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REVIEW

Exploring the Antibacterial Properties of Acmella Species: A Systematic Literature Review

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Abstract: The increasing prevalence of antibiotic-resistant bacteria has intensified the search for alternative antimicrobial agents, with plant-derived extracts emerging as promising candidates. The *Acmella* genus, known for its rich array of bioactive compounds, has been explored for its antibacterial potential; however, a comprehensive synthesis of the available evidence remains limited. This systematic review aims to evaluate the antibacterial properties of *Acmella* genus plant extracts by analysing studies retrieved from the Scopus, PubMed, and Web of Science databases. An advanced search identified 111 relevant articles, of which 14 met the inclusion criteria after a rigorous screening process. The selected studies predominantly investigated *Acmella oleracea* (syn. *Spilanthes acmella*), along with *Acmella ciliata, Acmella caulirhiza, Acmella paniculata*, and *Acmella uliginosa*. Ethanol and methanol were the primary solvents used for extraction, with methanolic extracts generally demonstrating superior antibacterial efficacy. Antibacterial activity was assessed using in vitro methodologies, including minimum inhibitory concentration (MIC), minimum bactericidal concentration (MBC), disc diffusion, and agar well diffusion assays. The results revealed significant inhibitory effects against Gram-positive bacteria such as *Streptococcus mutans* and *Staphylococcus aureus*, as well as Gram-negative bacteria like *Escherichia coli* and *Pseudomonas aeruginosa*. Notably, some studies reported biofilm inhibition properties, highlighting the potential of *Acmella* extracts in managing persistent infections. While these findings underscore the therapeutic promise of *Acmella*-derived compounds in oral health and wound care, the absence of in vivo and clinical studies limits their translational applicability. Future research should focus on isolating active compounds, evaluating their pharmacokinetics, and exploring synergistic effects with conventional antibiotics to enhance efficacy and minimize resistance development.

Keywords: *Acmella* genus, plant extracts, antibacterial activity, infection, antibiotic resistance

Introduction

There has been a gradual decline in antibiotic discovery, contributing to antibiotic resistance crisis. Aljeldah (2022)[1] reported that antibiotic resistance is advancing faster than solutions, leaving the world with few options for treating infections. This situation has become one of the major causes of morbidity and mortality worldwide. According to the 2024 WHO Bacterial Priority Pathogens List (WHO BPPL), *Pseudomonas aeruginosa, Enterococcus* species, *Acinetobacter baumannii, Staphylococcus aureus, Escherichia coli, Salmonella, Shigella*, and *Klebsiella* species are among the 24 pathogens identified as highly resistant to antibiotics. There is a critical need to intensify efforts in antibiotic development to address the escalating threat of antibiotic resistance.[2]

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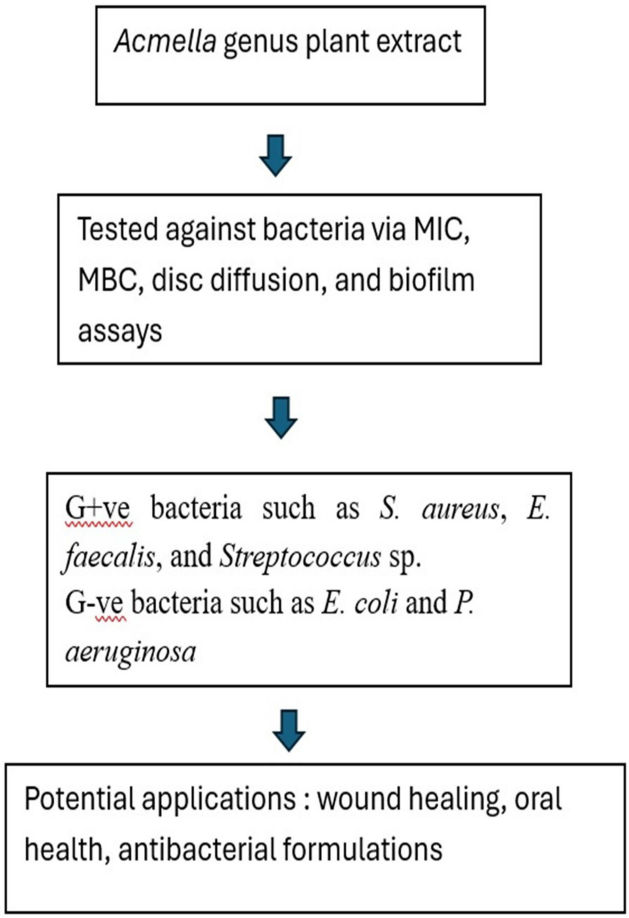
Graphical Abstract



Antibiotics, or antibacterial agents, are substances that specifically inhibit the growth of or kill bacteria. Most antibacterial agents currently used in clinical practice are derived from microorganisms such as bacteria and fungi. Some plant-derived compounds have also been successfully developed into antimicrobial agents with activity against bacteria, viruses, fungi, and parasites. Notable examples include quinine, artemisinin, and berberine. However, the number of antibacterial agents derived from plants remains limited.[3–5]

Natural plant-derived antimicrobial compounds hold promise as potential substitutes for traditional antibiotics. These compounds, found in various parts of the plant—including roots, stems, leaves, flowers, fruits, and seeds—have demonstrated significant inhibitory effects on bacterial growth.[6]

Plants from the *Acmella* genus are known to contain a variety of active compounds, including alkylamides, phenols, flavonoids, and tannins, which may contribute to their bactericidal properties.[7,8] Several species within the *Acmella* genus, such as *Acmella oleracea* (synonymous with *Spilanthes acmella*), are believed to possess antimicrobial activity and are traditionally used in some cultures to treat bacterial infections. Active compounds such as spilanthol have been shown to be effective against various bacteria, including *Staphylococcus aureus* and *Escherichia coli*.[9]

Acmella oleracea, Acmella uliginosa, Acmella caulirhiza, and Acmella paniculata are all members of the Acmella genus within the family Asteraceae, commonly referred to as the daisy or sunflower family. These plants are typically herbaceous and perennial and are commonly found in tropical and subtropical regions. They usually bear yellow or

orange flower heads that resemble daisies. Depending on cultural and regional naming conventions, they are also known as the toothache plant, buzz button, or paracress.[10]

Many plants from the *Acmella* genus are used in traditional medicine for their anti-inflammatory, antibacterial, and analgesic properties. The primary compounds of interest include spilanthol, along with other alkylamides and flavonoids, which are believed to contribute to their medicinal effects.[11–14]

Although these plants are all related through the *Acmella* genus, the species within this group are sometimes classified under different scientific names. The confusion surrounding the classification and nomenclature of herbal plants stems from several factors, including taxonomic revisions, regional and cultural variations in common names, morphological diversity, and the lack of a standardized classification system.[15,16]

This study aimed to conduct a systematic review of published literature to evaluate the antibacterial activities of extracts from plants within the *Acmella* genus, as supported by scientific evidence. To avoid taxonomic confusion, all species were collectively referred to as *Acmella* genus plants throughout the review. In the search for relevant journal articles, the keyword "Acmella" was used to retrieve publications related to various species, including *Acmella oleracea, Spilanthes acmella, Acmella uliginosa, Acmella paniculata*, and *Acmella caulirhiza.*

Materials and Methods

Search Strategy

The search strategy was developed using the PICO framework (Population, Intervention, Comparison, and Outcome) to structure the research question effectively. The goal was to identify relevant studies investigating the antibacterial actions of plants from the *Acmella* genus plants.

The search strategy was conducted in accordance with the Meta-Analysis and Systematic Reviews of Observational Studies (MOOSE) guideline[17] and the Preferred Reporting Items for Systematic Review and Meta-Analysis Protocols (PRISMA-P).[18]

A systematic review of the literature was conducted from December 2024 to February 2025 across Scopus, PubMed, and Web of Science databases using Medical Subjects Headings (MeSH) indexes and keyword searches. The string used included the entry term "Acmella", which was searched in combination (AND) with the terms "infection" OR "anti-microbial" OR "antibacterial*" The query "LIMIT-TO (DOCTYPE, 'ar')" was used to limit retrieve only original studies. The same combination of terms was used for all the databases. The search was limited to articles published within the past 10 years (2015–2025).

Inclusion Criteria

- Articles with available abstracts
- Peer-reviewed journal articles
- Studies reporting the antibacterial activities of plants from the *Acmella* genus

Exclusion Criteria

- Non-English language articles (due to limited resources for translation)
- Review articles or meta-analyses without primary data
- Letters, editorials, or case studies

Selection Criteria

This systematic review included all published articles that evaluated the antibacterial activity of *Acmella* genus plants, including *Spilanthes acmella, Acmella oleracea, Acmella paniculata, Acmella uliginosa*, and *Acmella caulirhiza*. All eligible studies were selected based on the PICOS criteria (Population, Intervention, Comparison/Comparator, Outcomes, and Study design)[19] (Table 1).

Articles included in the review were selected in three phases. First, the titles of all retrieved articles were screened, and any that did not meet the inclusion criteria were excluded. Duplicate entries were also removed during this phase. Second, the abstracts of the remaining articles were reviewed and excluded if they did not satisfy the inclusion criteria. In

Table 1 PIPOC Framework

	Inclusion	**Exclusion**
Population	Bacteria (Gram positive or Gram negative)	Fungus, virus, protozoa
Intervention	*Acmella* genus only	Combination of *Acmella* genus plants with carriers /emulgel
Comparison	Positive control group such as antibiotics or no treatment	–
Outcome	MIC, MBC, ZOI	–
Study Type	In vitro, animal studies	Case reports, editorials, communications, reviews, meta-analysis

the final phase, the full texts of the remaining articles were obtained and thoroughly assessed to exclude any that did not meet the inclusion criteria.

At least two reviewers (SNK and NFAH) independently carried out the screening process. Before proceeding to the data extraction phase, the inclusion of each article in the review was confirmed through agreement between the two reviewers. Any disagreements were resolved by consultation with a third reviewer (INM).

Data Extraction

Data extraction was performed in a standardized manner using a data collection form by SNK and ANQS. The extracted data included: (1) authors; (2) plant species and dosage; (3) study design and sample size; (4) study objectives; (5) parameters assessed; (6) key findings; and (7) conclusions. All extracted data were tabulated to facilitate comparative analysis.

Quality Assessment

ANS and INM assessed the quality of the included studies to ensure reliability using the SciRAP (Scientific Risk Assessment Portal) tool for in vitro studies. Studies rated as low quality were either excluded or had their limitations explicitly acknowledged in this review.

Data Synthesis

Data synthesis was conducted using a narrative synthesis approach. Key information extracted from the included studies is presented in a summary table (Table 2). This table summarizes important data in a clear and organized manner, enabling quick comparison and assessment of the characteristics, methodologies, and findings of the reviewed studies.

Handling Missing Data

For studies with missing or incomplete data, attempts were made to contact the corresponding authors for clarification or additional information. If no response was received, the study was either excluded or analyzed based solely on the available data.

Ethical Considerations

Although this systematic review did not involve direct experimentation on humans or animals, ethical research standards were upheld. All included studies were peer-reviewed publications that had obtained ethical approval for their respective experiments or clinical trials.

Results

The literature search across Scopus, PubMed, and Web of Science databases identified 111 relevant articles. After removing duplicates, 91 articles remained for abstract screening. Two reviewers (SNK and NFAH) independently assessed the titles and abstracts of all articles based on the inclusion and exclusion criteria. Any disagreements regarding article selection were resolved through discussion, with final decisions made by a third reviewer (INM). A total of 19 articles were retrieved for full-text assessment. Upon further scrutiny, five articles were excluded

Table 2 Summary Table for the 14 Studies Selected

	Authors	Plant Species and Dosage	Study Design and Types of Bacteria	Objective	Parameters & Bacteria	Findings	Conclusions
1	Fajardo et al, 2025[20]	Methanolic extract of *A. oleracea* leaves	*Gram +ve: S. epidermidis*, MRSA *Gram -ve: E. coli, P. aeruginosa*	To investigate the antibacterial activities of *A. oleracea* leaves on major bacteria causing wound infection	MIC and MBC, bacterial killing assay, and biofilm adhesion assessment. Positive control - azithromycin	MIC against *E. coli, S. epidermidis*, and MRSA was 1000 μg/mL, while MIC & MBC for *P. aeruginosa* was 500 μg/mL. Adhesion of *MRSA, P. aeruginosa*, and mixed biofilms was significantly reduced.	*A. oleracea* exerts potent antimicrobial effects on the major bacteria causing wound infection.
2	Bhamare et al, 2024[21]	*S. acmella* ethanolic extract	*E. faecalis - commonly found bacteria in endodontic canals*	To evaluate the efficiency of *S. acmella* extract on *E. faecalis* biofilm eradication.	MIC, time-kill assay, anti-biofilm activity –crystal violet assay Positive control - calcium hydroxide	MIC value *of S. acmella* against *E. faecalis* was 25 μg/mL. Time-kill assay: bacterial count was reduced gradually till 36 hours only. The mean biofilm reduction at 25 μg/mL SA, 1.83 ± 1.57	*S. acmella* has demonstrated antibacterial efficacy against *E. faecalis*
3	Shivananda et al, 2024[22]	*S. acmella* ethanol extract	*S. mutans, L. fermentum, P. gingivalis*, and *C. gingivalis*	To investigate the antibacterial action of *S. acmella on* bacteria that cause dental infection.	Well diffusion method. Positive control - erythromycin	*S. acmella* demonstrated concentration-dependent zone of inhibition.	*S. acmella* extract may be a viable alternative in the treatment of dental caries and periodontal infection
4	Ordóñez et al, 2024[23]	*Acmella ciliata (A. ciliata)*	*S. equi*	To evaluate the antibacterial activity of *A. ciliata*	MIC, Positive control - enrofloxacin	*MIC of 22.50 mg/mL for A. ciliata*	*A. ciliata* showed antibacterial activity against *S. equi*
5	Alam & Akash, 2023[24]	Methanol extract of *A. oleracea* leaves	*B. subtilis, S. aureus*, S. Typhi, *E. coli*, V. mimicus	To evaluate the antibacterial properties	Disc diffusion method Positive control - kanamycin	*A. oleracea* extract was effective against both Gram-positive and Gram-negative bacteria	*A. oleracea* extract may be a rich source of antibacterial activity,

(*Continued*)

Table 2 (Continued).

	Authors	Plant Species and Dosage	Study Design and Types of Bacteria	Objective	Parameters & Bacteria	Findings	Conclusions
6	Sanap & Khan, 2023[25]	Ethanol extract of *A. oleracea* flowers	*E. coli, P. aeruginosa, B. subtilis and S. aureus*	To explore the anti-bacterial activity of ethanol extract of *A. oleracea* flowers.	Agar well diffusion method Positive control - streptomycin	*A. oleracea* extract has anti-bacteria activities especially P. aeruginosa	*A. oleracea* extract displayed antibacterial activity for treatment of mouth ulcer.
7	Peretti et al, 2021al[26]	*A. oleracea* leaves of Pará variation and stem of Amapá variation	*S. mutans* (dental caries)	To determine the antibacterial activity of two regional variations of *A. oleracea*	MIC and MBC, anti-biofilm activity–crystal violet assay Positive control - Chlorhexidine digluconate 0.12%	Both variations of *A. oleracea* have similar MIC and MBC of 125 µg/mL against *S. mutans*. In the antibiofilm assay, *A. oleracea* leaves of Pará variation at 500 µg/mL (4xMIC) were as effective as chlorhexidine gluconate in inhibiting in biofilm.	*A. oleracea* leaves of Pará variation extract showed remarkable antibacterial activity against *S. mutans*
8	Namwase et al, 2021[27]	*A. caulirhiza*	*S. mutans* (dental caries)	To assess the anti-bacterial activity of *A. caulirhiza* Del. on *S. mutans*	Agar well diffusion method, MIC and MBC.	The aqueous plant extract of *A. caulirhiza* had the highest zones of inhibition. The MIC and MBC were 62.5mg/mL and 250mg/mL respectively	*A. caulirhiza* has antibacterial activity against *S. mutans*
9	Salehuddin et al, 2020[28]	*A. paniculata* leaves and flowers extracts (hexane, methanol, DCM and acetone)	*S. mutans* (dental caries)	To investigate the antibacterial activities of *A. paniculata* leaves and flowers extracts towards *Streptococcus mutans*	Disc diffusion method, MIC and MBC, anti-biofilm activity - crystal violet assay Positive control – sodium fluoride	Based on disc diffusion assay, hexane and methanol leave extracts and n-hexane and DCM flowers extracts exhibited anti-bacterial activities. Based on MIC and MBC values, these extracts were also bactericidal against *S. mutans*. These extracts also reduced biofilm formation with flower extracts being more potent.	n-hexane leaves extract, methanol leaves extract, n-hexane flowers extract, and DCM flowers extract of *A. paniculata* were bactericidal against *S. mutans*

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10	Lalthanpuii et al, 2020[29]	Ethyl acetate fraction from *A. oleracea* methanol extract	*B. subtilis*, *E. coli, K. pneumoniae, P. aeruginosa*	To study the antibacterial activities of *A. oleracea* extracts.	Disc diffusion method Positive control - Ceftriaxone	The *A. oleracea* extract showed higher zone of inhibition (ZOI) values against all the tested bacteria	*A. oleracea* extract was effective against all the tested bacteria with highest efficacy on B. subtilis.
11	Philip & Mahalakshmi, 2019[30]	*S. acmella*	*S. mutans and S. aureus*	To estimate the antibacterial effect of *S. Acmella* on denture plaque bacteria	Disc diffusion method	S. *acmella* had antibacterial effect against both bacteria.	S. *acmella* can be alternative treatment against denture plaque bacteria.
12	Thakur et al, 2019[31]	*S. Acmella*	*Bacillus cereus, Escherichia coli, Salmonella typhi and Staphylococcus aureus*	To screen the antibacterial activities of different solvents for extracts of different plant parts	Agar-well diffusion method.	Methanol extracts of all plant parts (leaf, flower, stem) were more effective against all the tested bacteria than acetone extracts. No antibacterial activity was recorded in the water extract of all parts. S. typhi was the most susceptible bacteria	Methanolic extracts of *S. Acmella* exhibited the best anti-bacteria activities.
13	Lagnika et al, 2016[32]	*A. uliginosa*	*Gram-positive: S. aureus, S. epidermidis, E. faecalis, MRSA Gram-negative: E. coli, P. aeruginosa*	To evaluate the antibacterial effect of *A. uliginosa*	MIC, Agar diffusion method Positive control - gentamicin	The antibacterial activity was broad spectrum, inhibiting both Gram-positive and Gram-negative bacteria. The minimum inhibitory concentration ranged from 0.625 to 5 mg/mL	*A. uliginosa* extracts contains antibacterial activities.
14	Sathyaprasad et al, 2015[33]	*S. acmella* flower	*S.aureus, Streptococcus sp., E. faecalis*	To test the antimicrobial effect of *S. Acmella* against common intracanal pathogens	Agar cup bioassay Positive control - calcium hydroxide	*S. acmella* had a significant antibacterial action for E. faecalis but was not as effective against S. aureus and Streptococcus sp.	*S. acmella* possesses antibacterial activity against E. faecalis, a common root canal pathogen.

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because either antibacterial activity was not the primary focus or the *Acmella* genus plant extract was combined with nanocarriers or emulgels, making it difficult to determine whether the extract contributed to the observed antibacterial effects. All selected articles were assessed for quality using the SciRAP tool and were deemed reliable and relevant. Ultimately, 14 articles were included in this review.[19–21,23,31,33–41] A flowchart outlining the selection process, including reasons for exclusion, is presented in Figure 1.

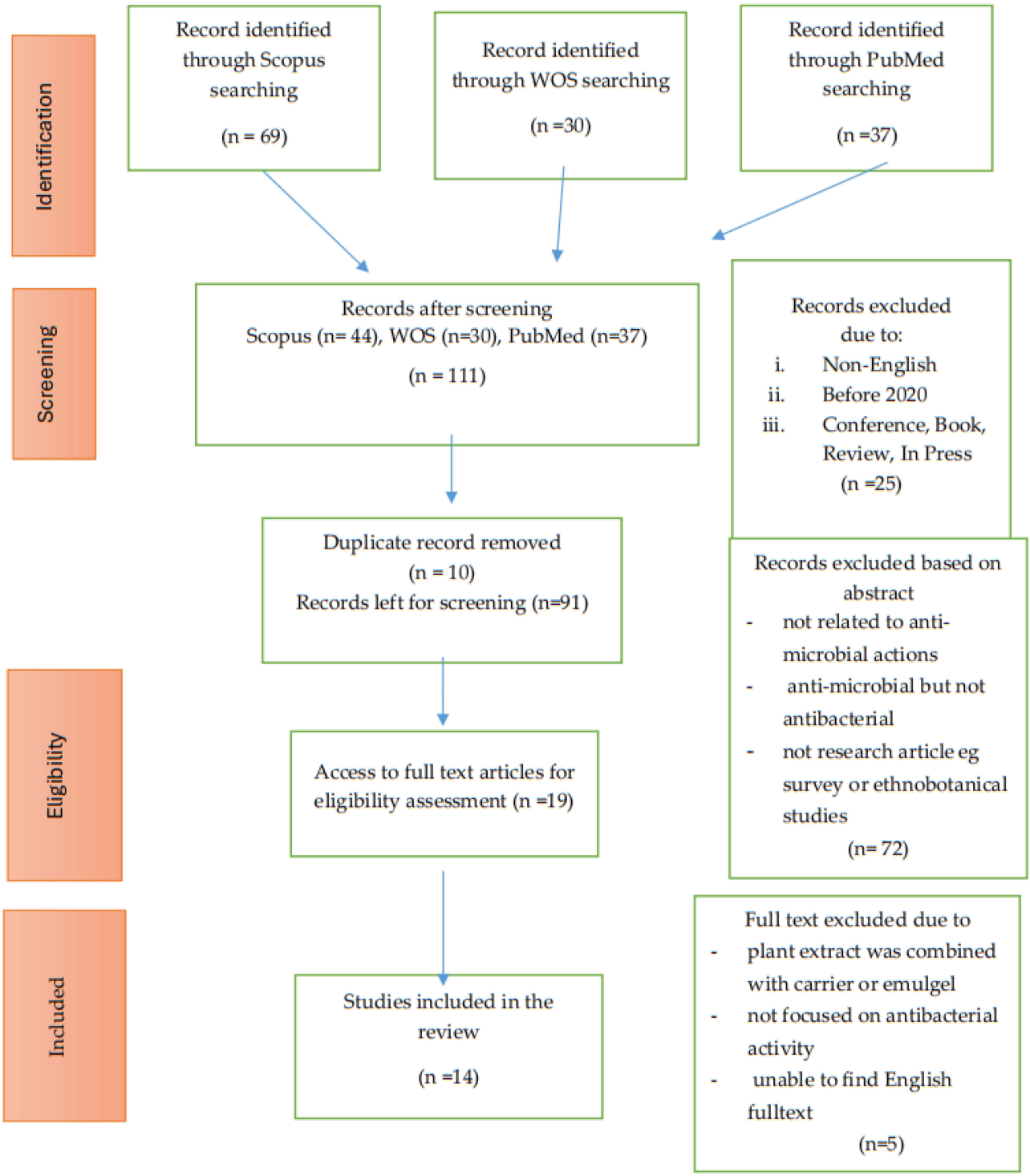

Figure 1 Flow diagram of the proposed searching study.

Types of Plants

The antibacterial potential of Acmella has been investigated across multiple species, reflecting the genus's ethnomedicinal importance and diverse phytochemical composition. Researchers have primarily focused on *A. oleracea* and its synonymous species *Spilanthes acmella*, while a smaller number of studies extended the scope to other less-studied species such as *A. ciliata, A. caulirhiza, A. paniculata*, and *A. uliginosa*. The primary objective of the included studies was to evaluate the antibacterial activity of *Acmella* genus plant extracts. Five of the fourteen studies investigated the antibacterial properties of the leaves, stems, or flowers of *Acmella oleracea*. Another five studies examined *Spilanthes acmella*, which is taxonomically synonymous with *A. oleracea*. The remaining studies focused on other *Acmella* species, including *A. ciliata, A. caulirhiza, A. paniculata*, and *A. uliginosa*. In the study by Thakur et al,[31] the methanolic extract of *S. acmella* demonstrated superior antibacterial activity compared to acetone or aqueous extracts.

Types of Bacteria

Given the clinical significance of bacterial infections, especially in dentistry and wound care, studies have tested Acmella extracts against a wide spectrum of Gram-positive and Gram-negative bacteria. The extracts were tested against various types of bacteria. In most studies, the bacterial strains were either commercially obtained or sourced from laboratory stock cultures. An exception was the study by Ordonez et al[23] which isolated *Streptococcus equi* from the pus of lymphadenitis in guinea pigs.

Seven of the studies evaluated the extracts against bacteria associated with dental infections. *Streptococcus mutans* was the primary bacterium tested, along with *Staphylococcus aureus, Enterococcus faecalis*, and other *Streptococcus* species.

Two of the studies, Fajardo et al[20] and Ordonez et al,[23] tested the extracts against major bacteria responsible for wound infections and lymphadenitis, respectively. The remaining studies evaluated the extracts against common bacterial strains, primarily *Staphylococcus aureus* as a representative Gram-positive bacterium, and *Escherichia coli* and *Pseudomonas aeruginosa* as representative Gram-negative bacteria.

Methods

The methodological approaches to evaluate both bacteriostatic and bactericidal effects varied across studies, with diffusion assays used for preliminary screening and MIC/MBC determinations providing quantitative insights into efficacy. All the included studies were conducted in vitro; no animal or in vivo studies were identified. Half of the studies performed minimum inhibitory concentration (MIC) testing to determine the lowest concentration of *Acmella* plant extract that inhibits bacterial growth, indicating bacteriostatic activity. Several studies also reported minimum bactericidal concentration (MBC) values, which assess the extract's ability to kill bacteria, indicating bactericidal activity. An extract is considered bactericidal if the MBC value is less than or equal to four times the MIC value, whereas bacteriostatic activity is indicated when the MBC value exceeds four times the MIC value.[42]

Many of the included studies employed disc diffusion or agar well diffusion assays as preliminary screening methods to assess the antibacterial activity of *Acmella* plant extracts by measuring the zone of inhibition. Other methods used included bacterial killing assays and anti-biofilm activity tests. A biofilm is a complex, structured community of microorganisms that adhere to a surface and are encased in a matrix of extracellular polymeric substances. Biofilms can form on various surfaces, including dental plaques. Four studies[26,42–44] evaluated the anti-biofilm activity of *Acmella* extracts in the context of wound and dental infections.

The antibacterial effects of the extracts were compared to positive controls, which included antibiotics such as erythromycin, enrofloxacin, streptomycin, gentamicin, ceftriaxone, and kanamycin, as well as antiseptics and chemicals such as chlorhexidine digluconate, sodium fluoride, and calcium hydroxide.

Antibacterial Actions

Across the included studies, *Acmella* extracts demonstrated consistent antibacterial effects, although potency varied depending on the species tested, extraction method, and bacterial strain. The results highlighted promising activity

against oral pathogens, wound-infecting bacteria, and several clinically relevant Gram-positive and Gram-negative organisms. *Streptococcus mutans, Enterococcus faecalis*, and *Staphylococcus aureus* are common bacteria associated with dental infections. Most of the studies related to dental pathogens tested the antibacterial activity of *Acmella* plant extracts against *S. mutans*. Well diffusion assays demonstrated the antibacterial effects of *Spilanthes acmella, Acmella oleracea, Acmella caulirhiza*, and *Acmella paniculata* against *S. mutans*.

Only two of these studies conducted MIC and MBC assays, and both reported that *Acmella* plant extracts exhibited bactericidal activity against *S. mutans.*

Regarding other dental pathogens, Bharmare et al[21] and Sathyaprasad et al[33] found that *S. acmella* inhibited the growth of *E. faecalis*.

In the study by Fajardo et al,[20] on bacteria associated with wound infections, *Acmella oleracea* demonstrated bacteriostatic effects against *Staphylococcus epidermidis, methicillin-resistant Staphylococcus aureus (MRSA*), and *Escherichia coli*, but exhibited bactericidal activity against *Pseudomonas aeruginosa*. In another study, Ordonez et al[23] reported that *Acmella ciliata* inhibited the growth of *Streptococcus equi*, which was isolated from the pus of lymphadenitis.

Five studies investigated *Acmella* extracts against common bacterial infections. All employed disc diffusion or agar well diffusion methods, which provide qualitative or semi-quantitative assessments of antibacterial activity. Only one study[40] conducted MIC testing. In all studies, *Acmella* plant extracts produced measurable zones of inhibition against both Gram-positive and Gram-negative bacteria. Specifically, *A. uliginosa* extract in the study by Lagnikan et al[32] recorded MIC values ranging from 0.625 to 5 mg/mL against the tested bacterial strains.

Discussion

A bacterial infection occurs when bacteria invade and multiply within the body. Such infections are typically treated with antibiotics or antibacterial agents, medications designed to kill bacteria or inhibit their growth. However, due to the decline in the discovery of new antibacterial agents and the rising threat of antibiotic resistance, there is an increasing need to explore alternative sources, such as plant extracts, with potential antibacterial properties.[34]

The *Acmella* genus comprises approximately 50 species, although the exact number may vary slightly depending on taxonomic revisions.[24,25] This review identified studies reporting antibacterial activity in six *Acmella* species. The evaluation of *Acmella* plant extracts for antibacterial efficacy has revealed promising antimicrobial properties, particularly against bacterial strains associated with dental and wound infections. A comprehensive literature search using the Scopus, PubMed, and Web of Science databases identified 14 eligible studies that provided valuable insights into the antibacterial potential of various *Acmella* species. The research predominantly focused on *Acmella oleracea*, often regarded as synonymous with *Spilanthes acmella*, while additional studies examined *Acmella ciliata, Acmella caulirhiza, Acmella paniculata*, and *Acmella uliginosa*.

Extraction of bioactive compounds primarily involved the use of ethanol or methanol as solvents, with methanolic extracts demonstrating superior antibacterial efficacy, as reported by Thakur et al,[31] This finding aligns with those of Truong et al,[35] and Ibrahim et al,[36] who also observed enhanced antimicrobial activity in methanolic extracts of medicinal plants, likely due to the higher solubility of phytochemicals in polar solvents.

A broad spectrum of bacterial strains was tested, with particular emphasis on pathogens associated with dental and wound infections. Most studies on dental infections referred to *Spilanthes acmella* as the *Acmella* genus plant extract, while one study used *Acmella oleracea*. Since both are commonly known as the "toothache plant," it is not surprising that numerous studies have explored their potential in dental-related treatments.

According to reputable botanical databases such as *Plants of the World Online* (Kew Science) and the Global Biodiversity Information Facility (GBIF), the species previously classified as *Spilanthes acmella* has been reclassified as *Acmella oleracea*. This reclassification reflects advancements in botanical taxonomy and an improved understanding of phylogenetic relationships within the Asteraceae family. Consequently, results reported for *Spilanthes acmella* and *Acmella oleracea* can be interpreted collectively, as they refer to the same plant species.

Streptococcus mutans, a principal contributor to dental caries, was extensively examined, with studies by Bharmare et al,[21] and Sathyaprasad et al[33] confirming the bactericidal effects of *Acmella* extracts against this pathogen. Additional

research also demonstrated inhibitory activity against *Enterococcus faecalis*, another key bacterium involved in endodontic infections. The effectiveness of *Acmella* extracts against dental pathogens is consistent with findings by Adamczak et al,[37] and Huang et al,[38] who reported similar antibacterial effects from plant-based extracts containing bioactive alkaloids and flavonoids. These findings suggest that *Acmella*-derived phytochemicals may serve as potential adjuncts in oral healthcare products.

Regarding wound infections, *Acmella oleracea* exhibited bacteriostatic effects against *Staphylococcus epidermidis*, methicillin-resistant *Staphylococcus aureus* (MRSA), and *Escherichia coli*, while demonstrating bactericidal activity against *Pseudomonas aeruginosa*, as reported by Fajardo et al.[20] These findings are consistent with those of Ordonez et al,[23] who reported that *Acmella ciliata* effectively inhibited *Streptococcus equi* isolated from lymphadenitis pus. These results support earlier studies by Farhadi et al,[39] and Suriyapom et al,[40] which demonstrated the efficacy of plant-derived extracts in controlling wound-related bacterial infections through mechanisms such as disruption of bacterial cell membranes and inhibition of bacterial adhesion. The biofilm-inhibitory potential of *Acmella* extracts further underscores their value in managing persistent infections, as biofilms are major contributors to bacterial resistance and chronic wound complications.

Methodologically, the included studies primarily employed in vitro assays such as minimum inhibitory concentration (MIC), minimum bactericidal concentration (MBC), disc diffusion, and agar well diffusion techniques. MIC and MBC analyses were conducted in approximately half of the reviewed studies, confirming the bactericidal or bacteriostatic properties of *Acmella* extracts, depending on the bacterial species tested. These findings are consistent with the work of Nascimento et al[41] and Morgana et al,[42] who emphasized the significance of these methodologies in evaluating the antimicrobial efficacy of plant-derived compounds.

The antibacterial activity of *Acmella* extracts was frequently compared to that of conventional antibiotics such as erythromycin, enrofloxacin, streptomycin, and gentamicin, as well as antiseptics like chlorhexidine digluconate and sodium fluoride. Although the zones of inhibition varied across studies, the overall trend indicated that *Acmella* extracts exhibited notable antimicrobial effects, albeit often at higher concentrations than standard antibiotics. This observation aligns with findings by Khameneh et al,[43] and Eloff et al,[44] who reported that plant-based antimicrobials may require higher dosages to achieve comparable effects but offer significant advantages, including lower toxicity and a reduced likelihood of promoting antibiotic resistance. Given the escalating global concern over antibiotic-resistant bacterial strains, the exploration of alternative antimicrobial agents derived from medicinal plants is of increasing importance.

Plants of the *Acmella* genus contain a variety of phytochemicals, with the alkylamide spilanthol and other compounds believed to contribute to their antibacterial activity. The antimicrobial properties of *Acmella oleracea* are likely associated with the presence of alkylamides such as spilanthol, as well as the phenolic metabolite vanillic acid. These bioactive molecules have been shown to disrupt microbial cell membranes, ultimately leading to cell rupture.[26,45]

The collective findings highlight the potential of *Acmella* genus plant extracts in combating bacterial infections, particularly in applications related to oral health and wound care. However, the exclusive reliance on in vitro studies represents a significant limitation, as in vivo and clinical investigations are necessary to validate both the therapeutic efficacy and safety profiles of these extracts.

The precise mechanisms underlying the antimicrobial activity of *Acmella* species remain undetermined and warrant further investigation. Future research should prioritize pharmacokinetic and toxicological evaluations, along with formulation strategies aimed at improving the bioavailability and stability of *Acmella*-derived bioactive compounds. Bio-guided fractionation approaches are also essential for isolating and characterizing the specific compounds responsible for the observed antibacterial effects.

In addition, evaluating the safety and efficacy of these compounds in vivo is crucial to assess their potential for clinical application. The possible synergistic interactions between *Acmella* extracts and conventional antibiotics merit further exploration, as such combinations may enhance antibacterial efficacy while reducing the risk of adverse effects and resistance development.

Conclusion

Acmella genus plant extracts exhibit notable antibacterial potential, particularly against pathogens implicated in oral and wound infections. Although in vitro studies have demonstrated their efficacy, further in vivo and clinical investigations are essential to confirm their therapeutic applicability. Future research should prioritize the isolation and characterization of active compounds, elucidation of their precise mechanisms of action, pharmacokinetic and toxicological assessments, and formulation strategies to enhance bioavailability. Additionally, exploring synergistic interactions with conventional antibiotics may further improve antibacterial efficacy and support the development of novel adjunct therapies.

Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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