herbal medicine and in current skin science (1, 2, 8-15).

The increased interest in products from *C. asiatica* demonstrates the possibility for translation. Recent research has expanded the field beyond traditional wound models toward formulation-driven and cosmeceutically relevant applications. These include serum systems with antioxidant, anti-inflammatory, anti-tyrosinase, and barrier-supportive activities; peel-off and hydrogel systems; transfersomal delivery; liposome-based recovery masks; postlaser barrier-repair products; and microneedle-enabled scar-oriented delivery (2, 3, 6, 10, 11, 13-16). Such developments signal that *C. asiatica* is no longer viewed as a mere crude medicinal extract but is increasingly recognized as an active ingredient that can be formulated into preparations whose activities are dependent on extract standardization, carrier design, and context-specific biological endpoints (2, 3, 10, 11, 13-15). Furthermore, the potential for scalable centelloside production and enhanced control of chemical composition to improve reproducibility and commercial translation is supported by advances in biomass engineering, hairy root culture and biosynthetic pathways (16, 17).

The current ingredient and regulatory environment further support this translational momentum. Materials obtained from *C. asiatica* are already part of the CosIng database of the European Commission, and the Cosmetic Ingredient Review Panel concluded that nine *C. asiatica*-derived ingredients are safe for use in cosmetic products at the present level and concentration limits (18-21). As such, *C. asiatica* is uniquely poised at the intersection of natural-product pharmacology, dermal delivery science, biomaterials, and evidence-based cosmetic science. Nonetheless, product relevance does not clarify how the research field has developed, which countries and institutions lead it, how the collaboration networks are structured, or whether the increase in publications reflects broader conceptual development in the field (18-21).

Even with the rapid growth of the literature, the overall research landscape of *C. asiatica* in cosmetic and skin-related applications remains insufficiently characterized. Earlier preclinical studies have largely investigated the underlying mechanisms, wound-healing efficacy, antiscarring activity, anti-inflammatory signaling, or formulation-specific outcomes (4, 6-17). While these studies are useful pieces of evidence, they do not portray the field as a whole, including which journals shape visibility, which countries and institutions drive output, how collaboration networks are structured and how thematic priorities have shifted from therapeutic skin repair toward dermocosmetic and consumer-oriented uses. Bibliometric analysis is well suited to fill this gap, as it allows quantitative assessment of scientific productivity, citation impact, collaboration, and theme development (22, 23). Programs such as VOSviewer and bibliometrix are valuable for evaluating citation networks, coauthorship, keyword co-occurrence, bibliographic coupling, and science mapping. Since wound repair, management of scarring, recovery from postprocedures, barrier-supportive dermocosmetics and routine cosmetic claims are conceptually related but distinct in terms of evidence, bibliometric mapping provides a useful macrolevel lens to clarify how they are related within the broader *C. asiatica* literature (22, 23).

Consequently, the objectives of this work were to map the global research landscape of cosmetic and skin-related applications of *C. asiatica* using a Scopus-based bibliometric approach. The publication growth, leading authors, journals, institutions, citation structures, collaboration networks, keyword hotspots, and thematic evolution were analyzed. Unlike broader bibliometric studies of medicinal plants or cosmetic botanicals, this study focused specifically on the skin-related translational spectrum of *C. asiatica*. The present study included wound healing, scar biology, and biomaterial-assisted repair as well as barrier-supportive dermocosmetics and skincare-related applications. Additionally, the analysis relied on a manually screened dataset of original research articles that allowed a more specific analysis than database records alone. The goal of this approach was to illustrate how the therapeutic, mechanistic, and cosmetic strands of the literature connect with one another; to clarify where the field is already well

developed; and to identify where clinically meaningful cosmetic evidence still remains limited. In this study, “skin-related applications” encompass wound healing, scar biology, dermatological treatment, skin-barrier support, biomaterial-assisted repair, and cosmetic or dermocosmetic applications.

MATERIALS AND METHODS

Study Design and Data Source

This study used a Scopus-based bibliometric design to map research on *C. asiatica* in cosmetic, dermatological, wound repair, scar, barrier-supportive, and related skin health applications. Scopus was selected because of its broad multidisciplinary coverage and suitability for bibliometric performance analysis and science mapping. The search covered publications from 1 January 2000 to 31 March 2026 and was conducted on 1 April 2026. The results of the records, identification, screening, eligibility assessment, and inclusion process were summarized using a PRISMA-style flow diagram (22-24). The fixed cutoff represented the actual database retrieval date and was retained to ensure a reproducible dataset. Records indexed after 31 March 2026 were therefore outside the predefined study period.

Search Strategy and Eligibility Criteria

The following query was applied directly in Scopus: TITLE-ABS-KEY ((“*Centella asiatica*” OR “Gotu kola” OR cica) AND (cosmetic* OR cosmeceutic* OR “skin care” OR skincare OR dermatolog* OR anti-aging OR antiaging OR photoaging OR photo-ageing OR photoageing OR “wound healing” OR scar* OR “skin barrier”). The accepted botanical name, *Centella asiatica* (L.) Urb., was used as the principal plant identifier. “Gotu kola” and “cica” were retained as supplementary common or cosmetic terms, and irrelevant uses were removed through manual screening. Active compounds were not used as independent search terms to maintain the plant-specific scope of the analysis. Records were eligible if they were English-language original research articles indexed in Scopus and directly related to *C. asiatica* in cosmetic, cosmeceutical, dermatological, wound-healing, scar, barrier, or related skin health contexts.

Reviews, conference papers, book chapters, short surveys, letters, editorials, retracted items, errata, conference reviews, non-English records, and review-like papers misclassified as articles in Scopus were excluded.

Screening, Data Cleaning, and Bibliometric Analysis

The comprehensive search yielded 562 records. After limiting the dataset to English-language articles, 350 records remained. Titles and abstracts were carefully reviewed for eligibility criteria. During this process, 27 items indexed as articles were eliminated because they were review-type publications and did not report original research. The final analysis dataset consequently included 323 English language original research publications.

Bibliographic metadata such as authors, titles, publication years, source titles, abstracts, author keywords, affiliations, document types, and language and citation counts were exported in CSV files. The citation fields were reviewed prior to analysis, ineligible records were discarded, keyword variants were harmonized for spelling, capitalization, hyphenation, and lexical repetition, and the institution and country names were standardized from the affiliation data. To improve terminological consistency, closely related terms such as “skin care” and “skincare” or “anti-aging” and “antiaging” were merged. The productivity of authors, institutions and countries was calculated by full counting after data cleaning. Institution-level results should be taken as standardized analytical outputs rather than raw database counts, given that the names of affiliations can be different in individual Scopus records.

The bibliometric study includes annual publishing output, total citations, mean citations per document, notable journals, authors, institutions, countries, highly cited papers, coauthorship networks, country collaboration, author-keyword frequency, keyword co-occurrence, and topic progression. Network visualizations were confined to objects that satisfied thresholds to ease the visualizations, and the cleaned dataset was used for the productivity summary. The minimum number of occurrences was 5 for author keywords, authors and countries or institutions, when applicable. Thematic evolution was assessed for the

periods 2000–2010, 2011–2018 and 2019–2026. Analyses and visualizations were conducted using bibliometrix/Biblioshiny and VOSviewer 1.6.20 (22, 23).

Statistical Analysis

The publication counts, publication count percentages, citation counts, mean citations per document, mean authors per paper, and productivity by journal, author, institution and nation were summarized using descriptive bibliometric statistics. Since the analysis was based on the entire eligible dataset rather than a sample, inferential hypothesis testing was not performed. Citation-based data were

interpreted descriptively, with the awareness that raw citation counts are influenced by publication age and should not be taken as direct assessments of study quality or clinical evidence. Annual publication growth was quantified using the compound annual growth rate (CAGR), which was calculated as $[(N_{\text{end}}/N_{\text{start}})^{(1/t)} - 1] \times 100$, where N_{start} and N_{end} are the publication counts in the first and last years, respectively, and t is the number of elapsed years. Exponential growth curves ($y = ae^{(bx)}$) were fitted to annual publication counts for 2000–2025 and 2020–2025, and goodness of fit was assessed using the coefficient of determination (R^2). The partial year 2026 was excluded from these trend calculations.

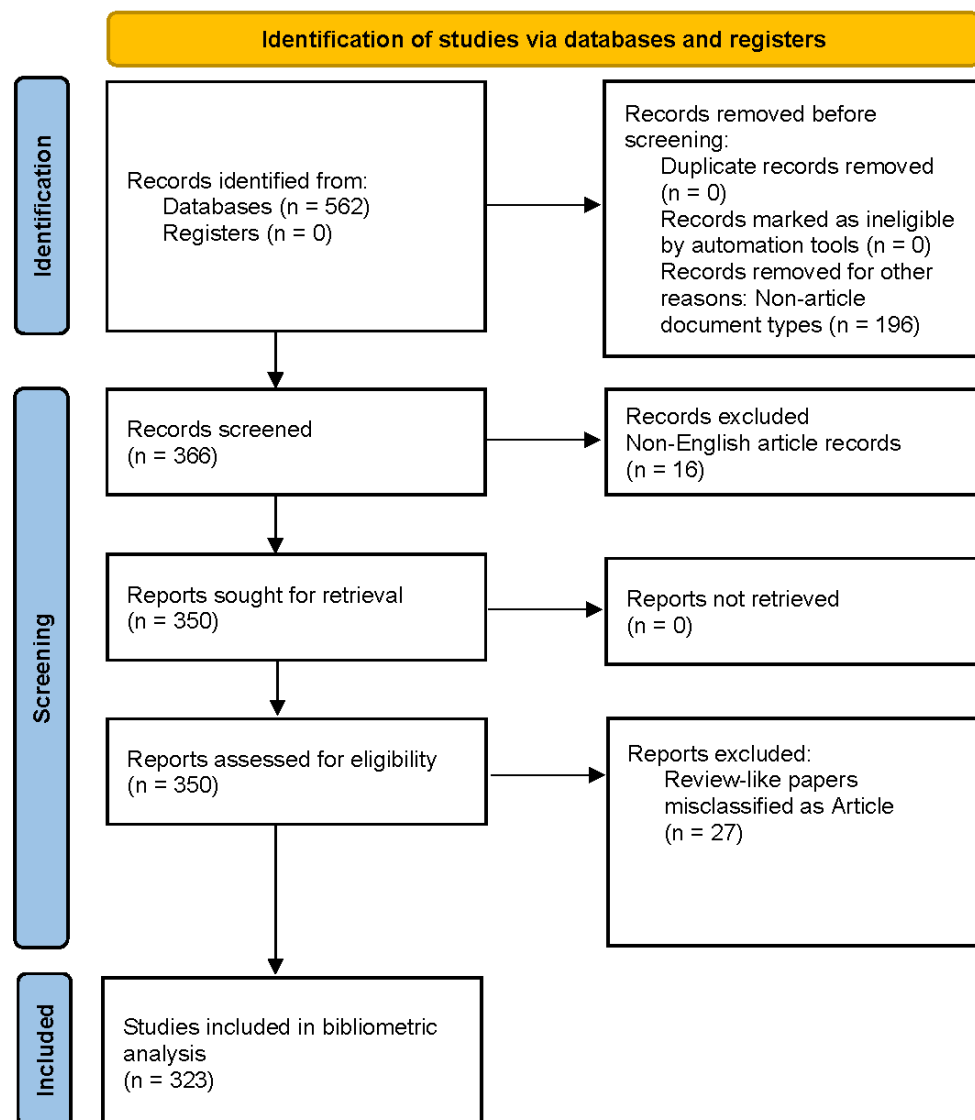


Figure 1. Flow diagram of literature retrieval, screening, and inclusion.

RESULTS

General Characteristics of the Dataset

The entire bibliometric data collection contains 323 English original research publications. PRISMA statistics revealed that 562 records were included in the prolonged retrieval window of 1 January 2000 to 31 March 2026. The initial 562 records consisted of 366 articles, 141 reviews, 21 conference papers, 16 book chapters, seven short surveys, three letters, three editorials, two retracted publications, two errata and one conference review. Among the 366 articles, 350 were published in English; after 27 review-type papers were excluded, 323 original research articles remained. English was the language for 543 records, followed by Korean, Spanish, Chinese, Portuguese, Italian, German, Turkish, French and Czech. The dataset was confined to articles in English, and 27 review-like papers that were misclassified as articles were removed, leaving 323 original research publications. The process of literature retrieval, screening and inclusion is summarized in Figure 1. Table 1 presents the general bibliometric features of the data collection. The data collection comprises 323 articles with 7032 citations and an average number of citations per document of 21.77. The years of publication spanned from 2000 to 2026, with an average of 6.03 authors per publication. The majority of the studies were performed in single-country circumstances (268 papers; 83.0%). However, 54

(16.7%) papers were international collaborations. One record had no valid data on national affiliation.

Annual Publication Trends

In the early years of the study period, publication output was limited, but it increased markedly over time. The dataset began with two publications in 2000, remained relatively modest throughout the 2000s, and expanded more rapidly in the 2020s. Annual output increased from 16 papers in 2020 to 28 in 2023, 29 in 2024, and 61 in 2025, with 2025 representing the peak publication year in the dataset. By 31 March 2026, Scopus had indexed 30 additional articles; therefore, 2026 was treated as a partial publication year and was not interpreted as a full-year trend. The temporal trend in annual publication output is shown in Figure 2. Overall, 201 of 323 papers (62.2%) were published from 2020 onward, and 148 papers (45.8%) were published during 2023–2026. On the basis of the cleaned dataset, the annual output increased from 2 publications in 2000 to 61 in 2025, corresponding to a compound annual growth rate (CAGR) of 14.65% per year. During the more recent expansion phase, the output increased from 16 publications in 2020 to 61 in 2025, corresponding to a CAGR of 30.69% per year. Exponential growth modeling also showed a strong fit for the period 2000–2025 ($R^2 = 0.848$) and an even stronger fit for 2020–2025 ($R^2 = 0.945$).

Table 1. General bibliometric characteristics of the final analytical dataset.

Indicator	Value
Initial records identified	562
Time span of retrieval	1 January 2000–31 March 2026
English-language records in retrieval frame	543
English-language records indexed as article in Scopus	350
Review-like papers manually excluded from article set	27
Final eligible records	323 original research articles
Document type in final dataset	Research articles only
Total citations	7,032
Mean citations per document	21.77
Mean authors per paper	6.03
Peak publication year	2025
Publications in peak year	61
Publications in 2026 (to 31 March)	30
Single-country papers	268
Papers with international collaboration	54
Records without usable affiliation-country data	1

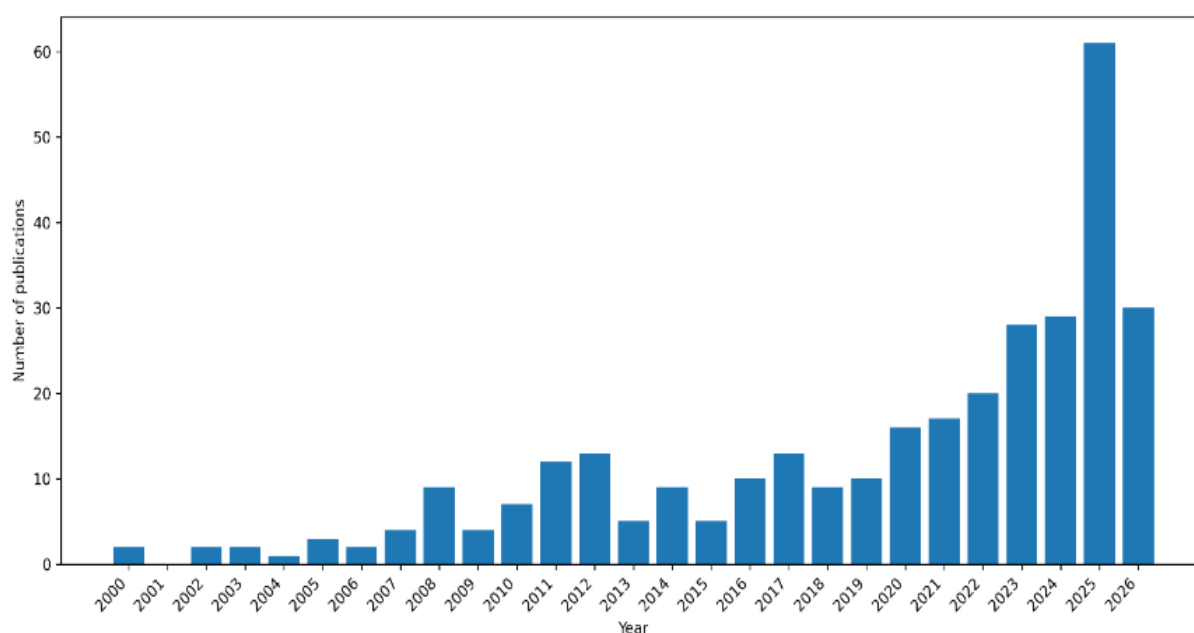


Figure 2. Annual publication trend of *Centella asiatica* research on cosmetic and skin-related applications from 2000 to 2026.

Table 2. Most productive journals, authors, institutions, and countries in the final analytical dataset.

Category	Name	Number of publications	Total citations
Journal	Journal of Ethnopharmacology	15	887
Journal	Journal of Cosmetic Dermatology	8	13
Journal	International Journal of Molecular Sciences	6	70
Journal	Journal of Wound Care	6	101
Journal	International Immunopharmacology	5	234
Journal	Cosmetics	5	39
Author	Dai Y.	8	418
Author	Liu Y.	7	154
Author	Gong Z.	6	409
Author	Nie X.	6	144
Author	Puttarak P.	6	131
Author	Tantisira M.H.	5	283
Author	Xia Y.	5	270
Author	Li Y.	5	230
Author	Wang L.	5	78
Author	Chen S.-G.	5	67
Institution	Prince of Songkla University	10	223
Institution	Chulalongkorn University	9	316
Institution	China Pharmaceutical University	8	435
Institution	Burapha University	6	283
Institution	Zunyi Medical University	6	144
Country	China	65	1,712
Country	Thailand	41	988
Country	India	38	738
Country	Turkey	30	513
Country	South Korea	29	537
Country	United States	24	438

Note: More than five journals are shown because two journals were tied at five publications. Productivity was assessed using the cleaned dataset and full-count attribution.

Leading Journals and Sources

The journal with the highest output was the Journal of Ethnopharmacology, with 15 articles and 887 citations. This was followed by the Journal of Cosmetic Dermatology with 8 publications, the International Journal of Molecular Sciences and the Journal of Wound Care with 6 publications each, and International Immunopharmacology and Cosmetics

with 5 publications each. Table 2 summarizes the leading journals, along with the leading authors, institutions, and countries. The source distribution reveals a concentration of publications across journals focused on ethnopharmacology, wound healing, dermatology, immunopharmacology, and experimental skin science. Fewer but increasingly visible publications have appeared in journals specifically focused on cosmetic products.

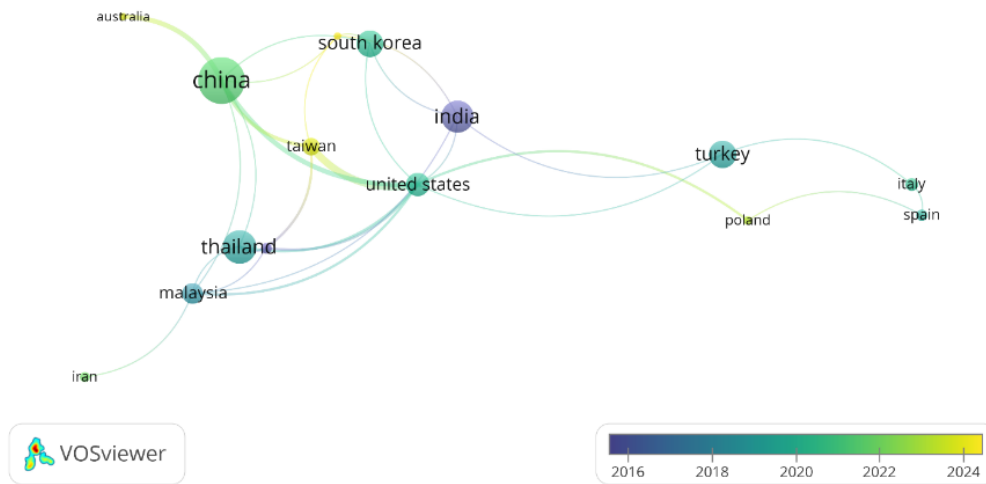


Figure 3. International collaboration network among countries contributing to *Centella asiatica* research in cosmetic and skin-related applications.

Table 3. Most cited publications in *Centella asiatica* cosmetic and skin-related research.

Rank	First author	Year	Short title	Journal	Citations
1	Somboonwong	2012	Wound healing activities of different extracts of <i>C. asiatica</i>	BMC Complementary and Alternative Medicine	200
2	Giday	2010	Ethnomedicinal study of plants used by Sheko ethnic group of Ethiopia	Journal of Ethnopharmacology	197
3	Chi	2021	Chinese herb microneedle patch for wound healing	Bioactive Materials	160
4	Tang	2011	Asiaticoside suppresses collagen expression in keloid fibroblasts	Archives of Dermatological Research	149
5	Yao	2017	Electrospun gelatin nanofibers containing <i>C. asiatica</i> extract	Journal of Tissue Engineering and Regenerative Medicine	145
6	Liu	2008	Madecassoside facilitates burn wound healing in mice	Planta Medica	139
7	Widgerow	2000	New innovations in scar management	Aesthetic Plastic Surgery	138
8	Kimura	2008	Asiaticoside at low doses in burn wound repair	European Journal of Pharmacology	122
9	Lee	2012	Asiaticoside enhances human skin cell migration and growth	Phytomedicine	117
10	Buranasudja	2021	Callus extract and asiaticoside in anti-skin-aging work	Scientific Reports	108

Leading Authors, Institutions, and Countries

In terms of full-count authorship, the most productive author was Dai Y., with 8 publications and 418 citations. Next was Liu Y., with 7 papers and 154 citations. The authors associated with 6 publications included Gong Z. (409 citations), Nie X. (144 citations), and Puttarak P. (131 citations). Other contributors with 5 publications were Tantisira M.H. (283 citations), Xia Y. (270 citations), Li Y. (230 citations), Wang L. (78 citations), and Chen S.-G. (67 citations). Table 2 provides summaries of the main contributors. In terms of institutions, the most productive affiliations were Prince of Songkla University (10 publications), Chulalongkorn University (9), China Pharmaceutical University (8), Burapha University (6), and Zunyi Medical University (6). Other notable institutions included Walailak University, Naresuan University, Khon Kaen University, and China Medical University. The top countries were China (65 papers; 1,712 citations), Thailand (41; 988), India (38; 738), Turkey (30; 513), South Korea (29; 537), and the United States (24; 438). The collaboration patterns between countries are shown in Figure 3.

Citation Structure

Among 323 papers published throughout the past three decades, wound healing, scar biology, fibroblast modulation, and triterpene-rich bioactive compounds were the most cited topics. According to the citation data, “Wound healing activities of different extracts of *Centella asiatica* in incision and burn wound models: an experimental animal study” received 200 citations. An ethnomedicinal study of plants used by the Sheko ethnic group of Ethiopia received 197 citations. The study on a Chinese herb microneedle patch for wound healing received 160 citations. A study in which asiaticoside suppressed collagen expression and TGF- β /Smad signaling in keloid fibroblasts yielded 149 citations. “Wound-healing effect of electrospun gelatin nanofibers containing *Centella asiatica* extract in a rat model” received 145 citations. As highlighted in Table 3, the top-cited papers are dominated by wound repair, scar modulation, and formulation-based therapeutic applications. Overall, these studies were the most highly cited in the dataset.

Collaboration Networks

Among the 323 records, 268 papers (83.0%) were produced within a single-country setting, whereas 54 papers (16.7%) involved international collaboration. Taiwan and the United States were the most common international collaboration pairs ($n = 6$), followed by Australia and China ($n = 4$) and China and the United States ($n = 4$). As depicted in Figure 3, the collaboration network at the country level indicates that although most of the publications in the study are produced in the context of a nationally bounded research system, a meaningful proportion involved multinational collaboration.

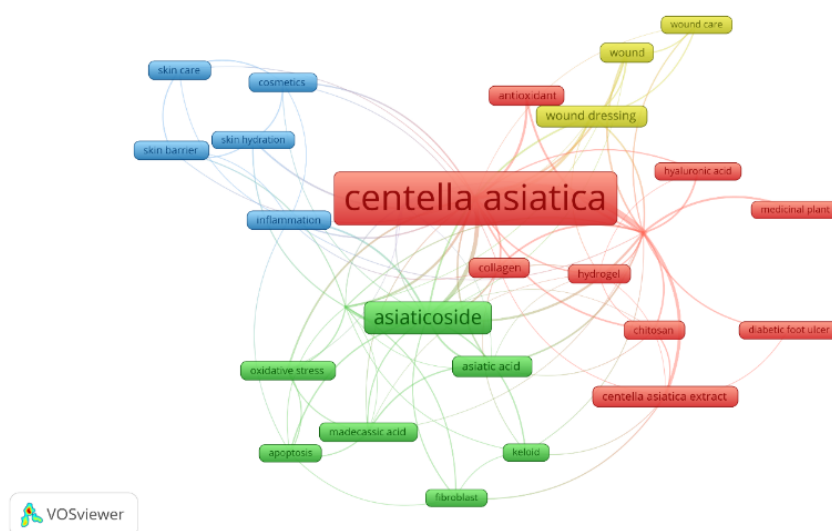
Keyword Co-occurrence and Research Hotspots

Analysis of author keywords revealed that the terms “*Centella asiatica*” (109), “wound healing” (76), “asiaticoside” (46), “madecassoside” (23), “wound dressing” (15), “asiatic acid” (12), and “*Centella asiatica* extract” (12) appeared most often. The thematic interpretations of the main keyword clusters and their co-occurrence network are shown in Figure 4, and the keyword structure highlights several major theme areas, as presented in Table 4. The first cluster contained terms such as wound dressing, burn wound, hydrogel, chitosan, and diabetic foot ulcer. Thus, these keywords are related to wound healing and repair technologies. A second group highlighted bioactive triterpenes and mechanistic skin biology, represented by asiaticoside, madecassoside, asiatic acid, collagen, oxidative stress, inflammation, and fibroblast terms. The third cluster showed strong interlinkages with cosmetic and dermocosmetic applications, such as skincare, cosmetics, skin barrier, skin hydration, and anti-aging. Terms associated with keloid biology, scar remodeling and delivery systems such as liposomes, microneedle patches, and nanofibers were also identified.

Table 4. Major keyword clusters, thematic interpretations, and emerging research hotspots.

Cluster	Representative keywords	Interpretation	Developmental status
Wound healing and dressings	wound healing; wound dressing; burn wound; hydrogel; chitosan; diabetic foot ulcer	Core therapeutic and biomaterials-oriented foundation of the field	Highly represented
Bioactive triterpenes and mechanisms	asiaticoside; madecassoside; asiatic acid; collagen; oxidative stress; inflammation; fibroblast	Mechanistic explanation for skin repair, scar modulation, and anti-inflammatory actions	Well represented
Cosmetic and skincare translation	skincare; cosmetics; skin barrier; skin hydration; anti-aging	Movement toward cosmetic or dermocosmetic outcomes and barrier-supportive formulations	Increasingly represented
Scar and remodeling biology	keloid; hypertrophic scar; collagen signaling; TGF-beta/Smad	Focus on abnormal healing and tissue remodeling	Moderately represented
Advanced delivery and formulation	hydrogel; liposome; microneedle patch; nanofibers	Sign of formulation engineering and translational product design	Emerging

Note: Keyword clusters were derived from the co-occurrence analysis of author keywords after harmonization of near-equivalent terms during data cleaning. Representative keywords are shown to aid interpretation of the thematic structure.

**Figure 4.** Co-occurrence network of author keywords showing the main thematic clusters in *Centella asiatica* research related to cosmetic and skin applications.

Thematic Evolution and Emerging Trends

Three significant development themes were identified in the analysis of time keywords. Between 2000 and 2010, the literature focused relatively on wound healing, triterpenes and medicinal plant framing. From 2011 to 2018, the theme expanded to include asiaticoside, madecassoside, collagen, keloid biology, and fibroblast mechanisms. From 2019–2026, the most recent literature focused on wound

dressings, skin, cosmetics, antioxidant activity, anti-inflammation, hydrogel systems, skin barriers, and diabetic wound models. The thematic landscape and time evolution of the field are depicted in Figure 5. Moreover, Figure 6 depicts the thematic knowledge structure, translational hotspots, and future directions. The overall temporal trend revealed a shift from early focus on phytotherapy and wound treatment toward broadening the context, such as formulation, biomaterials, and skin applications.

DISCUSSION

According to the findings of this study, investigations involving *C. asiatica* for cosmetic and skin-related applications have undergone notable growth in the past two decades. Furthermore, the rate of growth appears to have accelerated rapidly after the year 2020. Hence, *C. asiatica* is no longer peripheral to skin-related investigations. It is clearly an established subject of translational skin science and dermocosmetic investigations (2, 25, 26). Nonetheless, this expansion was not uniform across all the application areas. A review of the literature revealed that wound healing, scar biology, fibroblast modulation, collagen-related pathways, and triterpene-based mechanistic studies are the most studied topics (4, 6, 7, 11, 25, 27-36). A recent global botanical-skincare bibliometric study likewise reported rapid growth (12.3% annually, 2000–2024) but identified the United States as the leading country. In contrast, research specifically on *C. asiatica* was concentrated in China, Thailand, and India, highlighting the influence of regional medicinal use and scientific expertise.

The citation profile and keyword system further corroborate the centrality of this therapeutic base. The most highly cited papers were related to wound healing, burn repair, and hypertrophic scar treatment, as well as fibroblast signaling and the newest delivery systems for tissue repair (11, 25, 28, 32, 37). Similarly, other frequently occurring keywords included healing, asiaticoside, madecassoside, wound dressing, collagen, inflammation, oxidative stress, and hydrogel (4, 27, 30, 34, 38). Overall, the literature on the skin-related use of *C. asiatica* is considerably focused on regenerative/repair-like biology. Its relevance to cosmetic science therefore appears to rest on a strong therapeutic and mechanistic foundation rather than on product-led interest alone (6, 29, 33, 36).

The distribution of publication sources also supports this interpretation. The Journal of Ethnopharmacology has a strong influence on the field, but there is also a good representation from journals devoted to wound care, biomaterials, immunopharmacology and mechanistic dermatology. These findings suggest that the field remains dominated by pharmacognosy and translational skin

repair research. While there are representations from cosmetic and cosmetic-dermatology journals, the bulk of publications are from journals related to ethnopharmacology, wound care, biomaterials and mechanistic dermatology. The current literature appears to be dominated by studies investigating mechanistic plausibility and therapeutic relevance rather than rigorous validations of cosmetic endpoints (1, 2, 29, 30).

Geographical data on research output offer another useful perspective. According to the present analysis, the most productive countries were China, Thailand and India, while several of the top institutions were in Thailand and China. This concentration aligns with the historical medicinal use of *C. asiatica* in Asia, regional knowledge of plant pharmacology, and the proven role of plant materials in traditional and modern-day skincare. In addition, the prevalence of single-country publications indicates that the field is only moderately internationalized. Cross-national collaboration is becoming increasingly important for methodological harmonization, external validation, and multicenter clinical evidence development, which is becoming increasingly relevant for areas linked to cosmetic and dermocosmetic claims (13, 14, 39).

The analysis of thematic evolution clarified the development path of the field. The initial research in this domain was restricted mostly to framing medicinal plants, healing wounds and some triterpenes. During the middle period, the literature shifted toward collagen, scar biology, and fibroblast mechanisms. According to studies in the past few years, the use of terms such as wound dressings, hydrogels, skin barriers, skin care applications, cosmetics or dermocosmetic formulations has increased, which is indicative of a greater trend toward focused and biomaterial-enabled translation. Various types of studies cover these themes to different extents. On the basis of all the findings thus far, it can be concluded that the field has not only increased in volume but also shifted from mainly therapeutic wound repair bases to broader translational space that increasingly includes dermocosmetic and skincare applications. Much of the literature on wound healing and scar biology remains focused on applications. Although some studies have

entered clinical settings, relatively few have evaluated everyday cosmetic outcomes such as hydration, elasticity, wrinkle reduction, pigmentation control, and long-term barrier restoration in humans (2, 3, 30). This discrepancy may reflect structural differences in research incentives and study feasibility: wound-healing research benefits from established preclinical models, clearly measurable therapeutic endpoints, and stronger clinical and funding priorities, whereas cosmetic trials often require longer follow-up, validated consumer-relevant measures, standardized formulations, and costly controlled designs. In addition, commercially sponsored cosmetic studies may remain proprietary or unpublished.

The distinction between therapeutic dermatology and cosmetic translation is key to interpreting the present findings because the visibility of *C. asiatica* in the literature does not necessarily mean that cosmetic usefulness has been demonstrated to the same degree across outcome types. There is growing interest in sensitive skin care. Researchers are looking at barrier-supportive care, postlaser recovery, and postprocedure soothing formulations (13, 14, 39). Nonetheless, bibliometric prominence should not be interpreted as strong clinical evidence of cosmetic benefit (40-42). The literature highlights mostly themes pertaining to wound healing and mechanistic skin biology, while evaluation of ingredient/consumer-relevant cosmetic outcomes has been relatively less developed. As a result, the area attracted a great deal of mechanistic and translational interest, but fewer clinically oriented studies have addressed broad cosmetic claims across marketed outcome domains.

The literature highlights another essential issue: the standardization and comparability of formulations. Despite the frequent mention of triterpenes such as asiaticoside and madecassoside, visibility through bibliometrics does not ensure comparable analyses. *C. asiatica* influences the dermatological and cosmetic parameters depending on the plant source, extraction method, phytochemical ingredients, degree of purification, dose, formulation medium, and design of the delivery system (11, 16, 17, 43). Owing to the variable reporting of extract composition and formulation factors, it is often difficult to compare effects across study reports and to

distinguish between ingredient-driven effects and carrier effects. This is a challenging area of study, as commercial translation requires not only mechanistic plausibility but also reproducible formulation performance and clinically significant endpoints (16, 17). This means that further development of the discipline in real terms will depend not only on the discovery of interesting extracts or triterpenes but also on the demonstration that certain formulations operate consistently in well-defined cosmetic settings. The reported efficacy is also dependent on the vehicle type, active concentration, dosage schedule, user population, comparator selection and endpoint specification. The current analysis highlights major research gaps, translational challenges and future prospects. Crucially, the questions asked are not trivial minutiae but fundamental challenges that dictate how persuasively the topic moves from mechanistic promise to clinically useful cosmetic proof. These gaps include limited clinical cosmetic evidence, variable extract standardization, insufficient international collaboration, weak linkage between formulations and consumer-relevant outcomes, and incomplete alignment between cosmetic claims and supporting evidence, as summarized in Table 5.

The clusters of keywords indicate that formulation science is becoming more prominent, although this is not yet fully integrated with cosmetic clinical evaluation. The emergence of terms such as hydrogels, wound dressings, nanofibers, liposomes, and microneedle patches signifies the growing importance of delivery systems and material-based strategies (44, 45). Most of these are therapeutic and related to wound care, scar management or postprocedural use rather than daily cosmetic use. A key challenge in the field of skin repair is linking promising technologies to clinically relevant cosmetic outcomes that are defensible to consumers and regulators (13, 14, 39). An integrative conceptual summary of the evolution of the field and possibilities for future development is presented in Figure 6. Industrially, standardized and traceable *C. asiatica* ingredients may support sustainable sourcing, green cosmetics, evidence-based cosmeceuticals, and products tailored to specific skin conditions. Translation will require reproducible extracts and formulations together with clinically supported claims.

Table 5. Main research gaps, translational limitations, and future directions identified in the field.

Area	Current pattern	Limitation	Recommended next step
Clinical cosmetic evidence	Small number of recent human studies	Heterogeneous designs and endpoints	Standardized randomized or controlled clinical studies
Extract standardization	Frequent reference to triterpenes but variable extract descriptions	Limited cross-study comparability	Report full phytochemical fingerprints and source materials
Collaboration	Mostly single-country publications	Moderate international fragmentation	Build multicenter and multicountry consortia
Formulation science	Growing interest in hydrogels, liposomes, and dressing systems	Limited linkage to consumer-relevant cosmetic outcomes	Bridge formulation performance with clinical skin endpoints
Cosmetic claims	Strong mechanistic rationale	Risk of misalignment between mechanistic promise and clinically validated cosmetic endpoints	Align claims with evidence tier
Institutional concentration	Strong output from selected Asian institutions	Possible regional silos	Broaden geographic participation and validation studies

Notably, traditional use, mechanistic investigation, and translational application in the literature on *C. asiatica* are clearly linked (4, 27). The literature portrays a reasonably consistent story of translation. In addition, the literature remains heavily focused on wound-healing and repair narratives, and this may have caused further limitations in the broader diversification of the evidence base. Compared with routine cosmetic evaluation, skin repair has been performed more extensively (1, 2). More specialized studies that not only assess antioxidant, anti-inflammatory, and skin-repair activities but also evaluate standardized *C. asiatica* preparations in well-designed human studies using specific cosmetic endpoints are likely to strengthen the field (2, 13, 14, 39). Cumulatively, the literature supports *C. asiatica* as a scientifically credible and translationally relevant botanical suitable for skin application, although its evidence base in cosmeceuticals is uneven in depth, endpoint specificity and clinical maturity. The promise of *C. asiatica* will be strengthened by clearer standardization and by determining which preparations, formulations, and indications are supported by the most consistent evidence (16, 17).

The main strengths of this study are the well-defined Scopus dataset, precise eligibility criteria, and methodical analytical approach. Moreover, the application of productivity metrics, citation analysis, collaboration mapping, keyword co-occurrence and thematic evolution analysis allows a comprehensive

assessment of the field rather than a single-metric assessment (46). This approach allowed us to characterize not only the growth of publications but also the intellectual organization, subject priorities and translational direction of the literature. Moreover, widely known bibliometric tools and science mapping approaches enable a clear and uniform interpretation of the data (47).

Several limitations should be noted. First, we limited our analysis to Scopus-indexed publications. Using a single database might have excluded relevant studies indexed elsewhere or published in regional sources (46, 48-50). Focusing only on original research papers written in English may have limited the analysis and introduced a language bias. Additionally, the choice of publications may overlook work with local relevance from areas where *C. asiatica* is still an important plant. Citation-based metrics are influenced by time lag effects. More specifically, recent publications had a lower likelihood of receiving citations and thus had fewer citations than older studies did (46, 50). The methodology also has limitations because of the sensitivity of keyword analysis to both lexical variation and author keyword selection, as well as to changes in conceptual vocabulary over time (48, 50). As normalization procedures do not account for them, institution-level statistics could be affected by residual variation in affiliation naming. Finally, bibliometric analysis can be used to identify structure across the literature but not

methodology, clinical rigor, or level of evidence. Consequently, high publication or citation visibility should not be interpreted as a proxy for high-quality clinical validation (46, 48-50). In addition, the search strategy may not have captured studies that described proprietary ingredients or commercial formulations without explicitly mentioning *C. asiatica* in the title, abstract, or keywords.

Future studies should consider combining multiple bibliographic databases with a systematic appraisal of clinical study quality, formulation standardization, and evidence supporting specific cosmetic outcomes. Periodic bibliometric updates may also help determine whether the field is progressing from mechanistic and wound-healing research toward stronger human cosmetic evidence. Future bibliometric studies may complement raw citation counts with field- and time-normalized indicators, such as the FWCI or annualized citation rates, where these data are consistently available.

CONCLUSION

Through a Scopus-based bibliometric analysis, we found that research on cosmetic and skin-related applications of *C. asiatica* has increased markedly over the years. There is now enough literature available to define an explicit intellectual and translational core focusing on wound healing, triterpene-associated bioactivity, fibroblast-related mechanisms, scar biology, and biomaterial-assisted skin repair. Recent studies indicate growing interest in skincare, barrier-supporting formulations, and dermocosmetic applications. However, the strength of the evidence remains uneven. While mechanistic and preclinical research continues to increase in volume, clinical studies of routine cosmetic use remain limited and heterogeneous. On the whole, these findings lend weight to *C. asiatica* as a scientifically credible and translationally useful botanical candidate for skin-related applications and show that clinical evidence for cosmetic applications remains less well developed than the mechanistic wound-repair literature does. Thus, the present study helps clarify that the future of this field will depend not only on continued growth in publications but also on stronger clinical validation, clearer extract standardization, and better alignment between mechanistic findings and real cosmetic

endpoints. Future developments will depend on greater consistency of extracts, better clarification of formulations, more rigorous human trials using clinically relevant cosmetic endpoints and international collaboration. It is important to address all these priorities to generate a stronger clinical and commercially defensible evidence base from bibliometric momentum.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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