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Review Article

Extraction Strategies, Solvent Systems, and Phytochemical–Bioactivity Evidence in *Talinum paniculatum* (Jacq.) Gaertn.: A Scoping Review

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Abstract

Objectives: To map extraction methods, solvent systems, fractionation procedures, extraction yields, phytochemical profiles, and biological activities reported for *Talinum paniculatum* (Jacq.) Gaertn. and identify methodological gaps relevant to pharmaceutical research. **Data sources:** PubMed, Scopus, ScienceDirect, and Google Scholar were searched, with the final search performed on 31 May 2026. **Study selection:** Primary experimental studies reporting extraction procedures and relevant phytochemical, yield, or biological outcomes were eligible. One reviewer conducted screening and study selection, and the other authors verified the included studies. **Summary of contents:** Twenty-eight studies published between 2009 and 2026 were included. Leaves were investigated in 23 studies, and maceration-based extraction was used in 15. Ethanolic and hydroethanolic systems were frequently investigated, especially for leaf extracts. Extraction yields were available or calculable in 20 studies; 18 studies did not report additional fractionation. Chemical characterization ranged from qualitative screening to chromatographic and mass-spectrometric profiling. Antioxidant, antimicrobial, antifungal, and other preclinical pharmacological activities were reported, but extraction conditions and biological assays varied substantially. **Conclusion:** Leaf-based ethanolic or hydroethanolic extraction is frequently investigated and potentially relevant to pharmaceutical development, but the available evidence does not establish its superiority over alternative approaches. More standardized extraction reporting, quantitative chemical profiling, direct bioactivity testing, and safety evaluation are required.

Keywords: *Talinum paniculatum*; Java ginseng; extraction; solvent polarity; fractionation; phytochemical profiling; biological activity; scoping review.

INTRODUCTION

Natural products remain important sources for drug discovery because many approved therapeutic agents have been derived from or inspired by naturally occurring compounds. In natural product research, extraction is a fundamental preliminary step that enables the separation of target compounds from raw materials before further isolation, phytochemical profiling, and biological evaluation. The efficiency of this process is influenced by several parameters, including solvent properties, particle size, solvent-to-solid ratio, extraction temperature, and extraction duration. Among these factors, solvent selection is particularly important because solvent polarity affects the solubility and selectivity of extracted metabolites. Therefore, solvents with polarity compatible with the target compounds are generally more suitable for their recovery. Conventional extraction methods, such as maceration, percolation, and reflux extraction, remain widely used, although they may require large solvent volumes and prolonged extraction times. Modern techniques, including supercritical fluid extraction, pressurized liquid extraction, microwave-assisted extraction, and ultrasonic-assisted extraction, have been developed to reduce solvent consumption, shorten extraction time, and improve extraction selectivity[1].

Talinum paniculatum (Jacq.) Gaertn. is an accepted plant species belonging to the family Talinaceae, according to Plants of the World Online by the Royal Botanic Gardens, Kew[2]. This species has been reported as both a traditional medicinal plant and a food source, and previous studies have associated it with phytochemical constituents and biological activities, including antimicrobial potential. The leaves of *T. paniculatum* have attracted particular attention as an unconventional food plant because of their nutritional value and bioactive potential. Menezes et al.[3] reported that *T. paniculatum* leaves contain protein, insoluble dietary fiber, ascorbic acid, magnesium, potassium, and calcium. The same study evaluated several solvent systems,

including water, ethanol, ethanol/water, methanol, methanol/water, methanol/acetic acid, and acetone/water/acetic acid, for phenolic compound extraction and for the assessment of antioxidant and antibacterial activities. Methanol/acetic acid extraction produced the highest phenolic compound yield and DPPH antioxidant capacity among the tested solvent systems, while the extracts also inhibited the growth of *Bacillus cereus*, supporting the antibacterial potential of *T. paniculatum* leaves[3].

Beyond its food-related potential, *T. paniculatum* has been investigated in several pharmacological and phytochemical contexts. Souto et al.[7] evaluated an ethanolic leaf extract of *T. paniculatum* in a doxorubicin-induced cardiotoxicity model in hypertensive rats and reported that the extract may exert cardioprotective effects through mechanisms associated with serum antioxidant activity and angiotensin-converting enzyme inhibition. Antimicrobial evidence is more strongly represented by leaf-based studies, including hydroalcoholic extracts and solvent fractions evaluated against bacterial, fungal, and mycobacterial models[4,5,6]. Chemical characterization studies have also demonstrated the use of chromatographic and mass-spectrometric methods in *T. paniculatum* research, including LC-DAD-MS, GC-MS, HPLC-DAD, and UHPLC-Q-Exactive-Orbitrap-MS/MS[7,6,8]. dos Reis et al.[4] reported that a leaf extract of *T. paniculatum* was obtained by ethanol-water percolation and subsequently partitioned into hexane, ethyl acetate, butanol, and aqueous fractions. The same study evaluated the antibacterial, antifungal, antimycobacterial, and cytotoxic activities of the crude leaf extract and its fractions. More recently, Li et al.[8] reported that fresh *T. paniculatum* root contained at least 22 natural compounds identified using UHPLC-Q-Exactive-Orbitrap-MS/MS and proposed synephrine, N-trans-feruloyltyramine, and chikusetsusaponin IVa as anti-counterfeiting quality markers for *T. paniculatum* root.

Despite increasing interest in the phytochemical and pharmacological properties of *T. paniculatum*, the available experimental evidence remains limited and fragmented across different research objectives. Existing studies have investigated individual aspects of extraction, phytochemical composition, biological activity, or pharmaceutical formulation, often using different plant parts, solvent systems, extraction conditions, and analytical methods[3,7,8]. This fragmentation creates an important methodological gap because extraction procedures, chemical characterization, and biological outcomes are rarely examined within a consistently comparable experimental framework. Consequently, it remains difficult to distinguish frequently investigated extraction strategies from those supported by direct comparative evidence. An integrated mapping of these methodological and experimental characteristics is therefore needed to clarify the current evidence landscape, identify areas of concentrated research, and highlight underexplored extraction–phytochemical–bioactivity relationships relevant to natural product and pharmaceutical development.

A scoping review is appropriate for examining the extent, characteristics, and distribution of heterogeneous evidence, particularly when available studies differ substantially in methodology and reported outcomes[9,10]. Given the limited and methodologically diverse literature on *T. paniculatum* extraction and phytochemical investigation, this approach enables a structured assessment of the available experimental findings without assuming direct comparability between studies. Accordingly, the present review addresses the following research question: How have plant parts, extraction methods, solvent systems, fractionation procedures, extraction yields, phytochemical profiles, and biological activities been investigated in experimental studies of *T. paniculatum*, and what methodological and knowledge gaps remain? By integrating these dimensions, this review aims to provide an evidence-based overview of current extraction practices and to identify priorities for future phytochemical characterization, pharmacological evaluation, and pharmaceutical formulation research.

MATERIALS AND METHODS

1.Review Design

This study was conducted as a scoping review to map the available evidence on extraction methods, fractionation strategies, solvent systems, extraction yields, phytochemical profiles, and biological activities reported for *Talinum paniculatum* (Jacq.) Gaertn. A scoping review design was selected because the existing literature is heterogeneous in terms of plant part, extraction procedure, solvent type, phytochemical assessment, and biological assay, making evidence mapping more appropriate than estimation of a pooled effect size. The review was conducted in accordance with established methodological guidance for scoping reviews and reported following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews, PRISMA-ScR[10,9].

2.Review question and eligibility framework

The review question was formulated using the Population/Material–Concept–Context framework. The guiding research question was: How have plant parts, extraction methods, solvent systems, fractionation procedures, extraction yields, phytochemical profiles, and biological activities been investigated in experimental studies of *Talinum paniculatum*, and what methodological and knowledge gaps remain? The Population/Material consisted of studies using *T. paniculatum* from any plant part, including leaves, roots, stems, aerial parts, whole herbs, flowers, or seeds when available. The Concept included extraction methods, fractionation strategies, solvent types, solvent polarity or concentration, extraction yield, phytochemical screening or profiling, compound diversity, and biological activities. The Context included primary experimental laboratory studies, including in vitro, ex vivo, in vivo animal, pharmacognostic, phytochemical, extraction optimization, and formulation studies that reported data specific to *T. paniculatum*.

3.Eligibility criteria

Studies were included if they clearly investigated *T. paniculatum*, used plant material, crude extract, or fraction of *T. paniculatum*, reported the extraction method and solvent used, and provided extractable data on phytochemical screening, phytochemical profiling, extraction yield, and/or biological activity. Eligible studies included primary experimental studies, such as in vitro, ex vivo, in vivo animal, pharmacognostic, phytochemical, laboratory-based, extraction optimization, and formulation studies. Only full-text articles published in English or Indonesian were considered eligible.

Studies were excluded if they did not clearly investigate *T. paniculatum*, only mentioned *T. paniculatum* as part of a herbal mixture without extractable species-specific data, were reviews, editorials, opinion articles, or short proceedings without primary experimental data, did not report the extraction or fractionation method, or did not provide relevant extractable outcome data related to phytochemistry, extraction yield, or biological activity.

4.Information sources and search strategy

A literature search was conducted in PubMed, Scopus, ScienceDirect, and Google Scholar, with the final search performed on 31 May 2026. No restriction on publication year was applied. The search strategy combined botanical terms, extraction-related terms, phytochemical terms, and biological activity terms. The botanical terms included "*Talinum paniculatum*", "Java ginseng", and "ginseng jawa". These terms were combined with extraction-related keywords, including extract*, extraction, fraction*, solvent*, maceration, soxhlet, reflux, infusion, decoction, ultrasonic, ultrasound-assisted, and microwave-assisted. Phytochemical-related terms included phytochemical*, plant-derived compound*, plant-derived chemical*, plant bioactive compound*, bioactive compound*, and phytonutrient*. Biological activity terms included biological activit*, antioxidant, anti-inflammatory, antimicrobial, cytotoxic*, and wound healing.

For Google Scholar, the search was restricted to the first 80 records ranked by relevance using the predefined search queries. This predefined screening limit was applied to establish a consistent and manageable retrieval approach. The search was designed to identify experimental studies addressing the prespecified extraction-related and phytochemical or biological activity concepts rather than to retrieve all publications concerning the species irrespective of their research focus. The complete search expressions used for each source are provided in Supplementary Table 1.

5.Study selection

All retrieved records were compiled, and duplicate records were removed before screening. Study selection was performed in two stages. First, titles and abstracts were screened by a primary reviewer to identify potentially relevant studies based on the predefined eligibility criteria. Second, the full texts of potentially eligible articles were assessed by the same reviewer to determine their suitability for inclusion. The resulting selection of included studies was subsequently reviewed and verified by the other authors against the eligibility criteria and the information reported in the source publications. This verification process was intended to improve the consistency and accuracy of the final study selection but was not performed as independent duplicate screening.

A total of 176 records were identified from the databases, consisting of 9 records from Scopus, 2 from PubMed, 85 from ScienceDirect, and 80 from Google Scholar. After removal of 11 duplicates, 165 records were screened by title and abstract. Of these, 80 records were excluded, and 85 reports were sought for retrieval. Fourteen reports could not be retrieved, leaving 71 full-text reports assessed for eligibility. Forty-three reports were excluded at the full-text stage: 4 herbal-mixture studies without extractable *T. paniculatum*-specific data, 2 reviews, editorials, opinions, or short proceedings without primary data, 20 studies without reported extraction or fractionation methods, and 17 studies without relevant outcome data. Finally, 28 studies were included in this scoping review. The study selection process is presented in the PRISMA flow diagram.

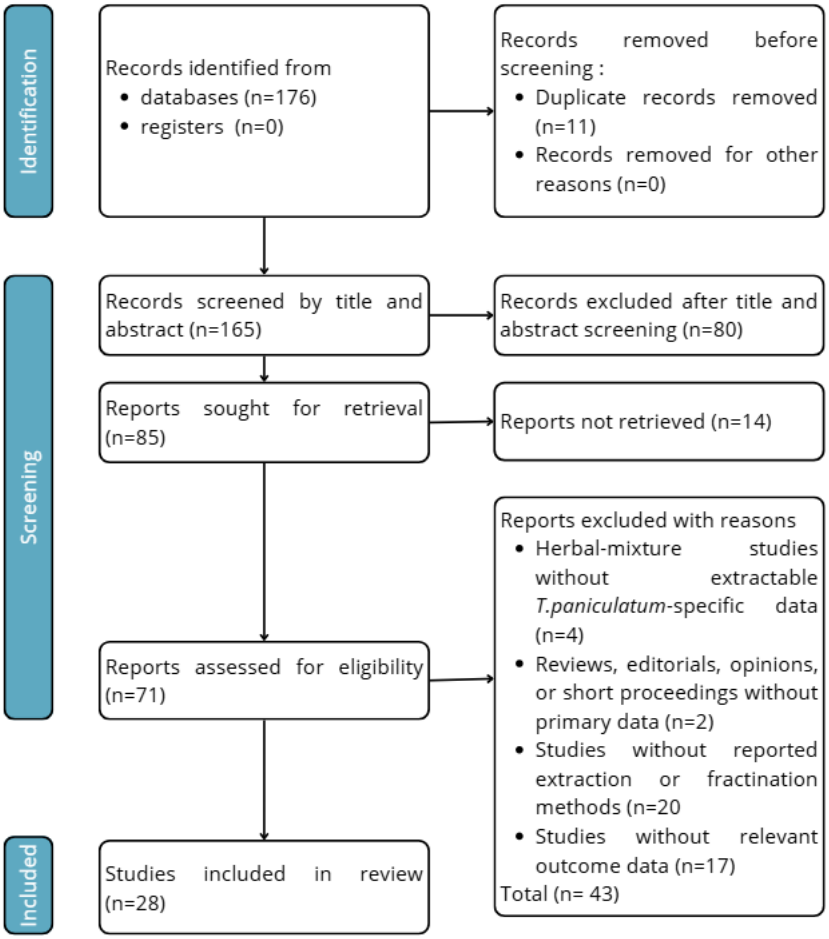


Figure 1. PRISMA flow diagram

6.Data charting

Data were charted using a standardized extraction form developed for this review. The data charting form was developed iteratively and refined during the extraction process to ensure that variables relevant to the review question were consistently captured. Extracted data included study identity, author, year, country, study design, plant part, plant material condition, extraction method, solvent used, solvent concentration or polarity, extraction conditions, fractionation method, extract or fraction type, extraction yield, phytochemical screening method, identified phytochemical classes or compounds, analytical instrument or profiling method, number or diversity of compounds, biological activity tested, assay or experimental model, dose or concentration, comparator, main findings, eligibility decision, and additional methodological notes.

Extraction yields explicitly reported by the original authors were recorded without modification. When sufficient information was available, extraction yield was calculated from the reported mass of recovered extract and the corresponding starting plant material and was clearly distinguished from directly reported values. Yield calculations were interpreted according to the material basis and extraction procedure described in each primary study. When yield was not reported and could not be reliably calculated, it was classified as "not reported" (NR). Crude extract yields, fraction recoveries, and mucilage yields were treated as distinct extraction outcomes because their denominators and experimental purposes may differ. Biological evidence was also categorized according to whether activities were directly evaluated through experimental assays or inferred from previously reported properties of identified compounds. Studies relying exclusively on compound-based predictions were retained for phytochemical mapping but were not considered direct experimental evidence of biological efficacy.

7.Data synthesis and evidence mapping

The extracted data were synthesized using descriptive and narrative approaches. Study characteristics were summarized according to publication year, country, study design, and plant part. Extraction strategies were mapped according to extraction method, solvent type, solvent polarity or concentration, extraction condition, fractionation method, extract or fraction type, and reported yield. Phytochemical findings were summarized according to screening method, compound class, analytical instrument, and number or diversity of identified compounds. Biological activities were grouped according to activity type, assay or experimental model, dose or concentration, comparator, and main outcome.

Owing to substantial heterogeneity in plant materials, extraction procedures, solvent concentrations, analytical techniques, experimental models, and reported outcomes, a quantitative meta-analysis was not

considered appropriate. Instead, the evidence was synthesized descriptively and narratively to identify recurring methodological patterns, the distribution of extraction approaches, and gaps in chemical characterization and biological validation. Frequencies were used to describe how often particular plant parts, extraction methods, solvents, and fractionation procedures were investigated. These frequencies were interpreted as indicators of research emphasis rather than evidence of comparative extraction efficiency or pharmacological superiority. Extraction yields and biological outcomes were discussed within the context of their respective experimental conditions, and direct comparisons were limited to findings supported by sufficiently comparable methods. Particular attention was given to the distinction between phytochemical characterization, direct experimental bioactivity testing, and biological activities inferred from compound databases.

8. Methodological limitations and appraisal approach

A formal critical appraisal or risk-of-bias assessment was not performed because the objective of this scoping review was to map the scope, characteristics, and gaps of the available evidence rather than to determine pooled effectiveness or exclude studies based on methodological quality. Nevertheless, methodological limitations were charted descriptively, including absence of extraction yield, incomplete reporting of extraction conditions, lack of compound-level profiling, absence of direct experimental bioactivity testing, and limited comparability between plant parts, solvent systems, and extraction methods.

RESULTS

1. Study selection

A total of 176 records were identified from the database searches, including 9 records from Scopus, 2 from PubMed, 85 from ScienceDirect, and 80 from Google Scholar. After removal of 11 duplicate records, 165 records were screened by title and abstract. Of these, 80 records were excluded, and 85 reports were sought for retrieval. Fourteen reports could not be retrieved, leaving 71 full-text reports assessed for eligibility. During full-text assessment, 43 reports were excluded: 4 studies were herbal-mixture studies without extractable *Talinum paniculatum*-specific data, 2 were reviews, editorials, opinions, or short proceedings without primary data, 20 did not report extraction or fractionation methods, and 17 did not provide relevant outcome data. Finally, 28 studies were included in this scoping review. The study selection process is presented in Figure 1.

2. General characteristics of included studies

The 28 included studies were published between 2009 and 2026. Most studies were conducted in Indonesia and Brazil. Twelve studies were from Indonesia[11,12,13,14,15,16,17,18,19,20,21,22]. Ten studies were from Brazil[5,6,4,23,3,24,25,7,26,27]. Two studies were from Thailand[28,29], and one study each was from China, India, Malaysia, and the Philippines[30,8,31,32].

The included studies covered a broad range of experimental designs, including phytochemical profiling, in vitro antioxidant and antimicrobial assays, in vivo animal pharmacological studies, ex vivo uterine contractility assays, toxicological studies, extraction optimization, and formulation-related investigations[5,6,4,30,8,7,28,26]. Several studies focused primarily on phytochemical screening or compound profiling without direct biological testing, whereas others evaluated specific biological activities, including antioxidant, antibacterial, antifungal, cardioprotective, gastroprotective, diuretic, antidiabetic, anticholesterol, immunomodulatory, uterine relaxant, antinociceptive, cytotoxicity, toxicity, or formulation-related outcomes[11,12,8,3,17,18,19,20,29].

A detailed summary of the included studies, including study characteristics, plant parts, extraction strategies, extract or fraction types, extraction yields, phytochemical or analytical profiling, biological activity models, and key findings, is presented in Supplementary Table 2. The distribution of plant parts, extraction approaches, fractionation procedures, and selected reporting characteristics across the 28 included studies is summarized in Table 1.

Table 1. Distribution of extraction approaches and reporting characteristics among the included studies.

Characteristic	Number of studies (n = 28)
Plant parts investigated	
Leaves	23
Roots	7
Stem-containing materials	6
Extraction approaches	
Maceration-based extraction	15
Fractionation and separation	
Studies reporting additional separation or fractionation	10
Studies without reported additional fractionation	18
Extraction yield reporting	
Extraction yield reported or calculable	20
Extraction yield neither reported nor calculable	8
Biological activity assessment	
Studies without direct biological bioassays	5

Note: Categories are not necessarily mutually exclusive because some studies investigated multiple plant parts or extraction approaches. Frequencies represent the number of studies reporting each characteristic. Additional separation includes fractionation and precipitation procedures as classified in the included studies.

3.Plant parts used for extraction

Leaves were the most frequently investigated plant part and were used either alone or as part of mixed plant materials in 23 studies[5,6,4,12,23,30,13,3,15,16,24,17,25,31,19,20,7,32,21,29,26,27,22]. Roots were used in seven studies[8,25,18,32,28,21,29]. Stem-containing materials, including stems, fronds, or young stems and leaves, were represented in six studies[11,30,14,25,32,22]. These plant-part categories were not mutually exclusive because several studies investigated more than one plant organ within the same experimental design. Accordingly, the frequencies represent the number of studies involving each plant part rather than independent or exclusive study groups.

Leaf-based studies covered the widest range of biological and formulation-related outcomes, including antioxidant activity, antibacterial activity, antifungal activity, cardioprotective and renoprotective effects, gastroprotective activity, diuretic activity, immunomodulatory activity, toxicity, nutritional evaluation, mucilage-related functional properties, and pharmaceutical formulation development[5,6,12,23,30,3,24,17,20,7,26,27]. Root-based studies were more commonly associated with uterine or reproductive activity, antidiabetic activity, antimicrobial interaction, and compound-level root profiling[8,18,28,21,29]. Stem-based studies were less frequently linked to direct biological testing and were more often included in comparative phytochemical, GC-MS, or formulation-related studies[11,14,32].

4.Extraction methods reported across studies

Maceration-based extraction was the most frequently reported strategy and was used in 15 studies[11,12,13,14,15,16,17,18,31,19,20,7,32,21,22]. Percolation-based extraction was reported in four studies, including hydroalcoholic leaf extraction and sequential extraction strategies[5,6,4,25]. Infusion followed by ethanol precipitation was used in three related Brazilian studies evaluating ethanol-soluble fractions from leaf material[24,26,27].

Decoction was reported in two studies, one involving aqueous root extraction for UHPLC-Q-Exactive-Orbitrap-MS/MS profiling and another involving mucilage extraction from fronds[30,8]. Soxhlet extraction was used to obtain methanolic root and leaf extracts and in sequential phytochemical work involving different plant parts[25,28,29]. Ultrasonic-assisted extraction was reported in one study of aqueous leaf extract from an unconventional food plant context[23]. Comparative solvent extraction across multiple solvent systems was reported in a leaf-based nutritional and antioxidant study[3].

5.Solvent systems and polarity-based extraction patterns

The included studies used diverse solvent systems, ranging from water and hydroalcoholic solvents to semi-polar and non-polar organic solvents. Ethanol or ethanol-containing systems were used in many leaf, root, stem, and tuber studies, including ethanol-water extraction, 70% ethanol, 95% ethanol, 96% ethanol, and 99.8% ethanol systems[11,5,6,4,12,14,16,17,18,19,20,7,21,22]. Water-based extraction was used in infusion, decoction, ultrasonic-assisted extraction, and mucilage extraction studies[23,30,8,3,24,26,27].

Methanol was mainly used in Soxhlet extraction, comparative solvent extraction, and root or leaf phytochemical studies[13,3,28,29]. Semi-polar and non-polar solvents, including ethyl acetate, hexane, petroleum ether, and dichloromethane, were used for sequential extraction, fractionation, or bioassay-guided isolation[5,6,4,13,17,25,31,32]. Overall, hydroalcoholic systems were most commonly linked to leaf extraction and biological assays, whereas semi-polar and non-polar solvents were more often used when the study aimed to fractionate or enrich specific bioactive constituents[5,6,4,25,31].

6.Fractionation and extract types

Most studies used crude extracts without further fractionation. Eighteen studies did not perform or did not report fractionation[11,12,23,13,8,14,3,15,16,18,19,20,7,32,28,21,29,22]. Ten studies applied additional separation steps, including liquid–liquid partitioning, ethanol precipitation, ethyl acetate fractionation, ethanol precipitation of mucilage, column chromatography, flash chromatography, or preparative TLC[5,6,4,30,24,17,25,31,26,27].

Liquid–liquid partitioning was used to obtain fractions such as hexane, ethyl acetate, n-butanol, and aqueous fractions from hydroalcoholic leaf extracts[5,6,4]. Ethanol precipitation was used after aqueous infusion or decoction to obtain ethanol-soluble fractions or mucilage[30,24,26,27]. Chromatographic isolation or TLC-guided fractionation was reported in studies aiming to isolate or enrich active constituents from sequential extracts[25,31].

7.Extraction yield

Extraction yield was reported or could be calculated for 20 of the 28 included studies[5,6,4,12,30,13,8,14,16,24,17,25,18,31,19,7,28,29,26,27]. Eight studies did not report extract yield as mass yield or percentage yield[11,23,3,15,20,32,21,22].

Reported extraction yields varied across solvent systems and experimental procedures; therefore, the available yield values should be interpreted as study-specific outcomes rather than directly comparable measures of extraction efficiency. Hydroalcoholic leaf extraction by maceration or percolation produced yields around 16–17% in several studies[5,6,4,7]. Ethanol leaf extracts reported in Indonesian studies showed yields of 12.22%, 12.58%, 14.5432%, and 17.12%[12,16,17,19]. In a comparative solvent study, extraction yield varied markedly by solvent, with hexane, ethyl acetate, ethanol, methanol, water, hot-water fresh-leaf extract, and hot-water dried-leaf extract producing different yields; the highest yield was observed for hot-water fresh-leaf extraction, followed by methanol and water extraction[13].

Root- and non-leaf-based studies also reported heterogeneous extraction yields, although direct comparisons with leaf-based extracts were limited by differences in starting material, extraction conditions, solvent systems, and yield calculations. Methanolic root

extraction produced a yield of 6.67%, while methanolic leaf extraction in the same study produced 9.62%[29]. Ethanolic root extraction produced approximately 2.93% based on extract mass and starting simplicia weight[18]. Ethanolic stem extraction produced approximately 8.17% based on reported extract mass and starting material[14]. Mucilage extraction from fronds produced experimental yields ranging from 2.32% to 4.90%, with an optimized predicted yield of 3.44% and validation yield of 3.43 ± 0.09%[30]. Ethanol-soluble fractions obtained after aqueous infusion were consistently reported at 3.42% of plant dry mass[24,26,27].

Although extraction yield was available in 20 of the 28 included studies, differences in reporting practices limited meaningful comparisons across publications. In particular, crude extract recovery, solvent-fraction recovery, and mucilage extraction represented different experimental outcomes and should not be interpreted using a single comparative framework. Furthermore, identical yield values reported in related publications do not necessarily represent independent extraction experiments. These findings highlight the need for clearer documentation of starting material, extraction conditions, yield calculation methods, and experimental reproducibility in future studies.

8. Phytochemical screening and compound profiling

The phytochemical approaches used in the included studies ranged from qualitative screening to advanced compound-level profiling. Qualitative phytochemical screening was commonly used and frequently assessed flavonoids, saponins, tannins or polyphenols, alkaloids, steroids, terpenoids, glycosides, quinones, coumarins, and related compound classes[16,17,18,19,20,28,22]. Spectrophotometric approaches were employed for both phytochemical quantification and antioxidant capacity assessment. Total phenolic content and total flavonoid content were used as chemical composition-related measurements, whereas DPPH, ORAC, and reducing power assays provided functional estimates of antioxidant capacity based on different analytical principles[23,13,3,15,17].

TLC or TLC-densitometry was used for phytochemical confirmation or extract profiling in several studies[25,31,19,32,22]. GC-MS or gas chromatography-based methods were used to characterize volatile, semi-volatile, phytosterol, or other extract constituents in leaf, root, and stem materials[11,25,32,21,29]. LC-based methods, including LC-DAD-MS, LC-ESI-QqQ-MS/MS, HPLC, LCMS, and UHPLC-Q-Exactive-Orbitrap-MS/MS, provided more detailed compound-level or semiquantitative evidence in a smaller number of studies[6,4,23,8,7,26].

The most detailed compound-level profiling was reported in mass spectrometry-based studies. An ethanolic leaf extract study annotated 32 compounds using LC-DAD-MS[7]. A leaf infusion-derived ethanol-soluble fraction study reported nucleosides, organic acids, chlorogenic acids, amino acids, and O-glycosylated flavonoids using LC-DAD-MS[26]. A fresh root study identified and quantified 22 compounds using UHPLC-Q-Exactive-Orbitrap-MS/MS and proposed synephrine, N-trans-feruloyltyramine, and chikusetsusaponin IVa as potential anti-counterfeiting quality markers[8]. GC-MS-based studies identified multiple compounds in leaves, roots, and stems, but several of these studies discussed biological relevance through compound databases rather than direct bioassays[11,32,21].

9. Biological activities reported

The biological evidence reported for *T. paniculatum* encompassed cell-free functional assays, in vitro biological investigations, ex vivo experimental models, and in vivo pharmacological studies. Antioxidant-related outcomes were assessed using different methodological approaches, including DPPH, ORAC, ferric thiocyanate, reducing power, and oxidative stress-related measurements. Because these assays differ in their underlying analytical principles and biological relevance, their findings were considered separately from measurements of total phenolic or flavonoid content[6,23,13,3,15,24,7]. Antibacterial activity was evaluated against organisms such as *Staphylococcus aureus*, *Shigella sonnei*, *Shigella dysenteriae*, *Bacillus cereus*, and other bacterial models[5,4,3,16,19,22]. Antifungal activity, particularly against *Candida albicans*, was investigated using crude extracts, fractions, or formulation products[6,4,20].

Systemic or organ-specific pharmacological activities were also reported. Ethanolic or hydroalcoholic leaf extracts were investigated for cardioprotective, renoprotective, antioxidant-related, ACE-inhibitory, diuretic, hemodynamic, gastroprotective, oxidative stress-modulating, and inflammatory marker-related effects in animal models[24,7,26]. Root extracts were investigated for estrogenic activity, uterine relaxant or tocolytic effects, and antidiabetic activity[18,28,29]. Other studies evaluated anticholesterol activity, immunomodulatory activity, antinociceptive and antiedematogenic activity, allelopathic or phytotoxic activity, cytotoxicity, genotoxicity, toxicity, irritation potential, and formulation-related properties[12,23,17,25,31,20,27].

Five studies did not perform direct biological bioassays and were therefore classified as analytical, inferred-activity, or formulation-focused evidence rather than direct experimental bioactivity studies[11,8,14,32,21]. Three of these studies discussed biological relevance based on GC-MS-identified compounds and database-supported pharmacological predictions[11,32,21]. One study focused on compound identification and quality-marker selection without direct biological testing[8]. One study focused on hydrogel formulation optimization without direct biological activity testing[14].

10. Evidence map of extraction strategies, phytochemical profiles, and biological activities

Evidence mapping showed that leaf-based ethanol or hydroalcoholic extraction was the most frequently represented strategy across the included studies. These extracts were repeatedly associated with phytochemical classes such as flavonoids, phenolics, saponins, tannins, alkaloids, steroids, and related compounds, and were linked to multiple biological activities, including

antioxidant, antimicrobial, cardioprotective, anticholesterol, immunomodulatory, and formulation-related outcomes[12,3,15,16,17,19,20,7].

Semi-polar and non-polar fractions were most often reported in studies evaluating antimicrobial, antifungal, antinociceptive, antiedematogenic, or immunomodulatory outcomes. Ethyl acetate and hexane fractions were repeatedly used in antimicrobial, antifungal, antinociceptive, antiedematogenic, or immunomodulatory studies[5,6,4,17,25]. Dichloromethane extract was identified as the most bioactive extract in an allelopathic or phytotoxic assay and was further subjected to chromatographic isolation[31]. These fractionation studies reported bioactivity in semi-polar and non-polar fractions, particularly in antimicrobial, antifungal, antinociceptive, antiedematogenic, and immunomodulatory models.

Water-based extraction strategies were mainly reported in traditional-use, nutritional, green-extraction, and formulation-related contexts. Infusion followed by ethanol precipitation produced ethanol-soluble leaf fractions that were repeatedly used in toxicity, diuretic, endocrine/reproductive safety, and gastroprotective studies[24,26,27]. Decoction and aqueous extraction were also used in root compound profiling, mucilage extraction, nutritional evaluation, and antioxidant or antimicrobial screening[23,30,8,3].

Overall, the evidence map revealed three recurring extraction-related research patterns. First, ethanolic and hydroethanolic extraction of leaves was frequently investigated in studies involving phytochemical screening, antioxidant assessment, antimicrobial testing, and pharmacological evaluation[12,3,16,17,19,7]. Second, ethyl acetate and hexane fractionation was primarily represented in investigations focusing on antimicrobial, antifungal, immunomodulatory, antinociceptive, and antiedematogenic outcomes[5,6,4,17,25]. Third, aqueous extraction and infusion-derived preparations were applied in nutritional, pharmacological, analytical, and formulation-oriented research[23,30,8,26]. However, these methodological patterns primarily reflect the distribution of existing research rather than direct evidence that particular solvents or extraction techniques consistently produce superior phytochemical recovery or biological activity. The limited integration of standardized extraction conditions, quantitative chemical profiling, and comparable biological assays remains a central gap in the available evidence.

DISCUSSION

1.Principal findings

This scoping review provides an integrated overview of extraction procedures, solvent systems, fractionation strategies, extraction yields, phytochemical characterization, and biological activities reported in experimental investigations of *Talinum paniculatum*. The principal finding is that the available evidence is concentrated around a relatively limited set of conventional extraction approaches, particularly leaf-based ethanolic and hydroethanolic preparations, while substantial methodological heterogeneity restricts direct comparisons of extraction performance and biological outcomes. Among the 28 included studies, leaves were the most frequently investigated plant part, maceration was the predominant extraction approach, and fractionation was less consistently reported. The available evidence also demonstrated an uneven integration of extraction yield measurements, compound-level chemical characterization, and direct biological validation. Importantly, the predominance of a particular extraction strategy should not be interpreted as evidence of its experimental superiority. Rather, the present findings identify where experimental knowledge is concentrated, where methodological reporting remains incomplete, and which extraction–phytochemical–bioactivity relationships require further investigation. This integrated perspective provides a basis for designing more standardized and directly comparable studies in natural product research and pharmaceutical development.

2.Importance of plant part selection

Plant part selection is a critical consideration in *T. paniculatum* research because different organs may differ in phytochemical composition, extractability, yield, and biological relevance[1,8]. The predominance of leaf-based studies is important because leaves were the plant part most consistently linked with nutritional, antioxidant, antimicrobial, cardioprotective, antifungal, diuretic, gastroprotective, immunomodulatory, and formulation-related outcomes[3,7,4,26]. Menezes et al.[3] reported that *T. paniculatum* leaves contain protein, insoluble dietary fiber, ascorbic acid, magnesium, potassium, and calcium, supporting the relevance of leaves as both nutritional and bioactive plant material. Leaf extracts also showed antioxidant and antibacterial potential in food-oriented assays, including inhibition of *Bacillus cereus*, which supports the prioritization of leaves in future extraction and formulation studies[3]. Ethanolic or hydroethanolic leaf extracts were further associated with systemic pharmacological effects in animal studies, including cardioprotective and renoprotective effects in a doxorubicin-induced cardiotoxicity model in hypertensive rats[7]. Leaf-derived ethanol-soluble fractions obtained after aqueous infusion were investigated for cardiorenal, toxicity, pubertal development, and gastroprotective outcomes, indicating that aqueous extraction followed by ethanol precipitation represents a repeated Brazilian research pathway for this species[26,27,24]. Root-based studies appear to represent a different research direction because roots were more often associated with reproductive, uterine, antidiabetic, antimicrobial-interaction, and compound-level quality-marker studies[8,28,29,18]. The root-focused study by Li et al. is particularly relevant because it identified and quantified 22 compounds using UHPLC-Q-Exactive-Orbitrap-MS/MS and proposed synephrine, N-trans-feruloyltyramine, and chikusetsusaponin IVa as anti-counterfeiting quality markers for *T. paniculatum* root[8]. Stem-based evidence remains comparatively limited and was represented mainly by GC-MS profiling and formulation-oriented work rather than extensive direct

bioactivity testing, indicating that stems are still underexplored compared with leaves and roots[11,14,32].

3.Solvent polarity and extraction strategy

Solvent selection is a major determinant of extract composition because extraction efficiency depends on the compatibility between solvent polarity and the solubility characteristics of target metabolites[1]. The recurrent use of ethanol and ethanol–water systems in *T. paniculatum* studies is consistent with broader natural product extraction literature, which recognizes alcohol-based solvents as useful for recovering a wide range of polar to semi-polar phytochemicals[1,33]. In the mapped studies, hydroethanolic leaf extraction was repeatedly associated with phytochemical classes such as phenolics, flavonoids, saponins, tannins, alkaloids, steroids, and related metabolites[4,7,19,17]. The broad range of phytochemical classes reported in ethanolic and hydroethanolic extracts is consistent with their use across different biological and formulation-related investigations. Nevertheless, the presence of these compound classes alone does not establish which constituents are responsible for the observed pharmacological effects, particularly when quantitative profiling and compound-specific biological validation are unavailable[3,7,12,17]. Methanol-containing systems produced strong phenolic recovery and antioxidant capacity in the comparative solvent study by Menezes et al., particularly methanol/acetic acid extraction, but methanol-based extraction is less suitable for direct food, herbal, or pharmaceutical translation than ethanol-based extraction because of toxicological and solvent-removal considerations[3,1].

Water-based extraction strategies remain important from traditional-use, safety-oriented, and green-extraction perspectives because water is accessible, low-cost, and more environmentally compatible than many organic solvents[33,26]. In *T. paniculatum*, water-based approaches were used in infusion, decoction, ultrasonic-assisted extraction, mucilage extraction, and aqueous root profiling, showing that water extraction is relevant for both ethnopharmacological and formulation contexts[26,30,8,23]. However, water-based extracts may not recover the same range of semi-polar or lipophilic constituents as hydroalcoholic or organic-solvent systems, which explains why several studies applied ethanol precipitation or liquid–liquid partitioning after aqueous or hydroalcoholic extraction[1,4,26].

4.Fractionation as a bioactivity-enrichment strategy

Fractionation is important when the objective is to enrich, localize, or compare biological activity across more defined extract fractions[4,5,6]. The study by dos Reis et al.[4] obtained a hydroalcoholic leaf extract by ethanol–water percolation and subsequently partitioned it into hexane, ethyl acetate, n-butanol, and aqueous fractions, allowing antimicrobial and cytotoxic activities to be compared across fractions. In that study, the crude leaf extract showed activity against *Serratia marcescens* and *Staphylococcus aureus*, the hexane fraction showed strong activity against *Micrococcus luteus* and *Candida albicans*, and the ethyl acetate fraction showed activity against *Escherichia coli*. Cerdeira et al. used crude leaf extract, hexane fraction, and ethyl acetate fraction to evaluate antimicrobial interactions with oxacillin against reference and clinical strains of *Staphylococcus aureus*[5]. Another study by Cerdeira et al. reported antifungal activity against *Candida albicans* and evaluated interactions with fluconazole, oxidative damage markers, and phytochemical constituents such as phytosterols, ascorbic acid, benzoic acid, chlorogenic acid, and caffeic acid[6]. These studies suggest that semi-polar and non-polar fractions may concentrate constituents responsible for antimicrobial or antifungal effects that may be less apparent in crude extract evaluation alone[4,5,6]. Ramos et al.[25] also reported that hexane and ethyl acetate extracts of *T. paniculatum* showed antinociceptive and antiedematogenic activities in a formalin-induced model, further supporting the relevance of semi-polar and non-polar fractions for activity-guided investigation. Nevertheless, fractionation should not be interpreted only as an improvement step because it increases process complexity, may reduce total mass yield, and may introduce solvent-residue, scalability, and standardization challenges before formulation development[1,33].

5.Phytochemical profiling and evidence fragmentation

A major finding of this scoping review is that phytochemical evaluation in *T. paniculatum* studies ranges from qualitative color-based screening to advanced chromatographic and mass-spectrometric profiling[7,8,19]. Qualitative screening is useful as an initial pharmacognostic step, but it is insufficient for extract standardization because it does not identify individual compounds, quantify marker compounds, or allow robust comparison across studies and laboratories[1,8]. More informative studies used LC-DAD-MS, LC-MS, HPLC, GC-MS, or UHPLC-Q-Exactive-Orbitrap-MS/MS to identify or annotate compounds in leaf, root, stem, or fractionated extracts[7,4,6,8]. Souto et al. annotated 32 compounds in an ethanolic leaf extract using LC-DAD-MS, which strengthened the chemical interpretation of cardioprotective and antioxidant-related findings in their preclinical model[7]. Tolouei et al. reported chlorogenic acids, amino acids, nucleosides, O-glycosylated flavones, and organic acids in an ethanol-soluble fraction from leaf infusion, linking an infusion-derived fraction with measurable chemical constituents[26]. Li et al. provided the most detailed root-level chemical profiling by identifying and quantifying 22 compounds and proposing three anti-counterfeiting quality markers for *T. paniculatum* root[8]. The proposal of quality markers is relevant because herbal quality control increasingly requires measurable and traceable marker compounds rather than only broad qualitative phytochemical classes[8,34]. Despite these advances, the mapped evidence remains fragmented because some studies reported biological activities without extensive compound-level profiling, whereas other studies reported detailed chemical profiles without direct experimental bioactivity assays[11,8,32,21]. This separation between phytochemical profiling and biological validation limits mechanistic interpretation and makes

it difficult to determine whether biological effects are driven by major compounds, minor constituents, synergistic mixtures, or extraction-related matrix effects[1,34].

6. Biological activity patterns and translational relevance

The biological activity evidence for *T. paniculatum* is diverse, but it is not yet sufficiently standardized to support direct ranking of extracts, solvents, or plant parts across outcomes[9,10]. Antioxidant activity was commonly evaluated using DPPH, ORAC, ferric thiocyanate, reducing power, total phenolic content, total flavonoid content, or oxidative stress-related endpoints, but these assays differ in chemical principle, biological relevance, and comparability[3,13,7,23]. Antibacterial and antifungal outcomes were also heterogeneous because the included studies used different organisms, extract concentrations, diffusion or microdilution methods, positive controls, and extract or fraction types[4,5,6,3]. The antimicrobial evidence is nevertheless important because multiple studies reported activity of leaf extracts or fractions against organisms such as *Staphylococcus aureus*, *Bacillus cereus*, *Serratia marcescens*, *Escherichia coli*, and *Candida albicans*[4,5,6,3]. The strongest translational evidence beyond in vitro screening comes from animal and ex vivo studies showing cardioprotective, cardiorenal, gastroprotective, toxicological, pubertal-development, uterine, and antidiabetic outcomes, although these models are not directly comparable to each other[7,26,27,24,28,18]. For wound-healing or oral-soft-tissue applications, relevant extract characteristics would include antioxidant, anti-inflammatory, antimicrobial, cytocompatible, fibroblast-supportive, and collagen-supportive activities because wound repair involves oxidative stress control, microbial control, inflammation regulation, fibroblast activity, and extracellular matrix remodeling[35,36]. The current *T. paniculatum* evidence supports antioxidant and antimicrobial potential, but it does not yet provide sufficient direct evidence on oral fibroblast proliferation, collagen deposition, epithelial closure, or oral mucosal wound-healing models[3,4,6,35]. Therefore, the available evidence is useful for selecting candidate extracts, but it is not sufficient to claim wound-healing efficacy without targeted cytocompatibility, fibroblast migration or proliferation, collagen deposition, inflammatory-marker, and oral-relevant antimicrobial assays[35,36].

7. Implications of extraction strategies for future pharmaceutical research

The findings of this scoping review suggest that extraction strategy selection for *T. paniculatum* should be guided by the intended research objective rather than by the frequency of solvent use alone. Ethanolic and hydroethanolic leaf extraction represents a frequently investigated approach with potential relevance to pharmaceutical research because these preparations have been evaluated across multiple phytochemical and biological contexts[7,4,3,19,17]. From a formulation perspective, ethanol and ethanol–water systems may also offer practical advantages over methanol-containing systems, particularly when solvent safety and downstream processing requirements are considered[1,33].

However, alternative solvent and fractionation strategies remain relevant for specific purposes. Ethyl acetate and hexane fractions have been investigated in antimicrobial, antifungal, immunomodulatory, antinociceptive, and antiedematogenic studies, suggesting their potential value for further bioactivity-guided fractionation and compound isolation[4,5,6,17,25]. Water-based extraction and infusion-derived preparations may be particularly relevant for traditional-use investigations, hydrophilic constituents, and selected formulation applications[26,30,8]. Furthermore, the application of UHPLC-Q-Exactive-Orbitrap-MS/MS to root extracts demonstrates the potential contribution of advanced analytical techniques to phytochemical characterization and quality-marker development[8].

Therefore, no single extraction strategy can presently be considered universally optimal for *T. paniculatum*. The existing evidence supports a purpose-oriented selection of extraction methods, followed by standardized assessment of extraction yield, phytochemical composition, biological activity, and safety. Direct comparative studies conducted under controlled experimental conditions are needed to establish whether specific extraction strategies provide superior performance for defined pharmaceutical applications.

8. Methodological gaps, strengths, and future directions

The first major methodological gap is incomplete reporting of extraction conditions, including solvent-to-solid ratio, temperature, extraction time, extraction repetitions, plant material preparation, and yield, which limits reproducibility and comparison across studies[1,9]. The second gap is inconsistent phytochemical standardization because many studies used qualitative screening without marker-compound quantification or chromatographic fingerprinting[19,20,16,1]. The third gap is limited integration between advanced profiling and biological validation because some GC-MS or UHPLC-based studies discussed biological relevance without direct bioassays, while some bioactivity studies did not identify major compounds[11,8,21,4]. Future studies should directly compare extraction methods using the same plant part, batch, particle size, solvent-to-solid ratio, extraction time, and temperature to determine whether differences in yield and activity are truly caused by extraction strategy rather than uncontrolled experimental variation[1]. Future studies should also combine extraction yield, total phenolic content, total flavonoid content, chromatographic fingerprinting, LC-MS or GC-MS profiling, and direct biological assays within the same experimental design[1,8]. For pharmaceutical or oral wound-healing development, future studies should prioritize ethanolic or hydroethanolic leaf extracts, ethyl acetate fractions, and aqueous ethanol-precipitated fractions as candidate materials for cytotoxicity, fibroblast proliferation, migration, collagen deposition, anti-inflammatory,

antioxidant, and antimicrobial testing[7,4,6,35]. Safety assessment should be incorporated early because promising bioactivity in antimicrobial or antioxidant assays does not necessarily indicate suitability for mucosal, oral, or systemic use[27,1]. Quality-control studies should explore whether the root markers proposed by Li et al. are specific to roots or whether additional leaf-specific markers are needed for leaf-based extracts and formulations[8,34]. An additional concern is the potential reuse of extraction procedures or previously characterized preparations across related publications. Although such studies may contribute distinct biological findings, repeated extraction yields or chemical profiles should not automatically be interpreted as independent experimental confirmation. Future investigations should therefore report whether extracts were freshly prepared, independently characterized, or obtained using previously established extraction protocols.

The principal strength of this scoping review lies in its integrated examination of extraction-related and biological evidence within a single plant species. Rather than evaluating phytochemical properties or pharmacological activities in isolation, this review considers plant part selection, extraction procedures, solvent characteristics, fractionation, extract recovery, analytical profiling, and experimental biological outcomes within a common descriptive framework. Another strength is the explicit distinction between experimentally demonstrated biological activities and pharmacological properties inferred from compound databases, thereby reducing the risk of overstating the evidence provided by phytochemical identification alone. The inclusion of studies addressing pharmaceutical formulations, pharmacological assays, extraction optimization, and analytical quality-marker development also allows the available evidence to be examined from the perspectives of both natural product research and pharmaceutical development.

Several limitations should be considered when interpreting the findings of this scoping review. First, the search strategy was designed around predefined botanical, extraction-related, phytochemical, and biological activity terms. Although this approach provided a focused retrieval framework, relevant studies that did not include terms from all required search concepts may have been missed. The relatively small number of records retrieved from PubMed and Scopus should therefore be interpreted in relation to the applied search expressions and indexing coverage rather than as a definitive measure of the total published literature concerning the species. Second, Google Scholar screening was restricted to the first 80 relevance-ranked records, potentially limiting retrieval coverage. Third, the inclusion of English- and Indonesian-language full-text articles may have excluded relevant evidence published in other languages, and the 14 reports that could not be retrieved may have introduced additional uncertainty regarding the completeness of the evidence base.

Study selection was conducted by one primary reviewer, followed by verification of the final included studies by the other authors. Although this verification improved the consistency of the compiled evidence, it did not constitute independent duplicate screening and therefore could not completely eliminate potential selection errors. In addition, no formal risk-of-bias assessment was conducted, consistent with the descriptive evidence-mapping objective of the review. Substantial heterogeneity in plant material, extraction conditions, solvent systems, analytical methods, assay models, and outcome reporting further limited direct comparisons between studies. Differences in extraction yield definitions and the possible reuse of extraction protocols across related publications also restricted interpretation of repeated findings as independent evidence of extraction reproducibility. Consequently, the conclusions of this review should be understood as a characterization of the available literature rather than a comparative determination of extraction efficacy or pharmacological superiority.

CONCLUSION

This scoping review mapped extraction methods, solvent systems, fractionation strategies, extraction yields, phytochemical profiles, and biological activities reported in 28 experimental studies of *Talinum paniculatum*. The available evidence was predominantly concentrated on leaf-based extraction, particularly using ethanolic and hydroethanolic solvent systems, while roots and stem-containing materials were investigated less frequently. Fractionation using ethyl acetate, hexane, and related solvents was mainly represented in studies evaluating specific biological activities, whereas aqueous extraction was applied across nutritional, analytical, pharmacological, and formulation-related contexts.

Despite these methodological patterns, substantial heterogeneity in extraction conditions, yield reporting, chemical characterization, and experimental assays prevents reliable determination of a universally superior extraction strategy. The current evidence therefore supports the selection of extraction approaches according to specific research objectives rather than frequency of use alone. Future investigations should prioritize standardized extraction procedures, transparent yield reporting, quantitative chromatographic and mass-spectrometric profiling, direct biological validation, and safety assessment to strengthen the reproducibility and pharmaceutical relevance of *T. paniculatum* research.

Conflict of Interest: The authors declare that they have no conflicts of interest.

References

1. Zhang QW, Lin LG, Ye WC. Techniques for extraction and isolation of natural products: A comprehensive review. Chinese Medicine. 2018;13:20. https://doi.org/10.1186/s13020-018-0177-x

2. Royal Botanic Gardens, Kew. *Talinum paniculatum* (Jacq.) Gaertn. Plants of the World Online. 2026. Available from: https://powo.science.kew.org/taxon/urn:lsid:ipni.org:names:1007146-2

3. Menezes FD, Ishizawa TA, Fontinelle Souto LR, de Oliveira TF. *Talinum paniculatum* (Jacq.) Gaertn. leaves: Source of nutrients, antioxidant and antibacterial potentials. Acta Scientiarum

Polonorum Technologia Alimentaria. 2021;20(3):253-263. https://doi.org/10.17306/J.AFS.2021.0892

4. dos Reis LFC, Cerdeira CD, de Paula BF, da Silva JJ, Coelho LFL, Silva MA, et al. Chemical characterization and evaluation of antibacterial, antifungal, antimycobacterial, and cytotoxic activities of *Talinum paniculatum*. Revista do Instituto de Medicina Tropical de São Paulo. 2015;57(5):397-405. https://doi.org/10.1590/S0036-46652015000500005

5. Cerdeira CD, da Silva JJ, Netto MFR, Boriollo MFG, Santos GB, dos Reis LFC, et al. *Talinum paniculatum* leaves with in vitro antimicrobial activity against reference and clinical strains of *Staphylococcus aureus* interfere with oxacillin action. Revista Colombiana de Ciencias Químico-Farmacéuticas. 2020;49(2):432-451. https://doi.org/10.15446/rcciquifa.v49n2.89894

6. Cerdeira CD, da Silva JJ, Rodrigues Netto MF, Boriollo MFG, Moraes GOI, Santos GB, et al. *Talinum paniculatum*: A plant with antifungal potential mitigates fluconazole-induced oxidative damage-mediated growth inhibition of *Candida albicans*. Revista Colombiana de Ciencias Químico-Farmacéuticas. 2020;49(2):401-431. https://doi.org/10.15446/rcciquifa.v49n2.89704

7. Souto CGRG, Lorençone BR, Marques AAM, Palozi RAC, Romão PVM, Guarnier LP, et al. Cardioprotective effects of *Talinum paniculatum* (Jacq.) Gaertn. in doxorubicin-induced cardiotoxicity in hypertensive rats. Journal of ethnopharmacology. 2021;281:114568. https://doi.org/10.1016/j.jep.2021.114568

8. Li J, Chai H, Li X, Chen S, Cai R, Wang L, et al. Simultaneous quantification of 22 compounds in *Talinum paniculatum* root and proposal of three anti-counterfeiting quality markers using a library-aided UHPLC-Q-Orbitrap-MS/MS method. Phytochemical Analysis. 2025;36(6):1778-1789. https://doi.org/10.1002/pca.3543

9. Munn Z, Peters MDJ, Stern C, Tufanaru C, McArthur A, Aromataris E. Systematic review or scoping review? Guidance for authors when choosing between a systematic or scoping review approach. BMC medical research methodology. 2018;18(1):143. https://doi.org/10.1186/s12874-018-0611-x

10. Tricco AC, Lillie E, Zarin W, O'Brien KK, Colquhoun H, Levac D, et al. PRISMA extension for scoping reviews (PRISMA-ScR): Checklist and explanation. Annals of Internal Medicine. 2018;169(7):467-473. https://doi.org/10.7326/M18-0850

11. Aini FN, Susilo S. Phytochemical profiling of Javanese ginseng (*Talinum paniculatum*) stem extract using GC-MS analysis and pharmacological potential. Tropical Journal of Natural Product Research. 2023;7(7):3272-3278. https://doi.org/10.26538/tjnpr/v7i7.1

12. Emelda A, Santi I, Widiastuti H, Yuliana D, Bambang NA. Anticholesterol assay of ethanol extract of ginseng leaves (*Talinum paniculatum*). Sarcouncil Journal of Plant and Agronomy. 2023;1(1):32-35. https://doi.org/10.5281/zenodo.8096850

13. Lestario LN, Christian AE, Martono Y. Aktivitas antioksidan daun ginseng jawa (*Talinum paniculatum* Gaertn). Agritech. 2009;29(2):71-78.

14. Lumbantoruan DMS, Rachmayanti AS, Rachdiati H. Optimasi formula sediaan hydrogel menggunakan ekstrak etanol batang ginseng Jawa (*Talinum paniculatum*) dengan berbagai polimer. Transformasi Kesehatan dan Teknologi Medis. 2026;7(1):85-100. https://ejurnals.com/ojs/index.php/tktm

15. Ngibad K, Wijayanti C, Patricia GA. Aktivitas antioksidan, fenolik total, dan flavonoid total pada daun ginseng Jawa dan daun sidaguri. Journal Pharmasci (Journal of Pharmacy and Science). 2026;11(1):150-159.

16. Oktaviani R, Fitriyanti F, Sari PK. Uji aktivitas antibakteri ekstrak etanol 70% daun ginseng Jawa (*Talinum paniculatum* (Jacq.) Gaertn) terhadap bakteri *Shigella dysenteriae*. Borneo Journal of Pharmascientech. 2024;8(1):25-33. https://doi.org/10.51817/bjp.v7i1.502

17. Puspitaningrum I, Franyoto YD, Munisih S. Aktivitas imunomodulator fraksi etil asetat daun som jawa (*Talinum paniculatum* (Jacq.) Gaertn) terhadap respon imun spesifik. Jurnal Ilmu Farmasi dan Farmasi Klinik. 2018;15(2):48-53.

18. Rizqia D, Susilowati AA, Febriana L. Uji efektivitas ekstrak akar ginseng (*Talinum paniculatum*) pada mencit (Mus musculus) sebagai alternatif penurun kadar gula darah. Mantra Bhakti. 2023;1(1):9-15.

19. Setyani W, Setyowati H, Ayuningtyas D. Pemanfaatan ekstrak terstandardisasi daun som jawa (*Talinum paniculatum* (Jacq.) Gaertn) dalam sediaan krim antibakteri *Staphylococcus aureus*. Jurnal Farmasi Sains dan Komunitas. 2016;13(1):44-51.

20. Setyowati H, Setyani W. Formulation of chewable lozenges of som jawa (*Talinum paniculatum* (Jacq.) Gaertn) leaves extract applied for *Candida albicans* topical infection. Jurnal Kedokteran dan Kesehatan Indonesia. 2019;10(1):14-23. https://doi.org/10.20885/JKKI.Vol10.Iss1.art4

21. Susilo S, Aini FN, Permanasari ED. Phytoconstituents of leaves and roots ethanolic extract of *Talinum paniculatum* and their biological activities. Research Journal of Pharmacy and Technology. 2024;17(2):679-685. https://doi.org/10.52711/0974-360X.2024.00105

22. Yeni LF, Chaerani, Mandasari J, Kamelia N, Triana D. Aktivitas antibakteri ekstrak etanol *Talinum paniculatum* lokal Kalimantan Barat terhadap *Shigella sonnei*. Quagga: Jurnal Pendidikan dan Biologi. 2022;14(1):51-58. https://doi.org/10.25134/quagga.v14i1.50801

23. Giuliani CDS, Farias CAA, Marquezan PK, Aguiar KL, Guerim PHF, Musachio EAS, et al. Phytochemical diversity, antioxidant potential, antimicrobial activity, cytotoxicity, and genotoxicity analyses of unconventional food plants: Cymbopogon citratus (DC.) Stapf, Pereskia aculeata Mill., Portulaca oleracea L., and *Talinum paniculatum* (Jacq.) Gaertn. Food Chemistry. 2025;492:145526. https://doi.org/10.1016/j.foodchem.2025.145526

24. Pegoraro Correa KG, do Carmo Barroso de Siqueira M, Zanovello M, Martins Belmudes M, de Souza P, Gasparotto Junior A, et al. Gastroprotective activity of *Talinum paniculatum* (Jacq.) Gaertn. in mice: An ethnopharmacological validation. Journal of Integrative Medicine. 2026;24(2):279-286. https://doi.org/10.1016/j.joim.2025.12.002

25. Ramos MPO, Silva GD, Duarte LP, Peres V, Miranda RRS, de Souza GHB, et al. Antinociceptive and edematogenic activity and chemical constituents of *Talinum paniculatum* Willd. Journal of Chemical and Pharmaceutical Research. 2010;2(6):265-274.

26. Tolouei SEL, Palozi RAC, Tirloni CAS, Marques AAM, Schaedler MI, Guarnier LP, et al. Ethnopharmacological approaches to *Talinum paniculatum* (Jacq.) Gaertn.: Exploring cardiorenal effects from the Brazilian Cerrado. Journal of Ethnopharmacology. 2019;238:111873. https://doi.org/10.1016/j.jep.2019.111873

27. Tolouei SEL, da Silva GN, Curi TZ, Passoni MT, Ribeiro DCK, Meldola HG, et al. Effects of *Talinum paniculatum* (Jacq.) Gaertn. leaf extract on general toxicity and pubertal development of rats. Human and Experimental Toxicology. 2021;40(1):124-135. https://doi.org/10.1177/0960327120945756

28. Sukwan C, Wray S, Kupittayanant S. The effects of Ginseng Java root extract on uterine contractility in nonpregnant rats. Physiological Reports. 2014;2(12):e12230. https://doi.org/10.14814/phy2.12230

29. Thanamool C, Papirom P, Chanlun S, Kupittayanant S. *Talinum paniculatum* (Jacq.) Gertn: A medicinal plant with potential estrogenic activity in ovariectomized rats. International Journal of Pharmacy and Pharmaceutical Sciences. 2013;5(2):478-485.

30. Ibrahim NH, Zakaria TNDT, Hamzah Y. Optimization of extraction conditions on yield, crude protein content and emulsifying capacity of mucilage from *Talinum paniculatum*. Asian Journal of Agriculture and Biology. 2019;7(1):156-165.

31. Salamanez KC, Sabaupan LAL, Mangao AM, Rodriguez EB. Potential allelopathic activity of dichloromethane extract from the leaves of *Talinum paniculatum* (Jacq.) Gaertn against Cyperus iria. UP Los Baños Journal. 2019;17:141-152.

32. Sudhakar R, Kannan R, Bhuvaneswari V, Hemalatha S. Phytochemical and structural characterization of *Talinum paniculatum* (Jacq.) Gaertn. Journal of Xidian University. 2025;19(8):262-275. https://doi.org/10.5281/zenodo.16754452

33. Chemat F, Vian MA, Cravotto G. Green extraction of natural products: concept and principles. International journal of molecular sciences. 2012;13(7):8615-8627. https://doi.org/10.3390/ijms13078615

34. Yang W, Zhang Y, Wu W, Huang L, Guo D, Liu C. Approaches to establish Q-markers for the quality standards of traditional Chinese medicines. Acta Pharmaceutica Sinica B. 2017;7(4):439-446. https://doi.org/10.1016/j.apsb.2017.04.012

35. Shah A, Amini-Nik S. The role of phytochemicals in the inflammatory phase of wound healing. International Journal of Molecular Sciences. 2017;18(5):1068. https://doi.org/10.3390/ijms18051068

36. Vitale S, Colanero S, Placidi M, Di Emidio G, Tatone C, Amicarelli F, et al. Phytochemistry and Biological Activity of Medicinal Plants in Wound Healing: An Overview of Current Research. Molecules (Basel, Switzerland). 2022;27(11):3566. https://doi.org/10.3390/molecules27113566