



# Bibliometric analysis of antibacterial activity of *Centella asiatica*: A study based on Scopus database

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## ABSTRACT

*Centella asiatica* (L.) Urb. has been recognized as a brain tonic. Other effects of *C. asiatica* have been widely investigated and reported, such as its antibacterial effect. However, there is no bibliometric study on this topic. Therefore, we performed bibliometric analysis to examine the papers related to the study of *C. asiatica* as an antibacterial agent. Bibliographic information of pertinent studies was collected from Scopus database. In this study, 89 papers published between 1997 and 2022 were selected. Bibliometric analysis was performed using Visualization of Similarities viewer (VOSviewer) version 1.6.18. Having been analyzed, it was found that Ubon Ratchathani University from Thailand was the most productive affiliation and the *Journal of Ethnopharmacology* was the most productive journal on the topic of antibacterial activity of *C. asiatica*. India was the most productive and the most collaborating country. According to the study of the most influential papers, author-based bibliographical coupling network, as well as keyword co-occurrence network and overlay, the variants of selected papers were from solvent extraction, bacteria-tested, plant components, and product formulations. We also found out that, following the formulation approach, both *in vivo* preclinical and clinical trials on this topic remain a potential study to be investigated to embrace phytomedicine as a therapeutic option.

## INTRODUCTION

Nearly every place on Earth contains bacteria, including the human body. Bacteria are found on the skin, nose, mouth, throat, vagina, and gut. Some bacteria are pathogenetic. Numerous mechanisms are used by pathogenic bacteria to wreak harm on human hosts (Wilson, 2002). One of the immunological defenses against bacterial infection is formed by human skin. Numerous bacteria can come into contact with or settle on the skin (Aljamali *et al.*, 2021). They typically wait until the skin is damaged before getting access to the underlying tissue (Sharma *et al.*, 2021). The condition of infection and the ability of bacteria to replicate depend on whether the skin damage is classified as

inflamed, colonized, localized/critically colonized, or invasively spread (Sharma *et al.*, 2021). When bacterial skin infections do arise, they can affect any part of the body, either a small patch or the full surface. They may be mild or potentially fatal, depending on their severity (Ki and Rotstein, 2008).

Natural compounds with antibacterial activity can be thought of as possible natural antibiotics (Pancu *et al.*, 2021). Many natural compounds have been reported to have antibacterial activity (Tafroji *et al.*, 2022), for example, *Centella asiatica* (Chauhan *et al.*, 2009; Nasution *et al.*, 2018; Restuati and Dinigrat, 2018). Common names for *C. asiatica* include Asiatic pennywort and Gotu kola (Shukurova *et al.*, 2021). It is a member of Umbelliferae family (Apiaceae) (Gohil *et al.*, 2010; Shukurova *et al.*, 2021) and a native plant from Southeast Asia (Chandrika and Prasad Kumara, 2015; Orhan, 2012). Phytosterols, triterpenoid saponins, genin triterpenoids, essential oils, and flavonoids are only a few of *C. asiatica* active components (Irham *et al.*, 2019).

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Tracking literature for a pertinent topic has been challenging for researchers due to the recent rapid growth in the volume of research work. Therefore, bibliometric analysis methods were used to handle this vast amount of data (Zupic and Čater, 2015). A bibliometric study is usually used to assess the quality and quantity of published papers in order to identify trends in a given topic of study (Zuraidi *et al.*, 2022). Large amounts of scientific data were investigated and analyzed by using bibliometric software, such as Visualization of Similarities viewer (VOSviewer), and scientific databases, such as Scopus (Donthu *et al.*, 2021). A bibliometric study had been conducted using Derwent Data Analyzer to investigate papers on the subject of antibiotic-resistant bacteria that were obtained from the Web of Science between 2010 and 2020 (Sun *et al.*, 2022). In the other studies, VOSviewer was used to determine the top 100 articles on the subject of antibiotics that were gathered from the Web of Science (Arshad *et al.*, 2020). In this study, bibliometric analysis was conducted to explore papers related

to the antibacterial activity of *C. asiatica* in order to help other researchers in finding prospects for future study, prospects for collaboration with other institutions or authors, and impacted journals for publication of any study on this topic.

## MATERIALS AND METHODS

### Data collection

Published papers about *C. asiatica* as an antibacterial agent were collected from Scopus database on November 10, 2022. Scopus database was chosen because it is a more thorough and larger database than the Web of Science, and it is beneficial both in keyword searching and citation analysis (Bamel *et al.*, 2020; Effendi *et al.*, 2021; Falagas *et al.*, 2008). Google Scholar was not used since its poor data quality raises concerns about its usefulness for research evaluation (Mongeon and Paul-Hus, 2016). Data collection was performed by the following search: [TITLE-ABS-KEY ("Centella asiatica")

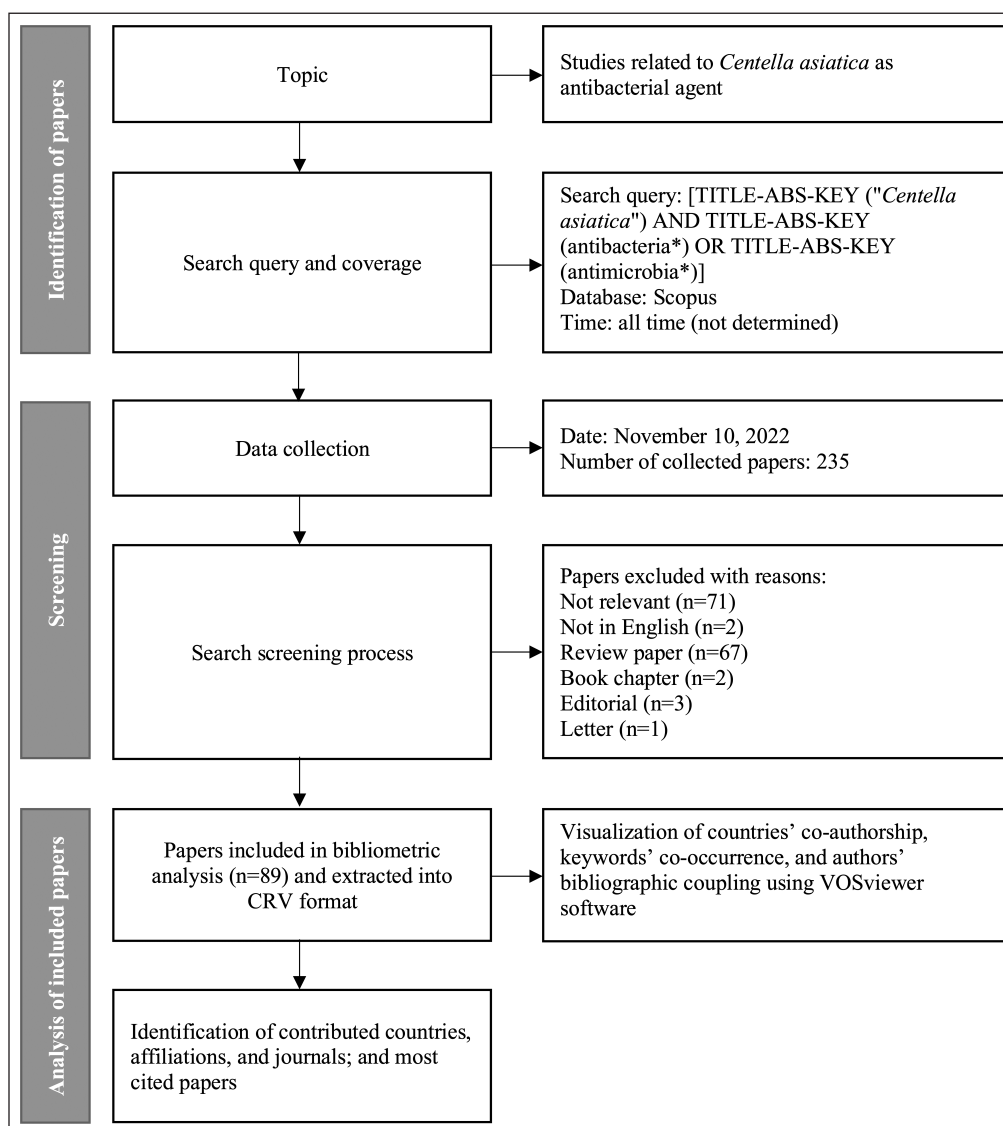


Figure 1. Flowchart of study methodology.

AND TITLE-ABS-KEY (antibacteria\*) OR TITLE-ABS-KEY (antimicrobia\*)]. The double quotation marks indicate a loose or approximate phrase. The asterisk or star-shaped symbol stands for any combination of characters in Scopus data syntax (Ha *et al.*, 2020). The search was limited to title, abstract, and keywords. The range of years was not determined.

### Data screening, extraction, and analysis

Only published papers that met the inclusion criteria would be analyzed. Original articles, conference papers, writing in English, and a study of the antibacterial activity of *C. asiatica* were among the inclusion criteria. Figure 1 provides a summary of the record-gathering and study-elimination procedure. For further analysis, the selected papers were extracted into CRV format (file.crv) and exported to VOSviewer version 1.6.18 as a bibliometric tool (Ha *et al.*, 2020). Countries' co-authorship, keywords' co-occurrence, and authors' bibliographic coupling were presented as network visualization maps. The items (countries, keywords, and authors) were visualized as a bubble. The size of the bubble is reflected by the weight of each item (van Eck and Waltman, 2022; Yeung *et al.*, 2020), which is proportional (Romero and Portillo-Salido, 2019). The color of the bubble describes the cluster where the item belongs.

Bubbles are connected by lines that represent links. The distance between the two bubbles represents the relatedness of co-authorship, co-occurrence, and bibliographic coupling between the items (Romero and Portillo-Salido, 2019). The full counting method was used in this study.

## RESULTS

### Publication trends

Among 235 of the collected published papers related to the antibacterial activity of *C. asiatica*, only 89 papers met the inclusion criteria (Table 1). All selected papers included 72 journals and 376 authors. The oldest paper was published in 1997 by *Fitoterapia* entitled "Antibacterial activity of *Centella asiatica*" (Srivastava *et al.*, 1997). The most recent paper was published in 2022 by the *Research Journal of Pharmacognosy* about the antimicrobial properties of *C. asiatica* and other plant extracts against *Staphylococcus aureus*, *Pseudomonas aeruginosa*, *Acinetobacter baumannii*, and methicillin-resistant *S. aureus* (Tavakoli *et al.*, 2022).

The number of publications on the topic of antibacterial activity of *C. asiatica* fluctuated over the years (Fig. 2). Between 1998 and 2002, and in 2013, there was no published paper on this topic. In 2020, scientists were expected

**Table 1.** Selected papers from early to recent years.

Authors	Title	Journal
Srivastava <i>et al.</i> (1997)	Antibacterial activity of <i>Centella asiatica</i>	Fitoterapia
Hamill <i>et al.</i> (2003)	Traditional herbal drugs of Southern Uganda, II: Literature analysis and antimicrobial assays	Journal of Ethnopharmacology
Sheela and Kannan (2003)	Antibacterial activities of medicinal plants <i>Thespesia populnea</i> , <i>Centella asiatica</i> and <i>Solanum trilobatum</i>	Asian Journal of Microbiology, Biotechnology and Environmental Sciences
Voravuthikunchai <i>et al.</i> (2004)	Effective medicinal plants against enterohaemorrhagic <i>Escherichia coli</i> O157:H7	Journal of Ethnopharmacology
Zaidan <i>et al.</i> (2005)	<i>In vitro</i> screening of five local medicinal plants for antibacterial activity using disc diffusion method.	Tropical Biomedicine
Oyedeki and Afolayan (2005)	Chemical composition and antibacterial activity of the essential oil of <i>Centella asiatica</i> growing in South Africa	Pharmaceutical Biology
Chomnawang <i>et al.</i> (2005)	Antimicrobial effects of Thai medicinal plants against acne-inducing bacteria	Journal of Ethnopharmacology
Parekh and Chanda (2006)	Screening of aqueous and alcoholic extracts of some Indian medicinal plants for antibacterial activity	Indian Journal of Pharmaceutical Sciences
Ngomdir <i>et al.</i> (2007)	Antibacterial evaluation of the extracts of edible parts of few plants used by tribal people of Tripura, India	Journal of Pure and Applied Microbiology
Pieme <i>et al.</i> (2008)	<i>In vitro</i> antimicrobial activity of extracts from some Cameroonian medicinal plants	Journal of Biological Sciences
Wei <i>et al.</i> (2008)	Antimicrobial properties of tropical plants against 12 pathogenic bacteria isolated from aquatic organisms	African Journal of Biotechnology
Kunta and Vadlapudi (2009)	<i>In vitro</i> antibacterial potentiality of <i>Centella asiatica</i>	Biomedical and Pharmacology Journal
Bobbarala and Maduri (2009)	<i>In vitro</i> antimicrobial activity of certain medicinal plant extracts against pathogens of sorghum	Journal of Pure and Applied Microbiology
Chauhan <i>et al.</i> (2009)	Antibacterial activity of <i>Centella asiatica</i> against seven pathogenic bacteria isolated from the urine of diabetic patients	Biomedicine (India)
Ullah <i>et al.</i> (2009)	Antimicrobial, cytotoxic and antioxidant activity of <i>Centella asiatica</i>	European Journal of Scientific Research

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Authors	Title	Journal
Rattanachaikunsopon and Phumkhachorn (2010)	Use of Asiatic pennywort <i>Centella asiatica</i> aqueous extract as a bath treatment to control columnaris in Nile tilapia	Journal of Aquatic Animal Health
Khurana <i>et al.</i> (2010)	Antioxidant and antimicrobial activity in some Indian herbal plants: Protective effect against free radical mediated DNA damage	Journal of Plant Biochemistry and Biotechnology
Vimal <i>et al.</i> (2010)	Anti-bacterial activity of herbal extracts, EuMiL® and antibiotics against <i>Helicobacter muridarum</i>	Pharmacognosy Journal
Jamal <i>et al.</i> (2011)	Phytochemical screening for antibacterial activity of potential Malaysian medicinal plants	African Journal of Biotechnology
Arumugam <i>et al.</i> (2011)	Phytochemical screening and antibacterial activity of leaf and callus extracts of <i>Centella asiatica</i>	Bangladesh Journal of Pharmacology
Bibi <i>et al.</i> (2011)	Regeneration of <i>Centella asiatica</i> plants from non-embryogenic cell lines and evaluation of antibacterial and antifungal properties of regenerated calli and plants	Journal of Biological Engineering
Lee and Vairappan (2011)	Antioxidant, antibacterial and cytotoxic activities of essential oils and ethanol extracts of selected South East Asian herbs	Journal of Medicinal Plant Research
Mohamad <i>et al.</i> (2011)	Antituberculosis potential of some ethnobotanically selected Malaysian plants	Journal of Ethnopharmacology
Garvey <i>et al.</i> (2011)	Medicinal plant extracts with efflux inhibitory activity against Gram-negative bacteria	International Journal of Antimicrobial Agents
Justin Packia Jacob and Shenbagaraman (2011)	Evaluation of antioxidant and antimicrobial activities of the selected green leafy vegetables	International Journal of PharmTech Research
Panomket <i>et al.</i> (2012)	Bioactivity of plant extracts against <i>Burkholderia pseudomallei</i>	Asian Biomedicine
Vadlapudi <i>et al.</i> (2012)	Antimicrobial profile of crude extracts <i>Calotropis procera</i> and <i>Centella asiatica</i> against some important pathogens	Indian Journal of Science and Technology
Rafat <i>et al.</i> (2012)	A novel source of bioactive compounds: Endophytic bacteria isolated from <i>Centella asiatica</i>	Journal of Pure and Applied Microbiology
Udaya Prakash <i>et al.</i> (2012)	A study on antibacterial activity of common weeds in Northern districts of Tamil Nadu, India	Research Journal of Medicinal Plant
Kalita and Saikia (2012)	Ethnomedicinal, antibacterial and antifungal potentiality of <i>Centella asiatica</i> , <i>Nerium indicum</i> and <i>Cuscuta reflexa</i> —widely used in Tiwa Tribe of Morigaon district of Assam, India	International Journal of Phytomedicine
Sultan <i>et al.</i> (2014)	Biological activities assessment of <i>Centella asiatica</i> (Linn.)	Journal of Herbs, Spices and Medicinal Plants
Panathula <i>et al.</i> (2014)	Phytochemical investigation and <i>in vitro</i> antimicrobial activity of <i>Centella asiatica</i> (L.) Urban. A potent antijaundice medicinal plant	International Journal of Phytomedicine
Sood and Yadav (2014)	Phytochemical screening and antimicrobial activity of four members of family apiaceae	International Journal of Phytomedicine
Kannahi and Dhivya (2014)	Production of health drink using effective microorganisms and medicinal plant extracts	Journal of Chemical and Pharmaceutical Research
Netala <i>et al.</i> (2015)	First report of biomimetic synthesis of silver nanoparticles using aqueous callus extract of <i>Centella asiatica</i> and their antimicrobial activity	Applied Nanoscience (Switzerland)
Logeswari <i>et al.</i> (2015)	Synthesis of silver nanoparticles using plants extract and analysis of their antimicrobial property	Journal of Saudi Chemical Society
Rattanakom and Yasurin (2015)	Chemical profiling of <i>Centella asiatica</i> under different extraction solvents and its antibacterial activity, antioxidant activity	Oriental Journal of Chemistry
Machado <i>et al.</i> (2015)	Screening antimycobacterial activity of <i>Baccharis dracunculifolia</i> , <i>Centella asiatica</i> , <i>Lantana camara</i> and <i>Pterodon emarginatus</i> [Atividade anti-micobacteriana de <i>Baccharis dracunculifolia</i> , <i>Centella asiatica</i> , <i>Lantana camara</i> e <i>Pterodon emarginatus</i> ]	Revista Brasileira de Plantas Mediciniais
Phumkhachorn and Rattanachaikunsopon (2015)	Use of <i>Cassia alata</i> aqueous extract as a bath treatment to control <i>Pseudomonas anguilliseptica</i> infection in tilapia ( <i>Oreochromis niloticus</i> )	Archives of Biological Sciences
Valle <i>et al.</i> (2015)	Antibacterial activities of ethanol extracts of Philippine medicinal plants against multidrug-resistant bacteria	Asian Pacific Journal of Tropical Biomedicine
Panda <i>et al.</i> (2016)	Large scale screening of ethnomedicinal plants for identification of potential antibacterial compounds	Molecules

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Authors	Title	Journal
Vijayarekha and Sengottaiyan (2016)	Study on the synergistic effect of ethanolic leaf extracts against some pathogenic microorganisms	Research Journal of Pharmaceutical, Biological and Chemical Sciences
Dhiman <i>et al.</i> (2016)	<i>In Vitro</i> antimicrobial activity of spices and medicinal herbs against selected microbes associated with juices	International Journal of Microbiology
Al-Talib <i>et al.</i> (2016)	Antimicrobial effect of Malaysian vegetables against enteric bacteria	Asian Pacific Journal of Tropical Biomedicine
Jose <i>et al.</i> (2017)	Development of a novel herbal formulation to inhibit biofilm formation in toxigenic vibrio cholera	Journal of Food Protection
Choi <i>et al.</i> (2017)	Antimicrobial and anti-biofilm activities of the methanol extracts of medicinal plants against dental pathogens <i>Streptococcus mutans</i> and <i>Candida albicans</i>	Journal of Microbiology and Biotechnology
Idris and Nadzir (2017)	Antimicrobial activity of <i>Centella asiatica</i> on <i>Aspergillus niger</i> and <i>Bacillus subtilis</i>	Chemical Engineering Transactions
Soyingbe <i>et al.</i> (2018)	<i>In vitro</i> antibacterial and cytotoxic activity of leaf extracts of <i>Centella asiatica</i> (L.) Urb, <i>Warburgia salutaris</i> (Bertol. F.) Chiov and <i>Curtisia dentata</i> (Burm. F.) C.A.Sm—medicinal plants used in South Africa	BMC Complementary and Alternative Medicine
Kesornbuakao <i>et al.</i> (2018)	The antibacterial and antioxidant activity of <i>Centella asiatica</i> chloroform extract-loaded gelatin nanoparticles	MATEC Web of Conferences
Jantarat <i>et al.</i> (2018)	<i>In vitro</i> antimicrobial activity of gel containing the herbal ball extract against <i>Propionibacterium acnes</i>	Scientia Pharmaceutica
Nasution <i>et al.</i> (2018)	Antimicrobial activities of <i>Centella asiatica</i> leaf and root extracts on selected pathogenic micro-organisms	Journal of Medical Sciences (Faisalabad)
Rekha <i>et al.</i> (2018)	Antibacterial efficacy and minimum inhibitory concentrations of medicinal plants against wound pathogens	Biomedical and Pharmacology Journal
Restuati and Diningrat (2018)	Antimicrobial profile of <i>Premna pubescens</i> . Blume and <i>Centella asiatica</i> extracts against bacteria and fungi pathogens	International Journal of Pharmacology
Rebia <i>et al.</i> (2019)	Natural antibacterial reagents (Centella, propolis, and hinokitiol) loaded into poly[(R)-3-hydroxybutyrate-co-(R)-3-hydroxyhexanoate] composite nanofibers for biomedical applications	Nanomaterials
Sardrood <i>et al.</i> (2019)	Chemical Composition and Biological Activity of Essential Oils of <i>Centella asiatica</i> (L.)	Toxicology and Environmental Health Sciences
Kanchan <i>et al.</i> (2019)	Virulence of <i>Aeromonas hydrophila</i> in Siamese fighting fish ( <i>Betta splendens</i> ) and the bacterium susceptibility to some herbal plants	Iranian Journal of Fisheries Sciences
Rukisah <i>et al.</i> (2019)	<i>In vitro</i> antibacterial efficacy of leaves extract of <i>Centella asiatica</i> against <i>Vibrio harveyi</i> and <i>Aeromonas hydrophila</i>	Indonesian Aquaculture Journal
Sari <i>et al.</i> (2019)	The application of multiplate resazurin reduction assay in the screening for anti-mycobacterial activity from Indonesian medicinal plants	Indonesian Journal of Pharmacy
Selvam <i>et al.</i> (2019)	Effects of extraction methods on antibacterial activity of <i>Centella asiatica</i> leaves against pathogenic <i>Staphylococcus aureus</i> and <i>Escherichia coli</i>	International Journal of Medical Toxicology and Legal Medicine
Mahmud <i>et al.</i> (2020)	Synergistic-antagonistic interaction of vegetable extracts, <i>Acalypha indica</i> , <i>Centella asiatica</i> , and <i>Sesbania grandiflora</i> : Wound healing, antioxidant, protectivity, and antimicrobial properties	Malaysian Journal of Microbiology
Mouro <i>et al.</i> (2020)	Preparation and characterization of electrospun double-layered nanocomposites membranes as a carrier for <i>Centella asiatica</i> (L.)	Polymers
Irham <i>et al.</i> (2020)	Phytochemicals screening and antibacterial activity of <i>Curcuma longa</i> linn, <i>Ziziphus mauritiana</i> and <i>Centella asiatica</i> L.Urban extract	Rasayan Journal of Chemistry
Park (2020)	Towards versatile protein fabrics: UV protection and antimicrobial property dyeing with <i>Centella asiatica</i> (L.) into silk	Fibers and Polymers
Saha and Bandyopadhyay (2020)	<i>In vivo</i> and <i>in vitro</i> antimicrobial activity of phytol, a diterpene molecule, isolated and characterized from <i>Adhatoda vasica</i> Nees. (Acanthaceae), to control severe bacterial disease of ornamental fish, <i>Carassius auratus</i> , caused by <i>Bacillus licheniformis</i> PKBMS16	Microbial Pathogenesis
Wahdany <i>et al.</i> (2020)	Antibacterial activity of asiaticoside towards <i>Enterococcus faecalis</i> in periapical infections	Biochemical and Cellular Archives
Pham <i>et al.</i> (2020)	Green synthesis and antibacterial activity of HAp@Ag nanocomposite using <i>Centella asiatica</i> (L.) urban extract and eggshell	International Journal of Biomaterials

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Authors	Title	Journal
Syed Zameer Ahmed <i>et al.</i> (2020)	Fabrication and evaluation of bamboo fabric coated with extracts of <i>Curcuma longa</i> , <i>Centella asiatica</i> and <i>Azadirachta indica</i> as a wound dressing material	Advances in Traditional Medicine
Sieberi <i>et al.</i> (2020)	Screening of the dichloromethane: Methanolic extract of <i>Centella asiatica</i> for antibacterial activities against <i>Salmonella typhi</i> , <i>Escherichia coli</i> , <i>Shigella sonnei</i> , <i>Bacillus subtilis</i> , and <i>Staphylococcus aureus</i>	Scientific World Journal
Rashmi <i>et al.</i> (2020)	Facile green synthesis of silver oxide nanoparticles and their electrochemical, photocatalytic and biological studies	Inorganic Chemistry Communications
Wang <i>et al.</i> (2021)	Preparation of <i>Centella asiatica</i> loaded gelatin/chitosan/nonwoven fabric composite hydrogel wound dressing with antibacterial property	International Journal of Biological Macromolecules
Pavan Kumar <i>et al.</i> (2021)	<i>Centella asiatica</i> mediated facile green synthesis of nano zinc oxide and its photo-catalytic and biological properties	Inorganic Chemistry Communications
Vasanth <i>et al.</i> (2021)	<i>In-vitro</i> study of the effect of <i>Centella asiatica</i> on cholera toxin production and the gene expression level of <i>ctxA</i> gene in <i>Vibrio cholerae</i> isolates	Journal of Ethnopharmacology
Wong <i>et al.</i> (2021)	Assessment of toxic effect of <i>Centella asiatica</i> extract and its application as natural preservative in fresh-cut mango, pear and cabbage	Journal of Food Processing and Preservation
Pakadang <i>et al.</i> (2021)	MIC and MKC analysis of herbal medicine in Indonesia against <i>Mycobacterium tuberculosis</i>	Pharmacognosy Journal
Suresh <i>et al.</i> (2021)	Investigations of bioactivity of <i>Acalypha indica</i> (L.), <i>Centella asiatica</i> (L.) and <i>Croton bonplandianus</i> (Baill) against multidrug resistant bacteria and cancer cells	Journal of Herbal Medicine
Mudaliana (2021)	Antimicrobial activity of <i>Centella asiatica</i> and <i>Gigantochloa apus</i>	Journal of Basic and Clinical Physiology and Pharmacology
Swastini <i>et al.</i> (2021)	Cold cream combination of <i>Garcinia mangostana</i> L. <i>Anredera cordifolia</i> (ten.) and <i>Centella asiatica</i> extracts on burn healing activity test	Research Journal of Pharmacy and Technology
Wong and Ramli (2021)	Antimicrobial activity of different types of <i>Centella asiatica</i> extracts against foodborne pathogens and food spoilage microorganisms	LWT
Raja <i>et al.</i> (2021)	The influence of chocolate fortification with <i>Centella asiatica</i> , <i>Abelmoschus esculentus</i> , and <i>Psidium guajava</i> on the content of biologically active substances	Journal of Food Processing and Preservation
Kuo <i>et al.</i> (2021)	Gelatin/chitosan bilayer patches loaded with cortex <i>Phellodendron amurense</i> / <i>Centella asiatica</i> extracts for anti-acne application	Polymers
Amornopparattanakul <i>et al.</i> (2021)	Development of oral cleansing products containing green tea and <i>Centella asiatica</i> extracts	Key Engineering Materials
Tavakoli <i>et al.</i> (2022)	Synergistic activity of three Iranian medicinal plants in combination with ceftazidime and neomycin against bacterial strains causing nosocomial infections	Research Journal of Pharmacognosy
Khatua <i>et al.</i> (2022)	Evaluation of antimicrobial, anticancer potential and Flippase induced leakage in model membrane of <i>Centella asiatica</i> fabricated MgONPs	Biomaterials Advances
Singh and Lamkang (2022)	Evaluation of antibacterial, antioxidant and cytotoxicity potential of silver nanoparticles synthesized from <i>Phlogacanthus thyrsoformis</i> and <i>Centella asiatica</i>	Medicinal Plants
Milanda <i>et al.</i> (2022)	Antibacterial and cytotoxic activity of selected raw-consumed vegetables in West Java, Indonesia	Pharmacognosy Journal
Haslinda <i>et al.</i> (2022)	Prevalence and antimicrobial susceptibility of non-typhoidal <i>Salmonella</i> (NTS) from salad vegetables at farms and retail markets in Terengganu, Malaysia	Food Research
Rashmi <i>et al.</i> (2022)	Facile green synthesis of lanthanum oxide nanoparticles using <i>Centella asiatica</i> and Tridax plants: Photocatalytic, electrochemical sensor and antimicrobial studies	Applied Surface Science Advances
Mehta <i>et al.</i> (2022)	Role of medicinal plants from North Western Himalayas as an efflux pump inhibitor against MDR AcrAB-TolC <i>Salmonella enterica</i> serovar typhimurium: <i>In vitro</i> and <i>in silico</i> studies	Journal of Ethnopharmacology
Khan <i>et al.</i> (2022)	Anti-quorum sensing, antibiofilm, and antibacterial activities of extracts of <i>Centella asiatica</i> L. leaves, and <i>in vitro</i> derived leaves-calli through tissue culture: a potential for biofouling-prevention	Biofouling

to become more interested in this topic based on the increasing number of papers. The largest number of publications occurred in 2021 with 12 papers.

### Contribution by countries and their collaborations

Twenty-seven countries performed a research study on the antibacterial activity of *C. asiatica* in 89 papers that were selected for this study. The number of papers by the most productive country in the field of the topic is presented in Table 2. The countries in the Asia continent dominated the list. The most productive country was India with 36 papers. It means India has made a noteworthy contribution to this topic compared to the rest of the countries. The second-most productive country was Malaysia with 15 papers, followed by

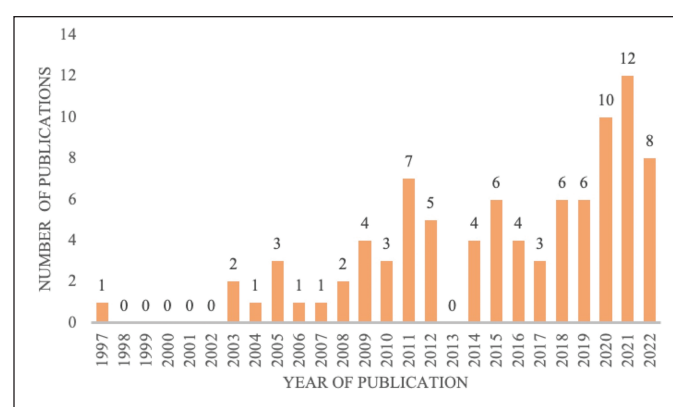


Figure 2. Publication trends on the topic of antibacterial activity of *C. asiatica*.

Table 2. The most productive countries on the topic of antibacterial activity of *C. asiatica*.

No.	Country	Number of papers	Citations	AC <sup>a</sup> per paper
1	India	36	803	22.31
2	Malaysia	15	452	30.13
3	Indonesia	10	31	3.10
4	Thailand	10	460	46.00
5	South Korea	3	80	26.67
6	United Kingdom	3	108	36.00

<sup>a</sup>AC: average number of citations.

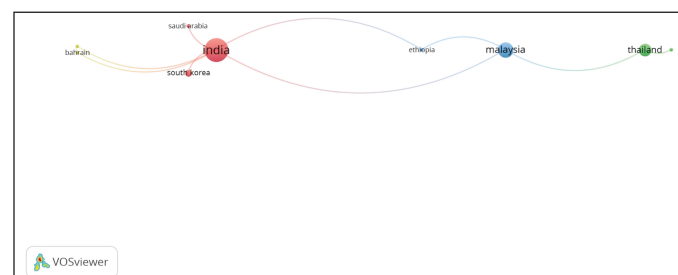


Figure 3. The network visualization of co-authorship analysis of countries on the topic of antibacterial activity of *C. asiatica*.

Indonesia and Thailand with 10 papers. Thailand came with the highest average number of citations (AC) among the most productive countries, followed by the United Kingdom.

The collaborations of countries were visualized using co-authorship analysis with countries as the unit of analysis on VOSviewer. The minimum number of papers and the minimum number of citations for a country were set at 1 and 0, respectively. The network visualization result of collaboration between countries that contributed to the research study on the antibacterial activity of *C. asiatica* is shown in Figure 3. Among 27 countries, the largest connected countries only consisted of nine: India, Saudi Arabia, South Korea, Australia, Thailand, Malaysia, Ethiopia, Bahrain, and Turkey. India had the greatest number of links, which was 6. Therefore, India came out as the country with the biggest collaboration. It collaborated with Saudi Arabia, South Korea, Malaysia, Ethiopia, Bahrain, and Turkey.

### Contribution by affiliations

Based on the 89 selected papers, 160 affiliations provided a research study on the antibacterial activity of *C. asiatica*. Table 3 shows the most productive affiliations, with at least two papers published on the topic. The most productive affiliation was Ubon Ratchathani University, with three papers. Among the 16 affiliations on the list, India had 7 affiliations, Malaysia had 6 affiliations, Thailand had 2 affiliations, and South Korea had 1 affiliation. All of the countries with the most productive affiliations are on the Asian continent. The highest AC among the most productive affiliations was Universiti Sains Malaysia, with 57.50. It indicates that the papers produced by Universiti Sains Malaysia on this topic are more influential than those from Ubon Ratchathani University.

### Contribution by journals

The 89 selected research papers on the antibacterial activity of *C. asiatica* were published in 72 journals. Ten of them published more than one paper. The top four journals with the most papers published on the topic are presented in Table 4. The most productive journal on this topic was the *Journal of Ethnopharmacology* from Elsevier Ireland Ltd. with 6 papers and AC 102.33 (the latest paper on the topic of the antibacterial activity of *C. asiatica* was published in 2022), followed by the *International Journal of Phytomedicine*, the *Journal of Pure and Applied Microbiology*, and the *Pharmacognosy Journal*, which published three papers. *The African Journal of Biotechnology*, the *Asian Pacific Journal of Tropical Biomedicine*, the *Biomedical and Pharmacology Journal*, the *Journal of Food Processing and Preservation*, *Polymers*, and *In Chemistry Communications* published two papers on the topic. This information will assist the scientists in seeking out a specific journal and submitting their reports of study on this topic to those journals (Arifah *et al.*, 2021). *The Journal of Ethnopharmacology* can be considered a targeted journal for the publication of articles on the antibacterial activity of *C. asiatica*.

### Analysis of authors and their bibliographical coupling network

Of the 89 selected papers, 376 authors contributed to the studies of the antibacterial activity of *C. asiatica*. Only 13

**Table 3.** The most productive affiliations on the topic of antibacterial activity of *C. asiatica*.

No.	Affiliations	Country	Number of papers	Citations	AC <sup>a</sup> per paper
1	Ubon Ratchathani University	Thailand	3	23	7.67
2	Universiti Sains Malaysia	Malaysia	2	115	57.50
3	Sapthagiri College of Engineering	India	2	74	37.00
4	Yeungnam University	South Korea	2	55	27.50
5	Visvesvaraya Technological University	India	2	74	37.00
6	International Islamic University Malaysia	Malaysia	2	17	8.50
7	Universiti Malaysia Sabah	Malaysia	2	37	18.50
8	Assumption University, Bangkok	Thailand	2	22	11.00
9	Andhra University	India	2	14	7.00
10	Universiti Malaya	Malaysia	2	9	4.50
11	Universiti Malaysia Terengganu	Malaysia	2	37	18.50
12	East West Institute of Technology	India	2	74	37.00
13	Vemana Institute of Technology	India	2	74	37.00
14	Universiti Pendidikan Sultan Idris	Malaysia	2	8	4.00
15	Vels Institute of Science, Technology & Advanced Studies	India	2	19	9.50
16	Dr. Lankapalli Bullayya College	India	2	14	7.00

<sup>a</sup>AC: average number of citations.

**Table 4.** The most productive journals on the topic of antibacterial activity of *C. asiatica*.

No.	Journal	Number of papers	Citations	AC <sup>a</sup> per paper
1	<i>Journal of Ethnopharmacology</i>	6	614	102.33
2	<i>International Journal of Phytomedicine</i>	3	21	7.00
3	<i>Journal of Pure and Applied Microbiology</i>	3	13	4.33
4	<i>Pharmacognosy Journal</i>	3	4	1.33

<sup>a</sup>AC: average number of citations.

authors published more than 1 paper; the highest number of papers per author was 2. It indicated the number of researchers who focused on this topic was low.

The most productive authors are presented in Table 5. They were affiliated with colleges in India (6), Thailand (3), Indonesia (2), and Malaysia (2). This is connected to the Southeast Asian region, where *C. asiatica* originated (Chandrika and Prasad Kumara, 2015; Orhan, 2012). By knowing the author's name, affiliation, and country of origin, other researchers interested in this topic can create and promote research collaboration (Arifah *et al.*, 2021).

A bibliographical coupling of authors was performed to analyze the authors who published two papers that cited the same third paper (Perianes-Rodriguez *et al.*, 2016) and stated in

coupling strength (Ma *et al.*, 2022). A higher coupling strength indicates more shared citations between the two papers (Ma *et al.*, 2022). The minimum number of papers for an author was set to 2. Thirteen authors met the criterion, but the largest set of linked authors consisted of only 8 authors.

The outcome of the network visualization of bibliographical coupling based on the authors' studies is shown in Figure 4. Three clusters were obtained. The clusters indicated that there was a relationship between the authors (Effendi *et al.*, 2021). Clusters 1, 2, and 3 were represented with red, green, and blue nodes, respectively. Cluster 1 consisted of Diky Setya Diningrat, Martina Restuati, and Varahalarao Rao Vadlapudi. Cluster 2 consisted of Parichat Phumkhachorn, Pongsak Rattanachaikunsopon, and Patchanee Yasurin. Cluster 3 consisted of Suzita Ramli and Junxian Wong. Due to the fact that each author had two papers, the bubble sizes are all the same.

There were 17 links among the authors. Each link has a strength representing the number of cited references that the two papers share (van Eck and Waltman, 2022). Patchanee Yasurin has the greatest number of links, which are linked to Parichat Phumkhachorn, Pongsak Rattanachaikunsopon, Diky Setya Diningrat, Martina Restuati, Suzita Ramli, and Junxian Wong. It indicated that Patchanee Yasurin's papers and those authors' shared some cited references in common. His first paper investigated the impact of *C. asiatica*'s solvent extraction on its chemical composition and antibacterial activity against various microbial pathogens (Rattanakom and Yasurin, 2015). It was similar to his linked authors' papers. The variants came from testing microorganisms, plant components, and solvent extractions (the brief of the study is presented in Table 5). Meanwhile, his second paper investigated the antibacterial



**Table 5.** The most productive authors on the topic of antibacterial activity of *C. asiatica*.

No.	Author name	Affiliation, country	Number of papers	Citations	AC <sup>a</sup> per paper	Brief of studies
1	Diningrat, D.S.	Universitas Negeri Medan, Indonesia	2	15	7.50	Tested material: aqueous, ethanol, and chloroform extracts of leaf and root of <i>C. asiatica</i> ; methanol extract of <i>C. asiatica</i> and <i>Premna pubescens</i> Method: agar-well diffusion test, filter paper disc Tested bacteria: <i>S. aureus</i> , <i>Staphylococcus albus</i> , <i>E. coli</i> , <i>P. aeruginosa</i> , <i>Streptococcus pneumoniae</i> , <i>Streptococcus pyogenes</i> , <i>Pseudomonas marginalis</i> , <i>Streptococcus mutans</i> , <i>Streptococcus salivarius</i> , <i>Penicillium expansum</i> , <i>Fusarium oxysporum</i> , <i>Xanthomonas compestries</i> , <i>Lactobacillus acidophilus</i>
2	Gurushantha, K.	Ramaiah Institute of Technology, India	2	74	37.00	Tested material: synthesized La <sub>2</sub> O <sub>3</sub> NPs and Ag <sub>2</sub> O NPs with <i>C. asiatica</i> leaf powder Method: agar-well diffusion test Tested bacteria: <i>S. aureus</i> , <i>Staphylococcus epidermidis</i>
3	Phumkhachorn, P.	Ubon Ratchathani University, Thailand	2	17	8.50	Tested material: aqueous extracts of <i>C. asiatica</i> and other plants Method: swab paper disc method, bath exposure of Nile Tilapia Tested bacteria: <i>Pseudomonas anguilliseptica</i> , <i>Flavobacterium columnare</i>
4	Ramli, S.	Universiti Pendidikan Sultan Idris, Malaysia	2	8	4.00	Tested material: ethanol extracts of <i>C. asiatica</i> Method: agar disc diffusion test and broth microdilution Tested bacteria: <i>Bacillus cereus</i> , <i>Escherichia coli</i> O157:H7, <i>Salmonella enterica</i> serovar Typhimurium, <i>S. aureus</i>
5	Vadlapudi, V.	Indian Institute of Chemical Technology, India	2	14	7.00	Tested material: aqueous and ethanol extract of <i>C. asiatica</i> ; hexane, chloroform, and methanol extract of <i>C. asiatica</i> and <i>Calotropis procera</i> Method: agar-well diffusion test Tested bacteria: <i>Escherichia coli</i> , <i>Enterobacter aerogens</i> , <i>Klebsiella pneumoniae</i> , <i>Mycobacterium glutamicus</i> , <i>Proteus vulgaris</i> , <i>Streptococcus mutans</i> , <i>Pseudomonas marginalis</i>
6	Yasurin, P.	Assumption University, Thailand	2	22	11.00	Tested material: <i>C. asiatica</i> chloroform extract-loaded gelatin nanoparticles; ethanol, chloroform, and hexane extract of <i>C. asiatica</i> Method: modified agar well diffusion, broth dilution Tested bacteria: <i>Salmonella enterica</i> Typhimurium U302, <i>S. enterica</i> Enteritidis, <i>S. enterica</i> 4,5,12: I human (US clone), <i>Bacillus cereus</i> and <i>B. subtilis</i>
7	Restuati, M.	Universitas Negeri Medan, Indonesia	2	15	7.50	Same as number 1
8	Harlapur, S.F.	Vemana Institute of Technology, India	2	74	37.00	Same as number 2
9	Ravikumar, C.R.	East West Institute of Technology, India	2	74	37.00	Same as number 2
10	Rashmi, B.N.	Vemana Institute of Technology, India	2	74	37.00	Same as number 2
11	Santosh, M.S.	Central Institute of Mining and Fuel Research India, India	2	74	37.00	Same as number 2
12	Rattanachaiunsopon, P.	Ubon Ratchathani University, Thailand	2	17	8.50	Same as number 3
13	Wong, J.X.	Universiti Pendidikan Sultan Idris, Malaysia	2	8	4.00	Same as number 4

<sup>a</sup>AC: average number of citations.

activity of gelatin nanoparticles loaded with *C. asiatica* chloroform extract (Kesornbuakao *et al.*, 2018).

Analysis of cited papers

The more the paper is cited, the higher its influence is on this topic. Among the 89 selected papers, 37 had been cited at least 10 times, and 5 had been cited at least 100 times. Table 6 shows the five most frequently cited papers, which have been cited more than 100 times. Logeswari’s team paper had the highest citation, having been cited 363 times. Their paper was published in the Journal of the Saudi Chemical Society in 2015 with the title “Synthesis of silver nanoparticles using plant extract and analysis of their antimicrobial properties.” They used the extracts of *C. asiatica*, *Ocimum tenuiflorum*, *Solanum trilobatum*, *Syzygium cumini*, and *Citrus sinensis* to synthesize silver nanoparticles and evaluated the antibacterial activity of the synthesized silver nanoparticles using the well diffusion method. Other top five cited papers were published earlier (before 2010), most of which were published in the Journal of Ethnopharmacology. It is in accordance with the results of the most productive journals.

Keyword co-occurrence network

The co-occurrence analysis of keywords was conducted to determine which one frequently occurred. It will help researchers spot the most popular topics and emerging trends in a field. In a paper, two words that cooccur quite often may have a stronger connection than

other word pairs (Romero and Portillo-Salido, 2019). The author keyword was chosen as the unit of analysis. Of the 89 selected papers, there were 286 keywords provided by the authors. The minimum number of occurrences of a keyword was set at 2. Thirty-four keywords met the threshold, but only 32 keywords made up the largest set of linked keywords. Figure 5 shows the mapping of the co-occurrence analysis of these 32 connected keywords. “*Centella asiatica*” had the most links, with 21 links. The co-occurrence strength between two keywords is represented by the thickness of the link line and it is directly proportional (Feng and Chen, 2020). “*Centella asiatica*” had a thicker link with both “antibacterial” and “antimicrobial activity” than the other keywords that connected to “*Centella asiatica*.” It related to the searches performed on the data collection. The keyword “*Centella asiatica*” was also connected to “wound healing”, “antioxidant activity”, “antifungal”, and “antibiofilm”, which indicated other pharmacological activities of *C. asiatica*. It had also been investigated in several studies.

The top seven keywords in selected papers on the topic of the antibacterial activity of *C. asiatica* were “*Centella asiatica*,” “antibacterial activity,” “antimicrobial activity,” “medicinal plants,” “antibacterial,” “antimicrobial,” and “antioxidant” (Table 7). In the early years, the terms such as “antimicrobial activity,” “apiaceae,” “disc diffusion,” and “plant extract” tended to appear frequently in author keywords. In contrast, “*Staphylococcus aureus*,” “wound healing,” “chitosan,” “cyclic voltammetry,” and “photocatalysis” appeared in recent years, indicating that they have been the current research hotspots.

The term “chitosan” was used in two papers that investigated the use of chitosan and *C. asiatica* in bilayer patches against *Propionibacterium acnes* (Kuo *et al.*, 2021) and in hydrogel as a wound dressing (Wang *et al.*, 2021). This showed that the recent research topic of the antibacterial activity of *C. asiatica* has included the formulation strategy. In view of the antibacterial activity of *C. asiatica* already explored in several solvent extractions (aqueous, ethanol, methanol, and chloroform) and bacteria (Nasution *et al.*, 2018), the formulation strategy remains promising to be explored and followed by *in vivo* preclinical and clinical trials of the developed products. For example, the *in vivo* preclinical or clinical trial of developed products of wound

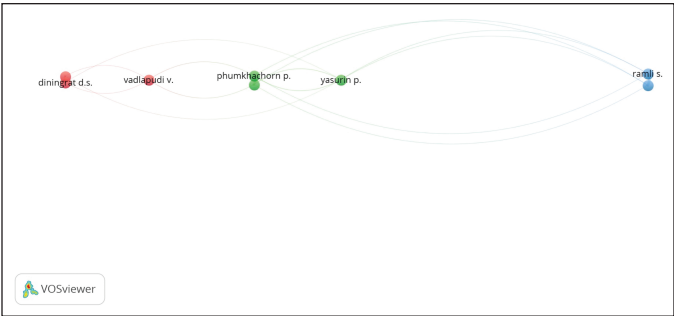


Figure 4. The network visualization of bibliographic coupling of authors on the topic of antibacterial activity of *C. asiatica*.

Table 6. Top five cited papers on the topic of antibacterial activity of *C. asiatica*.

Authors	Total citations	Title	Journal
Logeswari <i>et al.</i> (2015)	363	Synthesis of silver nanoparticles using plants extract and analysis of their antimicrobial properties	Journal of Saudi Chemical Society
Zaidan <i>et al.</i> (2005)	219	<i>In vitro</i> screening of five local medicinal plants for antibacterial activity using disc diffusion method	Tropical Biomedicine
Chomnawang <i>et al.</i> (2005)	217	Antimicrobial effects of Thai medicinal plants against acne-inducing bacteria	Journal of Ethnopharmacology
Voravuthikunchai <i>et al.</i> (2004)	180	Effective medicinal plants against enterohaemorrhagic <i>Escherichia coli</i> O157:H7	Journal of Ethnopharmacology
Hamill <i>et al.</i> (2003)	105	Traditional herbal drugs of Southern Uganda, II: Literature analysis and antimicrobial assays	Journal of Ethnopharmacology



No.	Keywords	Occurrences
1	<i>Centella asiatica</i>	26
2	Antimicrobial activity	16
3	Antibacterial activity	13
4	Medicinal plants	8
5	Antibacterial	7
6	Antimicrobial	7
7	Antioxidant	4

This study found a fluctuating number of papers related to the topic between 1997 and 2022. General information about the papers was also provided, including the most productive country (India), the most collaborating country (India), the most productive affiliation (Ubon Ratchathani University), the most productive journal (*Journal*

of *Ethnopharmacology*), the most cited paper (Synthesis of silver nanoparticles using plant extract and analysis of their antimicrobial properties by Logeswari *et al.* [2015]), and the most frequent keyword ("*Centella asiatica*"). Furthermore, information from the keyword co-occurrence network revealed that the formulation approach has been studied recently concerning the antibacterial activity of *C. asiatica*. The formulation strategy of *C. asiatica* as an antibacterial agent, followed by its *in vivo* preclinical and clinical trials, remains a promising study to be explored in order to adopt phytomedicine as a therapeutic option.

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## AUTHOR CONTRIBUTIONS

All authors made substantial contributions to the conception and design, acquisition of data, or analysis and interpretation of data; took part in drafting the article or revising it critically for important intellectual content; agreed to submit to the current journal; gave final approval of the version to be published; and agree to be accountable for all aspects of the work. All the authors are eligible to be an author as per the international committee of medical journal editors (ICMJE) requirements/guidelines.

## CONFLICTS OF INTEREST

The authors report no financial or any other conflicts of interest in this work.

## ETHICAL APPROVALS

This study does not involve experiments on animals or human subjects.

## DATA AVAILABILITY

All data generated and analyzed are included in this research article.

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## REFERENCES

Aljamali DNM, Al-zubaidy ZH, Enad AH. Bacterial infection and common bacterial diseases: a review. *Trends Pharm, Nanotechnol MAT J*, 2021; 3(2):13–22.

Al-Talib H, Ali NDM, Suhaimi MH, Rosli SSN, Othman NH, Mansor NAS, Shah AK, Ariffin NS, Al-Khateeb A. Antimicrobial effect of Malaysian vegetables against enteric bacteria. *Asian Pac J Trop Biomed*, 2016; 6(3):211–5; <https://doi.org/10.1016/j.apjtb.2015.12.009>

Amornopparattanakul N, Waranuch N, Lamlertthong S, Wisuitiprot W, Ingkaninan K. Development of oral cleansing products containing green tea and *Centella asiatica* extracts. *KEM*, 2021; 907:48–54; <https://doi.org/10.4028/www.scientific.net/KEM.901.48>

Arifah FH, Nugroho AE, Rohman A, Sujarwo W. A bibliometric analysis of preclinical trials of *Andrographis paniculata* (Burm.f.) Nees in diabetes mellitus. *S Afr J Bot*, 2021; 151:128–43; <https://doi.org/10.1016/j.sajb.2021.12.011>

Arshad AI, Ahmad P, Karobari MI, Asif JA, Alam MK, Mahmood Z, Abd Rahman N, Mamat N, Kamal MA. Antibiotics: a bibliometric analysis of top 100 classics. *Antibiotics*, 2020; 9(5):219; <https://doi.org/10.3390/antibiotics9050219>

Arumugam T, Ayyanar M, Koil Pillai YJ, Sekar T. Phytochemical screening and antibacterial activity of leaf and callus extracts of *Centella asiatica*. *Banladesh J Pharm*, 2011; 6(1):55–60; <https://doi.org/10.3329/bjp.v6i1.8555>

Bamel UK, Pandey R, Gupta A. Safety climate: systematic literature network analysis of 38 years (1980–2018) of research. *Accid Anal Prev*, 2020; 135:105387; <https://doi.org/10.1016/j.aap.2019.105387>

Bibi Y, Zia M, Nisa S, Habib D, Waheed A, Chaudhary FM. Regeneration of *Centella asiatica* plants from non-embryogenic cell lines and evaluation of antibacterial and antifungal properties of regenerated calli and plants. *J Biol Eng*, 2011; 5(1):1–8; <https://doi.org/10.1186/1754-1611-5-13>

Bobbarala V, Maduri DB. *In vitro* antimicrobial activity of certain medicinal plant extracts against pathogens of sorghum. *J Pure Appl Microbiol*, 2009; 3(1):205–9.

Chandrika UG, Prasad Kumara PAAS, Gotu Kola (*Centella asiatica*): nutritional properties and plausible health benefits. *Adv Food Nutr Res*, 2015; 76:125–57; <https://doi.org/10.1016/bs.afnr.2015.08.001>

Chauhan PK, Pandey IP, Awasthi G, Dhatwalia VK, Singh V. Antibacterial activity of *Centella asiatica* against seven pathogenic bacteria isolated from the urine of diabetic patients. *Biomed*, 2009; 29(1):62–4.

Choi H-A, Cheong D-E, Lim H-D, Kim W-H, Ham M-H, Oh M-H, Wu Y, Shin HJ, Kim GJ. Antimicrobial and anti-biofilm activities of the methanol extracts of medicinal plants against dental pathogens *Streptococcus mutans* and *Candida albicans*. *J Microbiol Biotechnol*, 2017; 27(3):1242–8; <https://doi.org/10.4014/jmb.1701.01026>

Chomnawang MT, Surassmo S, Nukoolkarn VS, Gritsanapan W. Antimicrobial effects of Thai medicinal plants against acne-inducing bacteria. *J Ethnopharmacol*, 2005; 101(1–3):330; <https://doi.org/10.1016/j.jep.2005.04.038>

Dhiman R, Aggarwal N, Aneja KR, Kaur M. *In vitro* antimicrobial activity of spices and medicinal herbs against selected microbes associated with juices. *Int J Microbiol*, 2016; 2016:9015802; <https://doi.org/10.1155/2016/9015802>

Donthu N, Kumar S, Mukherjee D, Pandey N, Lim WM. How to conduct a bibliometric analysis: an overview and guidelines. *J Bus Res*, 2021; 133:285–96; <https://doi.org/10.1016/j.jbusres.2021.04.070>

van Eck NJ, Waltman L. VOSviewer Manual. 2022. Available via [https://www.vosviewer.com/documentation/Manual\\_VOSviewer\\_1.6.18.pdf](https://www.vosviewer.com/documentation/Manual_VOSviewer_1.6.18.pdf) (Accessed 18 December 2022).

Effendi DN, Irwandani, Anggraini W, Jatmiko A, Rahmayanti H, Ichsan IZ, Rahman MM. Bibliometric analysis of scientific literacy using VOS viewer: analysis of science education. *J Phys Conf Ser*, 2021; 1796(1):012096; <https://doi.org/10.1088/1742-6596/1796/1/012096>

Falagas ME, Pitsouni EI, Malietzis GA, Pappas G. Comparison of PubMed, Scopus, Web of Science, and Google Scholar: strengths and weaknesses. *FASEB J*, 2008; 22:338–42; <https://doi.org/10.1096/fj.07-9492LSF>

Feng L, Chen Q. Bibliometric analysis of the synthesis of nanocatalyst (1999–2018). *IOP Conf Ser Earth Environ Sci*, 2020; 558(4):042042; <https://doi.org/10.1088/1755-1315/558/4/042042>

Garvey MI, Rahman MM, Gibbons S, Piddock LJV. Medicinal plant extracts with efflux inhibitory activity against Gram-negative bacteria. *Int J Antimicrob Agents*, 2011; 37(2):145–51; <https://doi.org/10.1016/j.ijantimicag.2010.10.027>

Gohil K, Patel J, Gajjar A. Pharmacological review on *Centella asiatica*: a potential herbal cure-all. *Indian J Pharm Sci*, 2010; 72(5):546; <https://doi.org/10.4103/0250-474X.78519>

Ha CT, Thao TTP, Trung NT, Huong LTT, Dinh NV, Trung T. A bibliometric review of research on STEM education in ASEAN: science mapping the literature in scopus database, 2000 to 2019. *EURASIA J Math Sci Tech Ed*, 2020; 16(10):em1889; <https://doi.org/10.29333/ejmsste/8500>



- Hamill FA, Apio S, Mubiru NK, Bukenya-Ziraba R, Mosango M, Maganyi OW, Soejarto DD. Traditional herbal drugs of Southern Uganda, II: literature analysis and antimicrobial assays. *J Ethnopharmacol*, 2003; 84(1):57–78; [https://doi.org/10.1016/S0378-8741\(02\)00289-1](https://doi.org/10.1016/S0378-8741(02)00289-1)
- Haslinda WH, Tang JYH, Tuan Zainazor TC, Mohd Khairi Hilman AL, Wan Norezah WM, Irdawaty T. Prevalence and antimicrobial susceptibility of non-typhoidal *Salmonella* (NTS) from salad vegetables at farms and retail markets in Terengganu, Malaysia. *Food Res*, 2022; 6(1):274–86; [https://doi.org/10.26656/fr.2017.6\(1\).493](https://doi.org/10.26656/fr.2017.6(1).493)
- Idris FN, Nadzir MM. Antimicrobial activity of *Centella asiatica* on *Aspergillus niger* and *Bacillus subtilis*. *Chem Eng Trans*, 2017; 56:1381–6; <https://doi.org/10.3303/CET1756231>
- Irhahm WH, Marpaung TL. Phytochemicals screening and antibacterial activity of *Curcuma longa* Linn, *Ziziphus mauritiana* and *Centella asiatica* L. Urban extract. *Rasayan J Chem*, 2020; 13(3):1978–83; <https://doi.org/10.31788/RJC.2020.1335809>
- Irhahm WH, Tamrin, Marpaung L, Marpongahtun. bioactive compounds in pegagan leaf (*Centella asiatica* L. Urban) for wound healing. *J Phys Conf Ser*, 2019; 1232(1):012019; <https://doi.org/10.1088/1742-6596/1232/1/012019>
- Jamal P, Karim IA, Abdullah E, Raus RA, Hashim YZ. Phytochemical screening for antibacterial activity of potential Malaysian medicinal plants. *Afr J Biotechnol*, 2011; 10(81):18795–9; <https://doi.org/10.5897/AJB11.2755>
- Jantarat C, Sirathananun P, Chuchue T, Konpian A, Sukkua G, Wongprasert P. *In vitro* antimicrobial activity of gel containing the herbal ball extract against propionibacterium acnes. *Sci Pharm*, 2018; 86(1); <https://doi.org/10.3390/scipharm86010008>
- Jose D, Lekshmi N, Goel AK, Kumar RA, Thomas S. Development of a novel herbal formulation to inhibit biofilm formation in toxigenic vibrio cholera. *J Food Protection*, 2017; 80(11):1933–40; <https://doi.org/10.4315/0362-028X.JFP-17-091>
- Justin Packia Jacob S, Shenbagaraman S. Evaluation of antioxidant and antimicrobial activities of the selected green leafy vegetables. *Int J Pharm Res*, 2011; 3(1):148–52.
- Kalita D, Saikia J. Ethnomedicinal, antibacterial and antifungal potentiality of *Centella asiatica*, *Nerium indicum* and *Cuscuta reflexa*—widely used in Tiwa Tribe of Morigaon district of Assam, India. *Int J Phytomed*, 2012; 4(3):380–5.
- Kanchan C, Imjai P, Kanchan N, Panchai K, Hatai K. Virulence of *Aeromonas hydrophila* in Siamese fighting fish (*Betta splendens*) and the bacterium susceptibility to some herbal plants. *Iran J Fish Sci*, 2019; 18(2):349–54; <https://doi.org/10.22092/ijfs.2018.116909>
- Kannahi M, Dhivya U. Production of health drink using effective microorganisms and medicinal plant extracts. *J Chem Pharm Res*, 2014; 6(6):496–500.
- Kesornbuakao K, Amornraksa S, Sriariyanun M, Asavasanti S, Yasurin P. The antibacterial and antioxidant activity of *Centella asiatica* chloroform extract-loaded gelatin nanoparticles. In: Wang J, Yang YF, editors. MATEC Web Conference, vol. 187, EDP Sciences, 2018; <https://doi.org/10.1051/mateconf/201818702002>
- Khan MA, Khan HM, Ganie IB, Kumar S, Shahzad A, Celik I, Shahid M. Anti-quorum sensing, antibiofilm, and antibacterial activities of extracts of *Centella asiatica* L. leaves, and *in vitro* derived leaves-calli through tissue culture: a potential for biofouling-prevention. *Biofouling*, 2022; 38(7):715–28; <https://doi.org/10.1080/08927014.2022.2117034>
- Khatua A, Prasad A, Behuria HG, Patel AK, Singh M, Yasasve M, Saravanan M, Meena R. Evaluation of antimicrobial, anticancer potential and Flippase induced leakage in model membrane of *Centella asiatica* fabricated MgONPs. *Biomater Adv*, 2022; 138:212855; <https://doi.org/10.1016/j.bioadv.2022.212855>
- Khurana R, Karan R, Kumar A, Khare SK. Antioxidant and antimicrobial activity in some Indian herbal plants: protective effect against free radical mediated DNA damage. *J Plant Biochem Biotechnol*, 2010; 19(2):229–33; <https://doi.org/10.1007/bf03263345>
- Ki V, Rotstein C. Bacterial skin and soft tissue infections in adults: a review of their epidemiology, pathogenesis, diagnosis, treatment and site of care. *Can J Infect Dis Med Microbiol*, 2008; 19(2):173–84; <https://doi.org/10.1155/2008/846453>
- Kunta RK, Vadlapudi V. *In vitro* antibacterial potentiality of *Centella asiatica*. *Biomed Pharmacol J*, 2009; 2(2):293–6.
- Kuo C-W, Chiu Y-F, Wu M-H, Li M-H, Wu C-N, Chen W-S, Huang CH. Gelatin/chitosan bilayer patches loaded with cortex *Phellodendron amurense*/*Centella asiatica* extracts for anti-acne application. *Polymers*, 2021; 13(4):1–15; <https://doi.org/10.3390/polym13040579>
- Lee TK, Vairappan CS. Antioxidant, antibacterial and cytotoxic activities of essential oils and ethanol extracts of selected South East Asian herbs. *J Med Plant Res*, 2011; 5(21):5284–90.
- Logeswari P, Silambarasan S, Abraham J. Synthesis of silver nanoparticles using plants extract and analysis of their antimicrobial property. *J Saudi Chem Soc*, 2015; 19(3):311–7; <https://doi.org/10.1016/j.jscs.2012.04.007>
- Ma TJ, Lee GG, Liu JS, Lan R, Weng JH. Bibliographic coupling: a main path analysis from 1963 to 2020. *IR*, 2022; 27; <https://doi.org/10.47989/irpaper918>
- Machado RRP, Dutra RC, Pittella F, Raposo NRB, Lesche B, Duarte RS, Soares GL, Kaplan MA. Screening antimycobacterial activity of *Baccharis dracunculifolia*, *Centella asiatica*, *Lantana camara* and *Pterodon emarginatus*. *Rev Bras Plantas Med*, 2015; 17(4):891–9; [https://doi.org/10.1590/1983-084X/14\\_148](https://doi.org/10.1590/1983-084X/14_148)
- Mahmud N, Ramasamy S, Manickam S, Al Qadr Imad Wan-Mohtar WA. Synergistic-antagonistic interaction of vegetable extracts, *Acalypha indica*, *Centella asiatica*, and *Sesbania grandiflora*: wound healing, antioxidant, protectivity, and antimicrobial properties. *Malaysia J Microbiol*, 2020; 16(6):491–510; <https://doi.org/10.21161/mjm.200792>
- Mehta J, Rolta R, Dev K. Role of medicinal plants from North Western himalayas as an efflux pump inhibitor against MDR AcrAB-TolC *Salmonella enterica* serovar typhimurium: *in vitro* and *in silico* studies. *J Ethnopharmacol*, 2022; 282:114589; <https://doi.org/10.1016/j.jep.2021.114589>
- Milanda T, Febriyanti RM, Kusuma ASW, Diantini A. Antibacterial and cytotoxic activity of selected raw-consumed vegetables in West Java, Indonesia. *Pharmacogn J*, 2022; 14(2):289–95; <https://doi.org/10.5530/pj.2022.14.36>
- Mohamad S, Zin NM, Wahab HA, Ibrahim P, Sulaiman SF, Zahariluddin ASM, Noor SS. Antituberculosis potential of some ethnobotanically selected Malaysian plants. *J Ethnopharmacol*, 2011; 133(3):1021–6; <https://doi.org/10.1016/j.jep.2010.11.037>
- Mongeon P, Paul-Hus A. The journal coverage of Web of Science and Scopus: a comparative analysis. *Scientometrics*, 2016; 106(1):213–8; <https://doi.org/10.1007/s11192-015-1765-5>
- Mouro C, Fanguero R, Gouveia IC. Preparation and characterization of electrospun double-layered nanocomposites membranes as a carrier for *Centella asiatica* (L.). *Polym*, 2020; 12(11):1–8; <https://doi.org/10.3390/polym12112653>
- Mudaliana S. Antimicrobial activity of *Centella asiatica* and *Gigantochloa apus*. *J Basic Clin Physiol Pharmacol*, 2021; 32(4):755–9; <https://doi.org/10.1515/jbcp-2020-0396>
- Nasution MY, Restuati M, Pulungan ASS, Pratiwi N, Diningrat DS. Antimicrobial activities of *Centella asiatica* leaf and root extracts on selected pathogenic micro-organisms. *J Med Sci*, 2018; 18(4):198–204; <https://doi.org/10.3923/jms.2018.198.204>
- Netala VR, Kotakadi VS, Nagam V, Bobbu P, Ghosh SB, Tartte V. First report of biomimetic synthesis of silver nanoparticles using aqueous callus extract of *Centella asiatica* and their antimicrobial activity. *Appl Nanosci (Switzerland)*, 2015; 5(7):801–7; <https://doi.org/10.1007/s13204-014-0374-6>
- Ngomdir M, Debbarma B, Debbarma A, Chanda S, Raha S, Saha R, Pal S, Choudhury R, Bhattacharjee PR, Goswami BB, De BK. Antibacterial evaluation of the extracts of edible parts of few plants used by tribal people of Tripura, India. *J Pure Appl Microbiol*, 2007; 1(1):65–8.
- Orhan IE. *Centella asiatica* (L.) Urban: from traditional medicine to modern medicine with neuroprotective potential. *Evid Based Complement Altern Med*, 2012; 2012:1–8; <https://doi.org/10.1155/2012/946259>



- Oyediji OA, Afolayan AJ. Chemical composition and antibacterial activity of the essential oil of *Centella asiatica* growing in South Africa. *Pharm Biol*, 2005; 43(3):249–52; <https://doi.org/10.1080/13880200590928843>
- Pakadang SR, Hilaria M, Dewi STR, Sinala S, Jumain. MIC and MKC analysis of herbal medicine in Indonesia against *Mycobacterium tuberculosis*. *Pharmacogn J*, 2021; 13(5):1058–64; <https://doi.org/10.5530/pj.2021.13.137>
- Panathula CS, Mahadev MD, Naidu CV. Phytochemical investigation and *in vitro* antimicrobial activity of *Centella asiatica* (L.) Urban. A potent antijaundice medicinal plant. *Int J Phytomed*, 2014; 6(2):195–200.
- Pancu DF, Scurtu A, Macaso IG, Marti D, Mioc M, Soica C, Coricovac D, Horhat D, Poenaru M, Dehelean C. Antibiotics: conventional therapy and natural compounds with antibacterial activity—a pharmacotoxicological screening. *Antibiotics*, 2021; 10(4):401; <https://doi.org/10.3390/antibiotics10040401>
- Panda SK, Mohanta YK, Padhi L, Park Y-H, Mohanta TK, Bae H. Large scale screening of ethnomedicinal plants for identification of potential antibacterial compounds. *Molecules*, 2016; 21(3); <https://doi.org/10.3390/molecules21030293>
- Panomket P, Wanram S, Srivorasmas T, Pongprom N. Bioactivity of plant extracts against *Burkholderia pseudomallei*. *Asian Biomed*, 2012; 6(4):619–23; <https://doi.org/10.5372/1905-7415.0604.100>
- Parekh J, Chanda S. Screening of aqueous and alcoholic extracts of some Indian medicinal plants for antibacterial activity. *Indian J Pharm Sci*, 2006; 68(6):835; <https://doi.org/10.4103/0250-474x.31032>
- Park Y. Towards versatile protein fabrics: UV protection and antimicrobial property dyeing with *Centella asiatica* (L.) into silk. *Fibers Polym*, 2020; 21(4):803–9; <https://doi.org/10.1007/s12221-020-9603-7>
- Pavan Kumar MA, Suresh D, Sneharani AH. *Centella asiatica* mediated facile green synthesis of nano zinc oxide and its photo-catalytic and biological properties. *Inorg Chem Commun*, 2021; 133:108865; <https://doi.org/10.1016/j.inoche.2021.108865>
- Perianes-Rodriguez A, Waltman L, van Eck NJ. Constructing bibliometric networks: a comparison between full and fractional counting. *J Informetr*, 2016; 10(4):1178–95.
- Pham XN, Nguyen HT, Pham NT. Green synthesis and antibacterial activity of HAP@Ag nanocomposite using *Centella asiatica* (L.) urban extract and eggshell. *Int J Biomater*, 2020; 2020; <https://doi.org/10.1155/2020/8841221>
- Phumkhachorn P, Rattanachaikunsopon P. Use of *Cassia alata* aqueous extract as a bath treatment to control pseudomonas anguilliseptica infection in tilapia (*Oreochromis niloticus*). *Arch Biol Sci*, 2015; 67(4):1165–72; <https://doi.org/10.2298/ABS150126092P>
- Pieme CA, Dzoyem JP, Kechia FA, Etoa FX, Penlap V. *In vitro* antimicrobial activity of extracts from some Cameroonian medicinal plants. *J Biol Sci*, 2008; 8(5):902–7; <https://doi.org/10.3923/jbs.2008.902.907>
- Rafat A, Philip K, Muniandy S. A novel source of bioactive compounds: endophytic bacteria isolated from *Centella asiatica*. *J Pure Appl Microbiol*, 2012; 6(1):11–20.
- Raja K, Gokula Narayanan SN, Thiruvengadam S, Romauld I. The influence of chocolate fortification with *Centella asiatica*, *Abelmoschus esculentus*, and *Psidium guajava* on the content of biologically active substances. *J Food Process Preserv*, 2021; 45(4):e15271; <https://doi.org/10.1111/jfpp.15271>
- Rashmi BN, Harlapur SF, Avinash B, Ravikumar CR, Nagaswarupa HP, Anil Kumar MR, Gurushantha K, Santosh MS. Facile green synthesis of silver oxide nanoparticles and their electrochemical, photocatalytic and biological studies. *Inorg Chem Commun*, 2020; 111:107580; <https://doi.org/10.1016/j.inoche.2019.107580>
- Rashmi BN, Harlapur SF, Gurushantha K, Ravikumar CR, Kumar MRA, Santosh MS, Kumar VD, Kumar AN, Azad AK, Murthy HA. Facile green synthesis of lanthanum oxide nanoparticles using *Centella asiatica* and tridax plants: photocatalytic, electrochemical sensor and antimicrobial studies. *Appl Surf Sci Adv*, 2022; 7:100210; <https://doi.org/10.1016/j.apsadv.2022.100210>
- Rattanachaikunsopon P, Phumkhachorn P. Use of Asiatic pennywort *Centella asiatica* aqueous extract as a bath treatment to control columnaris in Nile tilapia. *J Aquatic Anim Health*, 2010; 22(1):14–20; <https://doi.org/10.1577/H09-021.1>
- Rattanakom S, Yasurin P. Chemical profiling of *Centella asiatica* under different extraction solvents and its antibacterial activity, antioxidant activity. *Orient J Chem*, 2015; 31(4):2453–9; <https://doi.org/10.13005/ojc/310480>
- Rebia RA, Sadon NSB, Tanaka T. Natural antibacterial reagents (Centella, propolis, and hinokitiol) loaded into poly[(R)-3-hydroxybutyrate-co-(R)-3-hydroxyhexanoate] composite nanofibers for biomedical applications. *Nanomaterials*, 2019; 9(12):1665; <https://doi.org/10.3390/nano9121665>
- Rekha SR, Kulandhaivel M, Hridhya KV. Antibacterial efficacy and minimum inhibitory concentrations of medicinal plants against wound pathogens. *Biomed Pharmacol J*, 2018; 11(1):237–46; <https://doi.org/10.13005/bpj/1368>
- Restuati M, Diningrat DS. Antimicrobial profile of premna pubescens. Blume and *Centella asiatica* extracts against bacteria and fungi pathogens. *Int J Pharmacol*, 2018; 14(2):271–5; <https://doi.org/10.3923/ijp.2018.271.275>
- Romero L, Portillo-Salido E. Trends in sigma-1 receptor research: a 25-year bibliometric analysis. *Front Pharmacol*, 2019; 10:564; <https://doi.org/10.3389/fphar.2019.00564>
- Rukisah, Maulianawati D, Cahyadi J. *In vitro* antibacterial efficacy of leaves extract of *Centella asiatica* against *Vibrio harveyi* and *Aeromonas hydrophila*. *Indones Aquacult J*, 2019; 14(2):69–74; <https://doi.org/10.15578/iaj.14.2.2019.69-74>
- Saha M, Bandyopadhyay PK. *In vivo* and *in vitro* antimicrobial activity of phytol, a diterpene molecule, isolated and characterized from *Adhatoda vasica* Nees. (Acanthaceae), to control severe bacterial disease of ornamental fish, *Carassius auratus*, caused by *Bacillus licheniformis* PKBMS16. *Microb Pathog*, 2020; 141: 103977; <https://doi.org/10.1016/j.micpath.2020.103977>
- Sardrood SG, Saadatmand S, Assareh MH, Satan TN. Chemical composition and biological activity of essential oils of *Centella asiatica* (L.). *Toxicol Environ Health Sci*, 2019; 11(2):125–31; <https://doi.org/10.1007/s13530-019-0397-1>
- Sari M, Syahputra G, Kusharyoto W. The application of multiplate resazurin reduction assay in the screening for anti-mycobacterial activity from Indonesian medicinal plants. *Indones J Pharm*, 2019; 30(3):199–207; <https://doi.org/10.14499/indonesianjpharm30iss3pp199>
- Selvam DA, Ng CH, Razik RM, Al-Dhalli S, Shaari K. Effects of extraction methods on antibacterial activity of *Centella asiatica* leaves against pathogenic *Staphylococcus aureus* and *Escherichia coli*. *Int J Med Toxicol Legal Med*, 2019; 22(1-2):172–8; <https://doi.org/10.5958/0974-4614.2019.00037.8>
- Sharma A, Khanna S, Kaur G, Singh I. Medicinal plants and their components for wound healing applications. *Future J Pharm Sci*, 2021; 7(1):53; <https://doi.org/10.1186/s43094-021-00202-w>
- Sheela T, Kannan S. Antibacterial activities of medicinal plants thespesia populnea, centella asiatica and *Solanum trilobatum*. *Asian J Microbiol Biotechnol Environ Sci*, 2003; 5(1):135–6.
- Shukurova MK, Myint D, Yi SS, Saw OM, Watanabe KN. Morphological description and ethnobotanical review of the orphan crop myin-hkwa (*Centella asiatica* L.) from myanmar. *Front Sustain Food Syst*, 2021; 5:680862; <https://doi.org/10.3389/fsufs.2021.680862>
- Siebert BM, Omwenga GI, Wambua RK, Samoei JC, Ngugi MP. Screening of the dichloromethane: methanolic extract of *Centella asiatica* for antibacterial activities against *Salmonella typhi*, *Escherichia coli*, *Shigella sonnei*, *Bacillus subtilis*, and *Staphylococcus aureus*. *Sci World J*, 2020; 2020:6378712; <https://doi.org/10.1155/2020/6378712>
- Singh D, Lamkang TF. Evaluation of antibacterial, antioxidant and cytotoxicity potential of silver nanoparticles synthesized from *Phlogacanthus thyriformis* and *Centella asiatica*. *Med Plants*, 2022; 14(1):169–77; <https://doi.org/10.5958/0975-6892.2022.00019.3>

- Sood K, Yadav RNS. Phytochemical screening and antimicrobial activity of four members of family apiaceae. *Int J Phytomed*, 2014; 6(2):232–6.
- Soyingbe OS, Mongalo NI, Makhafole TJ. *In vitro* antibacterial and cytotoxic activity of leaf extracts of *Centella asiatica* (L.) Urb, *Warburgia salutaris* (Bertol. F.) Chiov and *Curtisia dentata* (Burm. F.) C.A.Sm—medicinal plants used in South Africa. *BMC Complement Altern Med*, 2018; 18(1); <https://doi.org/10.1186/s12906-018-2378-3>
- Srivastava R, Shukla YN, Darokar MP. Antibacterial activity of *Centella asiatica*. *Fitoterapia*, 1997; 68(5):466–7.
- Sultan RA, Mahmood SBZ, Azhar I, Ahmed SW, Mahmood ZA. Biological activities assessment of *Centella asiatica* (Linn.). *J Herbs Spices Med Plants*, 2014; 20(3):319–27; <https://doi.org/10.1080/10496475.2013.869521>
- Sun G, Zhang Q, Dong Z, Dong D, Fang H, Wang C, Dong Y, Wu J, Tan X, Zhu P, Wan Y. Antibiotic resistant bacteria: a bibliometric review of literature. *Front Public Health*, 2022; 10:1002015; <https://doi.org/10.3389/fpubh.2022.1002015>
- Suresh M, Alfonisan M, Alturaiki W, Al Aboody MS, Alfaiz FA, Premanathan M, Vijayakumar R, Umamageshwari K, Al Ghamdi S, Alsagaby SA. Investigations of bioactivity of *Acalypha indica* (L.), *Centella asiatica* (L.) and *Croton bonplandianus* (Baill.) against multidrug resistant bacteria and cancer cells. *J Herbal Med*, 2021; 28:100359; <https://doi.org/10.1016/j.hermed.2020.100359>
- Swastini DA, Udayana INK, Sri Arisanti CI. Cold cream combination of *Garcinia mangostana* L. *Anredera cordifolia* (ten.) and *Centella asiatica* extracts on burn healing activity test. *Res J Pharm Technol*, 2021; 14(5):2483–6; <https://doi.org/10.52711/0974-360X.2021.00437>
- Syed Zameer Ahmed S, Balu N, Khader SZA, Mahboob MR, Lakshmanan SO, Vetrivel M. Fabrication and evaluation of bamboo fabric coated with extracts of *Curcuma longa*, *Centella asiatica* and *Azadirachta indica* as a wound dressing material. *Adv Trad Med*, 2020; 21:83–90; <https://doi.org/10.1007/s13596-020-00503-0>
- Tafroji W, Margyaningsih NI, Khoeri MM, Paramaiswari WT, Winarti Y, Salsabila K, Putri JFM, Siregar C, Soebandrio A, Safari D. Antibacterial activity of medicinal plants in Indonesia on *Streptococcus pneumoniae*. *PLoS One*, 2022; 17(9):e0274174; <https://doi.org/10.1371/journal.pone.0274174>
- Tavakoli F, Emami A, Ranjbar AM, Beyk M. Synergistic activity of three iranian medicinal plants in combination with ceftazidime and neomycin against bacterial strains causing nosocomial infections. *Res J Pharmacogn*, 2022; 9(3):51–9; <https://doi.org/10.22127/rjp.2022.329711.1846>
- Udaya Prakash NK, Bhuvaneswari S, Jahnavi B, Abhinaya K, Gulbys Rajalin A, Prathap Kumar M, Sundaraman G, Elumalai K, Devipriya S, Kannan V, Sriraman V. A study on antibacterial activity of common weeds in Northern districts of Tamil Nadu, India. *Res J Med Plant*, 2012; 6(4):341–5; <https://doi.org/10.3923/rjmp.2012.341.345>
- Ullah MO, Sultana S, Haque A, Tasmin S. Antimicrobial, cytotoxic and antioxidant activity of *Centella asiatica*. *Eur J Sci Res*, 2009; 30(2):260–4.
- Vadlapudi V, Behara M, Kaladhar DSVGK, Suresh Kumar SVN, Seshagiri B, John Paul M. Antimicrobial profile of crude extracts *Calotropis procera* and *Centella asiatica* against some important pathogens. *Indian J Sci Technol*, 2012; 5(8):3132–6.
- Valle DL, Andrade JI, Puzon JJM, Cabrera EC, Rivera WL. Antibacterial activities of ethanol extracts of Philippine medicinal plants against multidrug-resistant bacteria. *Asian Pac J Trop Biomed*, 2015; 5(7):532–40; <https://doi.org/10.1016/j.apjtb.2015.04.005>
- Vasanth S, Mohanraj RS, Mandal J. *In-vitro* study of the effect of *Centella asiatica* on cholera toxin production and the gene expression level of ctxA gene in *Vibrio cholerae* isolates. *J Ethnopharmacol*, 2021; 279:113930; <https://doi.org/10.1016/j.jep.2021.113930>
- Vijayarekha P, Sengottaiyan N. Study on the synergistic effect of ethanolic leaf extracts against some pathogenic microorganisms. *Res J Pharm, Biol Chem Sci*, 2016; 7(2):763–0.
- Vimal SK, Sharma D, Bhatnagar M. Anti-bacterial activity of herbal extracts, EuMiL® and antibiotics against *Helicobacter muridarum*. *Pharmacogn J*, 2010; 2(11):436–1. [https://doi.org/10.1016/S0975-3575\(10\)80028-8](https://doi.org/10.1016/S0975-3575(10)80028-8)
- Voravuthikunchai S, Lortheeranuwat A, Jeeju W, Srirak T, Phongpaichit S, Supawita T. Effective medicinal plants against enterohaemorrhagic *Escherichia coli* O157:H7. *J Ethnopharmacol*, 2004; 94(1):49–54; <https://doi.org/10.1016/j.jep.2004.03.036>
- Wahdany NR, Pradopo, Moeharyon M. Antibacterial activity of asiaticoside towards enterococcus faecalis in periapical infections. *Biochem Cell Arch*, 2020; 20(2):4889–92.
- Wang L, Li D, Shen Y, Liu F, Zhou Y, Wu H, Liu Q, Deng B. Preparation of *Centella asiatica* loaded gelatin/chitosan/nonwoven fabric composite hydrogel wound dressing with antibacterial property. *Int J Biol Macromol*, 2021; 192:350–9; <https://doi.org/10.1016/j.ijbiomac.2021.09.145>
- Wei LS, Musa N, Sengm CT, Wee W, Shazili NAM. Antimicrobial properties of tropical plants against 12 pathogenic bacteria isolated from aquatic organisms. *Afr J Biotechnol*, 2008; 7(13):2275–8.
- Wilson JW. Mechanisms of bacterial pathogenicity. *Postgraduate Med J*, 2002; 78(918):216–4; <https://doi.org/10.1136/pmj.78.918.216>
- Wong JX, Ramli S. Antimicrobial activity of different types of *Centella asiatica* extracts against foodborne pathogens and food spoilage microorganisms. *LWT*, 2021; 142:111026; <https://doi.org/10.1016/j.lwt.2021.111026>
- Wong JX, Ramli S, Chen SN. Assessment of toxic effect of *Centella asiatica* extract and its application as natural preservative in fresh-cut mango, pear and cabbage. *J Food Process Preserv*, 2021; 45(10):e15824; <https://doi.org/10.1111/jfpp.15824>
- Yeung AWK, Tzvetkov NT, Balacheva AA, Georgieva MG, Gan R-Y, Jozwik A, Pyzel B, Horbańczuk JO, Novellino E, Durazzo A, Lucarini M. Lignans: quantitative analysis of the research literature. *Front Pharmacol*, 2020; 11:37; <https://doi.org/10.3389/fphar.2020.00037>
- Zaidan MR, Noor Rain A, Badrul AR, Adlin A, Norazah A, Zakiah I. *In vitro* screening of five local medicinal plants for antibacterial activity using disc diffusion method. *Trop Biomed*, 2005; 22(2):165–70.
- Zupic I, Čater T. Bibliometric methods in management and organization. *Organ Res Methods*, 2015; 18(3):429–72; <https://doi.org/10.1177/1094428114562629>
- Zuraidi E, Zainol R, Ahmad Y, Achmad A. Understanding the evolution and global trends of resilience and urban planning studies: a bibliometric analysis. *Planning Malaysia*, 2022; 20(24); <https://doi.org/10.21837/pm.v20i24.1203>

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