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Review

Phytochemical composition, anti-inflammatory, antioxidant, antimicrobial, antiplasmodial, antidiabetic and anticancer activities of *Sonchus arvensis* L.

[Composición fitoquímica, actividades antiinflamatorias, antioxidantes, antimicrobianas, antiplasmodiales, antidiabéticas y anticancerígenas de *Sonchus arvensis* L.]

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Abstract

Context: *Sonchus arvensis* L. is widely used both as a traditional medicine and as a nutritional vegetable for its diverse bioactivities. Despite its widespread use, a comprehensive evaluation of its phytochemical profile and therapeutic potential remains limited.

Aims: To conduct a review for knowledge mapping on *S. arvensis* phytochemical composition, as well as its potential as an anti-inflammatory, antioxidant, antimicrobial, antiplasmodial, antidiabetic, and anticancer agent reported in studies.

Methods: A review of peer-reviewed articles published between 2004 and March 2024 was performed using databases including Google Scholar, PubMed, Scopus, and EBSCOhost. A grey literature search was conducted on Google Scholar, university repositories, and industrial and governmental reports in Indonesia. Boolean operators such as “AND”, “OR”, and truncations were used to develop the search query. Relevant articles were identified by screening titles, abstracts, and full texts.

Results: Eighty-four articles met the inclusion criteria. Most studies originated from Indonesia and involved *in vitro* (60%) and *in vivo* (39%) experiments. Leaf extracts (72%) and maceration methods (49%) were mostly investigated and used. Phytochemical analyses revealed the presence of abundant flavonoids, phenols, and terpenoids. Pharmacological studies indicated significant antioxidant (24%) effect with several dominant bioactivity such as anti-hyperuricemia (12%), antibacterial (10,67%), anti-inflammatory (6,67%), antiplasmodial (6.67%), anti-diabetic (2.67%), anti-gout arthritis (4%), anticancer (4%), several organ protective effect (1-4%), and larvicidal effect (2.67%).

Conclusions: The compiled evidence suggests that *S. arvensis* may serve as a valuable source of bioactive compounds with numerous therapeutic potentials. However, additional research is necessary to clarify its mechanisms, optimize the extraction method, and confirm its clinical safety and efficacy.

Keywords: bioactivity; medicinal plant; phytochemicals; *Sonchus arvensis*; traditional medicine.

Resumen

Contexto: *Sonchus arvensis* L. se utiliza ampliamente en medicina tradicional y como verdura nutritiva debido a sus diversas bioactividades. A pesar de su amplio uso, la evaluación exhaustiva de su perfil fitoquímico y de su potencial terapéutico sigue siendo limitada.

Objetivos: Realizar una revisión exploratoria para el mapeo del conocimiento sobre la composición fitoquímica de *S. arvensis*, así como sobre su potencial como agente antiinflamatorio, antioxidante, antimicrobiano, antiplasmodial, antidiabético y anticancerígeno, reportado en estudios.

Métodos: Se realizó una revisión exploratoria de artículos revisados por pares publicados entre 2004 y marzo de 2024, utilizando bases de datos como Google Scholar, PubMed, Scopus y EBSCOhost. Se realizó una búsqueda de literatura gris en Google Scholar, en repositorios universitarios y en informes industriales y gubernamentales de Indonesia. Se utilizaron operadores booleanos como "AND" y "OR", así como truncamientos, para desarrollar la consulta de búsqueda. Se identificaron artículos relevantes mediante la revisión de títulos, resúmenes y textos completos.

Resultados: Ochenta y cuatro artículos cumplieron los criterios de inclusión. La mayoría de los estudios se originaron en Indonesia e incluyeron experimentos *in vitro* (60%) e *in vivo* (39%). Se investigaron y se utilizaron principalmente extractos de hojas (72%) y métodos de maceración (49%). Los análisis fitoquímicos revelaron la presencia de abundantes flavonoides, fenoles y terpenoides. Los estudios farmacológicos indicaron un efecto antioxidante significativo (24%) con varias bioactividades dominantes, como antihiperuricemia (12%), antibacteriano (10,67%), antiinflamatorio (6,67%), antiplasmodial (6,67%), antidiabético (2,67%), antiartritis gotosa (4%), anticancerígeno (4%), efecto protector de varios órganos (1-4%) y efecto larvicida (2,67%).

Conclusiones: La evidencia recopilada sugiere que *S. arvensis* puede ser una valiosa fuente de compuestos bioactivos con numerosos potenciales terapéuticos. Sin embargo, se requiere investigación adicional para aclarar sus mecanismos, optimizar el método de extracción y confirmar su seguridad y eficacia clínicas.

Palabras Clave: bioactividad; planta medicinal; fitoquímicos; *Sonchus arvensis*; medicina tradicional.

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INTRODUCTION

The global utilization of medicinal plants for therapeutic purposes has increased significantly, driven by the demand for cost-effective, accessible, and culturally relevant healthcare alternatives. These products are widely used by individuals to address a range of medical conditions (Abu-Odeh et al., 2023). Moreover, most conventional medications also derive from natural sources (Nigussie et al., 2021). Bioactive compounds derived from plants have long served as the basis for traditional medicine at both the individual and community levels and play an important role in the discovery of new pharmacological agents (Mohammed et al., 2014). A significant proportion of bioactive natural products, such as polyphenols, alkaloids, terpenoids, and flavonoids, exhibit multifaceted mechanisms of action that target diverse physiological pathways. Notably, various secondary metabolites have shown potential as analgesics and anti-inflammatories (Mohammed et al., 2014). On the other side, there have been reports of the use of herbal remedies to manage wound healing, suggesting that they might be appropriate and reasonably affordable (Mulisa et al., 2015).

Sonchus arvensis L. is an herbaceous species of the family *Asteraceae*, commonly referred to as 'milk thistle' or 'perennial sow-thistle'. It is known for its yellow inflorescences, milky latex, an intense horizontal root system, and prominent excavation stems that reach a height of 1 to 6 feet. The shrub develops showy yellow flowers (Asif & Saeed, 2020). Recent morpho-anatomical and DNA-barcode analyses further confirm that *S. arvensis* can be reliably distinguished from related species based on anatomical traits of stem, root, leaf, fruit, and seed, as well as plastid rbcL and matK barcoding (Wahyuni et al., 2019). Traditionally, the plant has been consumed as a leafy vegetable and incorporated into ethnomedicinal preparations in various countries, particularly in Southeast Asia and Europe (Khuluk et al., 2021). The therapeutic utility of *S. arvensis* has been attributed to its rich phytochemical composition, including polysaccharides, polyphenols and flavonoids (e.g., luteolin, apigenin, kaempferol), coumarins, phenolic acids (Ren et al., 2023), and essential oils (Kanaani & Mohamadi, 2015). In addition, they contain inositol, taraxasterol, coumarin, scopoletin, and various phenolic acids (Khuluk et al., 2021), quinic acid esters (Xu et al., 2008), and sesquiterpenes (Xia et al., 2012). Recent studies have investigated its various biological activities, such as antioxidant, anti-inflammatory, antimicrobial, antiplasmodial, antidiabetic, and hepatoprotective properties. Several ethnomedicinal studies indicate that *S. arvensis* has been used as a natural remedy for anemia, colitis, and throat inflammation in Italy (Ruiz-Rocamora et al., 2025) and for hypertension, rheumatism, gout-arthritis, and bruises in Indonesia (Wahjono et al., 2021).

Previous reviews on *S. arvensis* have generally focused on specific aspects of the plant, such as a single bioactivity like antimicrobial effects (Zulkefle et al., 2025), or focused on particular compound groups such as polysaccharides (Liu et al., 2024), or traditional uses combined with pharmacological analysis (Rafi et al., 2022b). While these studies provide valuable depth with narrower scopes, they do not offer a comprehensive mapping of the full range of experimental evidence available for this species. In contrast, this review provides a more structured and comprehensive mapping of the available evidence by systematically compiling evidence from all relevant studies published between 2004 and 2024. A broader and more inclusive search strategy enabled the capture of diverse bioactivities, major phytochemical groups, extraction approaches, and geographic research trends within a single analytical framework. As a result, this review offers a clearer and more holistic overview of the research landscape on *S. arvensis*, thereby providing a stronger foundation for future mechanistic, clinical, and translational studies.

Despite these findings, a consolidated evaluation of its bioactivities, methodological approaches, and phytochemical constituents has not been comprehensively conducted. The full extent, range, and nature of the research conducted on this plant have not yet been comprehensively mapped. This lack of a consolidated overview of the literature makes it difficult to ascertain the current state of research, identify the types of evidence available, and pinpoint specific knowledge gaps for future investigation. Given the broad and potentially disparate nature of the literature, a review is the ideal methodology to map the existing research landscape comprehensively. Therefore, this review was conducted to comprehensively map and synthesize the available evidence on the phytochemical composition and pharmacological activities of *S. arvensis* to support future pharmacological investigations and its integration into evidence-based herbal medicine.

MATERIAL AND METHODS

A review methodology was employed to map the breadth and characteristics of research on the phytochemical and pharmacological properties of *S. arvensis*, as reported in articles published between 2004 and 2024. The methodological framework was based on Arksey and O'Malley's five-step approach, which includes: (i) developing a research question, (ii) literature identification, (iii) literature selection, (iv) data charting and extraction, and (v) evidence synthesis and reporting (Arksey & O'Malley, 2005). The reporting of

this review was conducted in accordance with the PRISMA-ScR checklist (Tricco et al., 2018).

Ethical consideration

As this studywas a review of published data, ethical approval was not required.

Stage 1: Developing research question

The research question was developed using the Population, Concept, and Context (PCC) framework as recommended in review writing. The population of interest was *S. arvensis*, including all its parts such as leaves, roots, stems, and flowers. The concept centered around the phytochemical profile of *S. arvensis*, focusing on its metabolites and secondary metabolites derived from plant extracts. The context was defined by the reported biological and pharmacological activities of these phytochemicals, particularly their potential anti-inflammatory, antioxidant, antiplasmodial, and antidiabetic properties. Therefore, this review aimed to answer the following research question: *What is the current scope of evidence on the phytochemical composition and pharmacological activities of S. arvensis, and to what extent have its therapeutic potentials been scientifically substantiated?*

Stage 2: Literature identification

Literature search was performed across several databases, namely Scopus, PubMed, EBSCOhost, and Google Scholar. Grey literature was searched using Google Scholar, Indonesian university repositories, and government reports. The search strategy was formulated in line with the PCC strategy. Search terms included "*Sonchus arvensis*," "*S. arvensis*", "tempuyung", "field sow thistle", "perennial sow thistle", "phytochemical", "metabolite", "secondary metabolite", "bioactive compound", "plant extract", and "extract", "anti-inflammatory," "antioxidant," "antimicrobial," "antiplasmodial," "antidiabetic," and "phytochemical composition," combined using Boolean operators (AND, OR). Truncation (*) was applied to broaden search results for selected terms, except for species names. The search was restricted to peer-reviewed papers published from 2004 to March 2024. The general search string used was as follows: ("*Sonchus arvensis*" OR "*S. arvensis*" OR "tempuyung" OR "field sow thistle" OR "perennial sow thistle") AND (phytochemical* OR metabolite* OR secondary metabolite* OR bioactive compound* OR plant extract* OR extract*) AND (antioxidant* OR antimicrob* OR anti-inflammat* OR antidiabetic* OR antiplasmodi* OR antimalari* OR anticancer*). The search strings were customized in accordance with the different rules that each database uses for query formulation and indexing. Detailed search queries for each database are presented in the Supplementary Data (Table S2). All identified records were managed in Mendeley Desktop (version 1.19.8) to deduplicate them. After duplicate removal, the cleaned dataset was exported and prepared for the subsequent screening stages.

Stage 3: Literature selection

The screening process was carried out by four authors. The Rayyan website (rayyan.ai) was used by four authors (ES, ASPP, CTU, RKA) to independently screen the studies. Blind function was activated to ensure that every decision was not influenced by another author's decision. Screening was conducted based on pre-established inclusion and exclusion criteria. Studies were eligible for inclusion if: (1) reported original research on *S. arvensis*, (2) assessed at least one of the following: phytochemical composition, anti-inflammatory, antioxidant, antimicrobial, antiplasmodial, or antidiabetic activity with clear methodology described, (3) were published in English, and (4) provided full-text access. Studies were excluded if they were: (1) review articles, conference abstracts, reports, and grey literature, (2) had no clear methodology described, (3) were non-comparative studies, and (4) were published before 2004 or after 2024. Any conflicting decisions were resolved through discussion until a consensus was reached. All studies selected were included in the review. Each selected study was assessed for its quality using the Mixed Method Appraisal Tool (MMAT) based on the methodological guidance proposed by Hong et al. (2018). Studies are categorized as high, moderate, or low quality based on a 10-point scoring system. The appraisal was performed individually by four authors (ES, ASPP, CTU, RKA). A detailed critical appraisal tool was presented in Supplementary Data (Table S4). The quality assessment score was evaluated for each article using the following criteria: (1) a clear definition of the study objective and aim, (2) research objective(s) relevant to the review, (3) study design appropriate for the stated aims, (4) type of study clearly defined, (5) extraction solvent and method reported, (6) methodology clearly described, (7) quantity of plant extract used clearly stated, (8) study results described, (9) discussions and conclusions justified, and (10) study limitations discussed. The quality assessment for each article was scored based on a simple binary system (1 for "yes" and 0 for "no"). For each study, scores ranged from 0 to 10, where 0–4 indicated low quality, 5–7 moderate quality, and 8–10 high quality.

Stage 4: Data charting and extraction

A standardized form was used to extract data on the type of study, study objective, country, plant part used, extraction solvent and method, compound

identified, bioactivity, and study outcomes, as shown in Supplementary File Table S3.

Stage 5: Evidence synthesis and reporting

Data extracted from all eligible studies are systematically organized and mapped to yield both numerical and thematic overviews. A numerical summary presents the distribution of publications by country of origin, study type, plant parts examined, and extraction methods. A qualitative thematic synthesis is conducted to aggregate findings across studies, facilitating the comparison of experimental outcomes and methodological approaches. The themes are grouped based on the phytochemical classes reported, the analytical techniques used, and the type of bioactivity evaluated (e.g., anti-inflammatory, antimicrobial, antioxidant, and anticancer). The synthesis process also highlights the connection between experimentally verified pharmacological activities and traditional medicinal use.

RESULTS

Study selection

Of 1737 records retrieved from PubMed, Google Scholar, EBSCOhost, and Scopus, and 40 additional records from grey literature, 87 studies met the inclusion criteria. The entire selection workflow was documented using the PRISMA flow diagram (Fig. 1). A summary of included studies on *S. arvensis* can be shown in Table 1.

Geographic distribution and study design

The majority of the studies (84%) were conducted in Indonesia, followed by China (7%), Pakistan (4%), and other countries (5%) as shown in Fig. 2A. Study types included *in vitro* (60%), *in vivo* (39%), and mixed (1%) models as shown in Fig 2B. All studies included in the review article were published between 2004 and 2024.

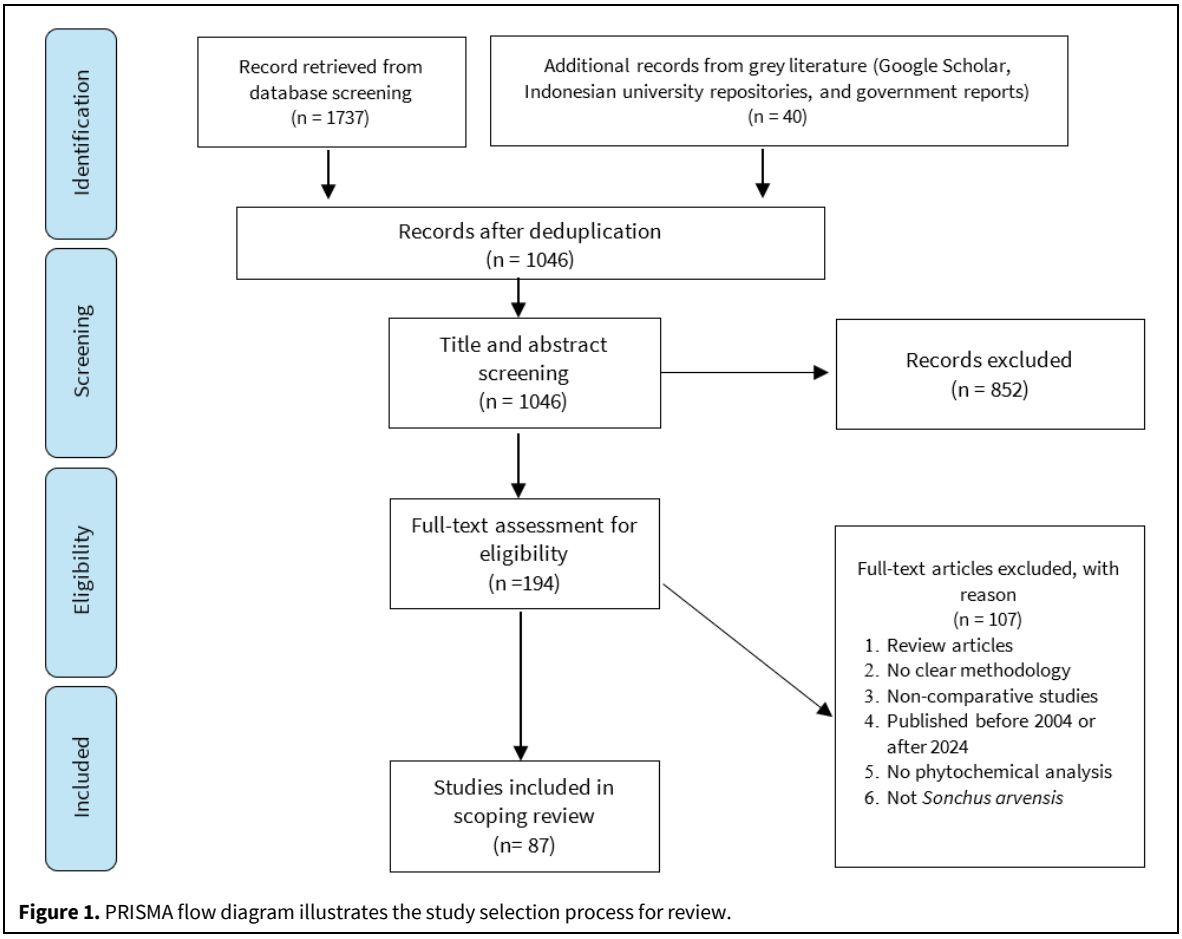


Figure 1. PRISMA flow diagram illustrates the study selection process for review.

Table 1. Summary of included studies on *Sonchus arvensis* L.: Study type, objectives, and key outcomes.

Type of study	Study objectives	Country	Plant part used	Extraction solvent and method	Compound identified	Bioactivity	Outcomes of study	Reference
In vivo	To examine how *S. arvensis* extract protects mice from colitis caused by dextran sulphate sodium (DSS) by modifying the diversity of gut bacteria.	China	Whole plant (leaves and stems)	Maceration/ 2500 ml of distilled water	Flavonoid, polysaccharides	Anti-ulcerative disease, anti-inflammatory	*S. arvensis* significantly improves the pathological alterations in mice caused by ulcerative colitis induced by dextran sulphate sodium (DSS) and improves gut microbiota.	(Ren et al., 2023)
In vitro	To determine the antioxidant efficacy of various *S. arvensis* fractions.	Pakistan	Whole plant (leaves, stem, flowers, and seeds)	NR/ 80% methanol	Flavonoid, phenolic	Antioxidant source	*S. arvensis* fractions are an effective source of antioxidant by its polyphenolic compound.	(Khan, 2012)
In vitro	To investigate structural characteristics, growth responses, metabolic composition, and antiplasmodial potential of *S. arvensis*.	Indonesia	Leaf explants	Maceration/ ethanol and methanol	Terpenoid, ketones, glycoside	Antiplasmodial activity	Dolomite usage on *S. arvensis* cultivation can improve *S. arvensis* growth, enhancing antiplasmodial effect, and has an effect on its metabolite profile.	(Wahyuni et al., 2021)
In vivo	To examine the effects of aqueous *S. arvensis* extract supplementation on exercise-induced physical fatigue in trained C57BL/6 mice.	China	Leaves	NR/water	Flavonoid, phenolics, polysaccharides	Anti-fatigue activity	*S. arvensis* aqueous extract enhances exercise performance and exerts anti-fatigue effects by reducing oxidative stress and improving metabolic and muscle parameters.	(Yuan et al., 2019)
In vitro	To assess the antioxidant, antimicrobial, and antiplasmodial potential of the ethyl acetate fraction of *S. arvensis*.	Indonesia	Leaves	Maceration/ ethyl acetate and n-hexane	Terpenoid	Antioxidant, antimicrobial, and antiplasmodial activities	Ethyl acetate fractions of *S. arvensis* (especially Fraction IV) exhibit strong antioxidant activity and demonstrate antiplasmodial and antibacterial effects that enhance inhibitory activities against *Plasmodium falciparum* as well as *Escherichia coli* and *Staphylococcus aureus.*	(Wahyuni et al., 2023a)
In vitro	To establish an analytical approach for the simultaneous detection and quantification of flavonoids in *S. arvensis.*	Indonesia	Roots, stems, and leaves	Methanol	Flavonoid	NR	*S. arvensis* leaves show higher flavonoid content than roots and stems that analysed using HPLC-DAD.	(Khuluk et al., 2021)

Table 1. Summary of included studies on *Sonchus arvensis* L.: Study type, objectives, and key outcomes (continued...)

Type of study	Study objectives	Country	Plant part used	Extraction solvent and method	Compound identified	Bioactivity	Outcomes of study	Reference
In vivo	To investigate fractionated *S. arvensis* extracts in order to enhance constituents with anti-inflammatory potential for gout arthritis.	Indonesia	Leaves	Maceration/ 96% ethanol	Flavonoid, phenolic, terpenoid, alkaloid, saponin	Anti-gout arthritis, Anti-inflammatory	*S. arvensis* exhibits anti-gout effects in monosodium urate–induced arthritis by suppressing synovial inflammation through reduced IL-1β and TNF-α expression.	(Parisa et al., 2021)
In vitro	To describe the isolation, structural elucidation, and cytotoxic properties of the identified compounds in *S. arvensis.*	China	Whole plant	Reflux/ 95% ethanol	Steroid	Anticancer activity	The isolated compounds exhibit moderate cytotoxic effects against endometrial carcinoma cell lines (ECC-1 and Ishikawa), with compound 8 showing the strongest activity. This effect is associated with pronounced morphological alterations (cell shrinkage, reduced cell size, and decreased adhesion), resulting in cytotoxic efficacy comparable to or exceeding that of etoposide.	(Xia et al., 2020)
In vivo	To investigate the anti-inflammatory effects of ethanolic *S. arvensis* extract on pro-inflammatory cytokine regulation in gout-induced rat models.	Indonesia	Leaves	Maceration/ 96% ethanol	NR	Anti-gout arthritis, Anti-inflammatory	*S. arvensis* extract demonstrates anti-gout activity in monosodium urate–induced arthritis by alleviating synovial inflammation. This effect is mediated by suppression of MSU-induced pro-inflammatory cytokine production, particularly IL-1β and TNF-α, in joint-associated inflammatory responses.	(Hidayat et al., 2020)
In vivo	To determine the irritant effects of sesquiterpene lactone glycosides obtained from *S. arvensis* herb.	Pakistan	Whole plant	Soxhlet/ methanol	Terpenoid	Anti-irritant activities	Sesquiterpene lactone glycosides from *S. arvensis* were irritant and potentially toxic, yet demonstrated anti-inflammatory and sedative effects at repeated low oral doses, with oral delivery safer than topical application in diffuse erythema.	(Asif & Saeed, 2020)
In vivo	To determine the key compound responsible for blood pressure modulation and elucidate its predicted cardiac mechanism.	Indonesia	Leaves	Maceration/ ethanol 96%	Flavonoid, phenolic, terpenoid, alkaloid, steroid, saponin, quinone, tannins	Anti-hypertensive	*S. arvensis* showed antihypertensive activity linked to its semi-polar flavonoids, supporting its potential use in traditional medicine. Luteolin was identified as a key contributor to blood pressure regulation.	(Suryani et al., 2020)

Table 1. Summary of included studies on *Sonchus arvensis* L.: Study type, objectives, and key outcomes (continued...)

Type of study	Study objectives	Country	Plant part used	Extraction solvent and method	Compound identified	Bioactivity	Outcomes of study	Reference
In vitro	To identify the phytocomponents of *Sonchus arvensis* L. With the use of Gas chromatography – Mass Spectrometry analysis.	Ukraine	Leaves	NR/ methanol	Phenolic, terpenoid	Antioxidant properties	The study concludes that the antioxidant properties of methanol extracts of leaves of *S. arvensis* are the most predominant. The raw material of *S. arvensis* is a part of dietary supplement, and *S. arvensis* garden is used as a diuretic.	(Delyan, 2016)
In vitro	To develop an efficient method for callus induction from leaves in *S. arvensis* and investigate its antimalarial potential through *in vitro* assays.	Indonesia	Leaves and petioles	NR/ methanol	NR	Antiplasmodial	A combination of 1 mg/L 2,4-D and 0.5 mg/L BAP produced the highest callus yield in the shortest time. Methanolic extracts of *S. arvensis* callus exhibited *in vitro* antiplasmodial activity, indicating antiplasmodial potential.	(Wahyuni et al., 2020a)
In vitro	To investigate the impact of shade conditions and vermicompost treatment on yield and flavonoid accumulation in *S. arvensis.*	Indonesia	Seed	NR/ ethanol	Flavonoid	NR	Increased shading reduced vegetative growth, whereas vermicompost significantly enhanced leaf number and fresh and dry weights. Leaf chlorophyll content showed a positive correlation with *S. arvensis* leaf weight.	(Putri et al., 2018)
In vivo	To evaluate the dose-dependent effects of *S. arvensis* leaf extract on renal histopathology in *Plasmodium berghei*-infected mice.	Indonesia	Leaves	Maceration/ ethyl acetate	NR	Antiplasmodial and nephroprotective effect	*S. arvensis* extract was safe and improved renal histology in *Plasmodium berghei* exposed mice by reducing hydropic degeneration and necrotic cells. However, it showed only limited improvement in glomerular atrophy, suggesting potential as an alternative therapy for malaria-associated renal complications.	(Wahyuni et al., 2023b)
In vivo	To evaluate the hepatoprotective effects of *S. arvensis* extract (SME) against CCl_4-induced liver injury in rats.	Pakistan	Not stated	NR	NR	Hepatoprotective effect	*S. arvensis* treatment reversed CCl_4-induced alterations in serum marker enzymes and cholesterol profiles toward normal levels. It restored hepatic antioxidant enzyme activities and glutathione levels while reducing lipid peroxidation elevated by CCl_4-induced liver injury.	(Alkreathy et al., 2014)

Table 1. Summary of included studies on *Sonchus arvensis* L.: Study type, objectives, and key outcomes (continued...)

Type of study	Study objectives	Country	Plant part used	Extraction solvent and method	Compound identified	Bioactivity	Outcomes of study	Reference
In vitro	To elucidate the isolation process, structural features, and antibacterial properties of these compounds.	China	Whole plant	Reflux/ 85% ethanol	Terpenoid	Antibacterial activities	The newly isolated compounds exhibited weak or no antibacterial activity against *Streptococcus* mutans ATCC 25175. NMR analysis and acid hydrolysis confirmed the presence of a D-glucopyranoside moiety identified as D-glucose.	(Xia et al., 2011)
In vitro	To evaluate the inhibitory activity of n-hexane fractions from *S. arvensis* leaves as potential SARS-CoV-2 antiviral agents.	Indonesia	Leaves	Maceration/ n-hexane	Terpenoid	Antiviral	*S. arvensis* leaf fractions showed potential SARS-CoV-2 antiviral activity, associated with the presence of α-amyrin and β-amyrin. Both compounds demonstrated strong binding to viral targets (helicase, RdRp, Mpro, and RBD-Spike) with higher binding affinity than the control drug and stable ligand–protein interactions.	(Wahyuni et al., 2022)
In vitro	To report the isolation process, structural identification, and corresponding antibacterial activity of these compounds.	China	Whole plant	Reflux/ 85% ethanol	Flavonoid, phenolic	Antibacterial activities	The study confirmed that plants biosynthesize sulphated sesquiterpene lactones. These compounds likely play a key role in the plants' chemical defense.	(Xia et al., 2010)
In vitro/ in vivo	To characterize the phytochemical constituents and examine their cytotoxic, antioxidant, and antiplasmodial activities of *S. arvensis* leaf extracts *in vitro* and *in vivo*.	Indonesia	Leaves	Maceration/ ethyl acetate, n-hexane, and ethanol	Flavonoid, phenolic, alkaloid, terpenoid, saponin	Antioxidant and antiplasmodial activities	The study confirmed that ethyl acetate extract of *S. arvensis* L. exhibited antiplasmodial activity *in vitro* and *in vivo*, along with antioxidant, nephroprotective, hepatoprotective, and immunomodulatory effects with low toxicity. These findings indicate its potential as an antimalarial agent.	(Wahyuni et al., 2023c)
In vitro	To investigate the impact of temperature on callus induction and metabolite composition of *S. arvensis.*	Indonesia	Leaves	Maceration/ methanol	Flavonoid, terpenoid, alkaloid, saponin	NR	Phytochemical screening of *S. arvensis* revealed flavonoids, alkaloids, terpenoids, and saponins, with 17 compounds identified by GC–MS. Temperature significantly affected callus induction and metabolite profiles. All treatments achieved 100% callus induction efficiency.	(Wahyuni et al., 2020b)

Table 1. Summary of included studies on *Sonchus arvensis* L.: Study type, objectives, and key outcomes (continued...)

Type of study	Study objectives	Country	Plant part used	Extraction solvent and method	Compound identified	Bioactivity	Outcomes of study	Reference
In vivo	To evaluate the potential of *S. arvensis* as a nephroprotective agent.	Indonesia	Leaves	Reflux/ 96% ethanol	Flavonoid, terpenoid, steroid, tannin, saponin	Nephroprotective effects	*S. arvensis* L. demonstrated nephroprotective effects by increasing endogenous antioxidant activity and reducing free radical levels in test animals. It also lowered thiobarbituric acid-reactive substances (TBARS) levels and enhanced catalase activity in models of kidney failure. Additionally, treatment reduced serum urea and creatinine, supporting its protective effect against kidney damage.	(Suliska et al., 2021a)
In vivo	To evaluate the protective potential of A. cordifolia and *S. arvensis* L. extracts combination against gentamicin-induced kidney damage in rats.	Indonesia	Leaves	Maceration/ 96% ethanol	NR	Nephroprotective effect	The combination of *Anredera cordifolia* and *S. arvensis* extracts protected rats against gentamicin-induced nephrotoxicity by lowering urinary N-acetyl-β-D-glucosaminidase activity, serum urea, and serum creatinine. Histopathological analysis confirmed reduced tubular damage compared to untreated controls.	(Suliska et al., 2021c)
In vivo	To evaluate the effects of ethanol extract of *S. arvensis* on blood urea nitrogen (BUN), serum creatinine (SCr), alanine aminotransferase (ALT), aspartate aminotransferase (AST), and acute toxicity in healthy male albino mice following daily administration for 14 days.	Indonesia	Leaves	Maceration/ 70% ethanol	Flavonoid	NR	Ethanol extract of *S. arvensis* leaves was safe for the kidneys, as indicated by unchanged BUN and SCr levels. However, it significantly affected ALT levels, suggesting a hepatic response.	(Harun et al., 2019)
In vitro	To establish a Thin Layer Chromatography (TLC)-based fingerprint analysis of *S. arvensis* to support quality control measures.	Indonesia	Whole plants	NR/ methanol	Flavonoid	NR	The mobile phase composition enabled clear separation, with luteolin detected at an Rf of 0.22 under UV light at 366 nm after derivatization with 10% sulfuric acid. Fingerprint analysis of *S. arvensis* from Malang, Solo, and Yogyakarta revealed no significant differences. The method was validated and complied with quality control standards for *S. arvensis*.	(Fauziah et al., 2023)

Table 1. Summary of included studies on *Sonchus arvensis* L.: Study type, objectives, and key outcomes (continued...)

Type of study	Study objectives	Country	Plant part used	Extraction solvent and method	Compound identified	Bioactivity	Outcomes of study	Reference
In vivo	To investigate the effect of *S. arvensis* leaf ethanolic extract on gentamicin-induced acute tubular necrosis (ATN) based on kidney histology and serum creatinine.	Indonesia	Leaves	Maceration/ 96% ethanol	Flavonoid, phenolic, terpenoid, tannin, saponin	Nephroprotective effect	Histopathological examination of gentamicin-treated rats showed degenerative changes in kidney tubules. Co-administration of *S. arvensis* with gentamicin ameliorated nephrotoxic effects, improving histopathological features and normalizing serum creatinine. These results indicate that *S. arvensis* provides protection against gentamicin-induced acute tubular necrosis.	(Imelda et al., 2018)
In vivo	To assess the protective effect of the ethanol extract of *S. arvensis* leaves on gentamicin-induced renal damage in rats based on blood urea level alterations.	Indonesia	Leaves	Maceration/ 96% ethanol	NR	Nephroprotective effect	Ethanol extract of *S. arvensis* leaves significantly reduced blood urea levels in gentamicin-induced renal injury in rats. Urea decreased from 29.50 ± 1.29 mg/dL in the gentamicin control group to 26.50 ± 0.58 mg/dL and 22.25 ± 1.26 mg/dL at 100 and 200 mg/kg doses, respectively.	(Imelda et al., 2017)
In vivo	To provide a basis for the future development of herbal medicines from the methanolic extract of *S. arvensis.*	Nepal	Aerial parts	Soxhlet / Methanol	Flavonoid, steroid	Anti-inflammatory activity	*S. arvensis* exhibited strong anti-inflammatory activity and dose-dependent inhibition of gastrointestinal motility and spontaneous locomotor activity. No skeletal muscle relaxant effects were observed in the traction and inclined plane tests. The findings highlight potent phytochemicals with anti-inflammatory activity and inhibitory effects on spontaneous locomotion and gastrointestinal motility.	(Poudel et al., 2015)
In vivo	To assess the impact of perennial *S. arvensis* leaf extract on streptozotocin-induced changes in blood glucose and plasma insulin in mice.	Indonesia	Leaves	Infusion/ 1000 mL of distilled water	Flavonoid	Anti-diabetic	*S. arvensis* leaf extract reduced postprandial and blood glucose spikes over 14 days. The most effective dose for lowering blood glucose was 150 mg/kg body weight (BW). Plasma insulin levels increased at 60 minutes, with an effective dose of 50 mg/kg BW.	(Haryta et al., 2021)

Table 1. Summary of included studies on *Sonchus arvensis* L.: Study type, objectives, and key outcomes (continued...)

Type of study	Study objectives	Country	Plant part used	Extraction solvent and method	Compound identified	Bioactivity	Outcomes of study	Reference
In vitro	To identify functional groups that have dominant antioxidant activity.	Indonesia	Leaves	Maceration/ water and ethanol	Flavonoid	Antioxidant activity	The 70% ethanol extract of *S. arvensis* leaves showed the highest total phenolic content and antioxidant activity. Principal component analysis (PCA) clustered all extracts by group with a total PC1 and PC2 of 95%, and Fourier transform infrared spectroscopy (FTIR) predicted -OH and C-O functional groups as contributors to antioxidant activity. FTIR-based fingerprinting, combined with chemometrics, proved useful for clustering and characterizing the extracts' antioxidant properties.	(Rafi et al., 2021)
In vitro	To evaluate clustering patterns of *S. arvensis* extracts using FTIR and metabolite detection, along with their antioxidant activity.	Indonesia	-	Maceration/ water and ethanol	Flavonoid, phenolic, terpenoid	Antioxidant	The free radical-scavenging activity of *S. arvensis* extracts was influenced by their metabolite composition. FTIR combined with metabolite peak areas allowed grouping of extracts by solvent, showing that solvent type affected metabolite profiles and antioxidant activity.	(Rafi et al., 2022a)
In vivo	To investigate the cardioprotective potential of *S. arvensis* leaves in isoproterenol-induced myocardial injury and *in vitro* cardiomyocyte survival under nutrient deprivation.	Indonesia	Leaves	Reflux/ ethanol 96%, n-hexane, ethyl acetate, and water	Flavonoid	Cardioprotective effect	Pre-treatment with n-hexane and ethyl acetate fractions of *S. arvensis* for 14 days did not prevent increases in AST, ALT, creatine kinase, creatine kinase-MB, and lactate dehydrogenase after isoproterenol administration. These fractions also showed cardiotoxic effects on cardiomyocyte viability. In contrast, the water fraction at 100 mg/kg BW protected the myocardium and exerted cardioprotective effects, likely by inhibiting TNF-α production.	(Kurniati et al., 2018)

Table 1. Summary of included studies on *Sonchus arvensis* L.: Study type, objectives, and key outcomes (continued...)

Type of study	Study objectives	Country	Plant part used	Extraction solvent and method	Compound identified	Bioactivity	Outcomes of study	Reference
In vitro	To investigate the effects of harvesting methods on leaf yield, flavonoid content, antioxidant activity, and flavonoid profiles of three *S. arvensis* accessions.	Indonesia	Seeds and leaves	NR/ methanol	Flavonoid	Antioxidant activity	Simultaneous harvest increased leaf number by 65%, fresh weight by 55%, and dry weight by 60% compared to gradual harvest. Antioxidant activity was influenced by factors beyond total flavonoids, with Tawangmangu accession showing higher antioxidants in lower leaves, while simultaneous harvest yielded the highest total flavonoid content and antioxidant activity in upper leaves. These findings suggest that simultaneous harvesting is recommended to maximize *S. arvensis* production and quality.	(Raisawati et al., 2023)
In vivo	To assess flavonoid levels and antioxidant potential in ten *S. arvensis* accessions cultivated under experimental conditions.	Indonesia	Leaves	Maceration/ 96% ethanol	Flavonoid, vitamin	NR	Significant variation existed among the ten *S. arvensis* accessions. Banjararum accession had the highest total flavonoid content, whereas Sumbersekar accession showed the strongest antioxidant activity with the lowest DPPH IC_{50} value.	(Raisawati et al., 2020)
In vivo	To investigate secondary metabolites in *S. arvensis* leaf ethanol extract and their effects on blood glucose levels and tissue histopathology in male rats induced with streptozotocin.	Indonesia	Leaves	Maceration / 96% ethanol	Flavonoid, phenolic, alkaloid, tannin, steroid	Anti-diabetic	Ethanol extract of *S. arvensis* L. leaves contains secondary metabolites including alkaloids, flavonoids, phenols, tannins, and steroids. A dose of 300 mg/kg BW effectively reduced blood glucose levels, comparable to the positive control. The same dose promoted regeneration of kidney tubule cells, with an average damage value of 0.28.	(Tandi et al., 2020)
In vitro	To present the first comprehensive GC and GC-MS analysis of essential oil from wild-growing *S. arvensis* subsp. uliginosus populations in Serbia.	Serbia	Stems with inflorescences	Hydro-distillation/ volatile oil	Fatty acids	NR	Essential oil-poor *S. arvensis* species (yields <0.1%) mainly contained fatty acid- and carotenoid-derived compounds. In contrast, essential oil-rich taxa (yields >0.1%) were characterized by the production of mono- and sesquiterpenoids and/or phenylpropanoids.	(Radulović et al., 2009)

Table 1. Summary of included studies on *Sonchus arvensis* L.: Study type, objectives, and key outcomes (continued...)

Type of study	Study objectives	Country	Plant part used	Extraction solvent and method	Compound identified	Bioactivity	Outcomes of study	Reference
In vivo	To assess the efficacy of *S. arvensis* leaves as an antipyretic in male white rats.	Indonesia	Leaves	NR	NR	Antipyretic activities	Infusion of *S. arvensis* leaves demonstrated antipyretic activity. The most effective dose to reduce fever was 10 mg/kg BW.	(Mbaubedari et al., 2020)
In vitro	To determine the total phenolic content and phytochemical profile of ethanol *S. arvensis* leaf extract.	Indonesia	Leaves	Maceration/ 96% ethanol	Flavonoid, alkaloid, tannin, saponin, steroid, terpenoid, glycoside	NR	Ethanolic extract of *S. arvensis* leaves contained 45.04 ± 0.46 mg gallic acid equivalent (GAE) per gram of extract, indicating high total phenolic content. Phytochemical screening revealed the presence of flavonoids, alkaloids, tannins, saponins, steroids, terpenoids, and glycosides.	(Hapsari et al., 2018)
In vitro	To investigate the solubilizing effect of dried tea leaves on calcium oxalate with once and twice-daily administration.	Indonesia	Leaves	NR/ water	NR	Kidney stone (calcium oxalate) solubility	Administration of *S. arvensis* tea leaves twice daily increased calcium oxalate solubility compared with a once-daily regimen. After seven consecutive days of twice-daily treatment, calcium oxalate solubility reached 27.49%.	(Mukaromah & Anggraini, 2009)
In vitro	To evaluate six-month room temperature stability (25 ± 2°C) of *S. arvensis* extract based on the International Conference on Harmonisation 2003.	Indonesia	Leaves	Maceration/ methanol	Terpenoid	NR	Methanol extract of *S. arvensis* was found to be unstable at room temperature. Stability was maintained for three months with approximately 2.92% compound degradation, while six months of storage resulted in the highest degradation of about 25.16%.	(Itam et al., 2013)
In vitro	To assess the effect of *S. arvensis* root ethanol fraction on colon cancer cells based on caspase-9 gene expression.	Indonesia	Roots	NR	NR	Anticancer activity	The ethanolic fraction of *S. arvensis* root exhibited an IC_{50} of 2865.5 µg/mL, reflecting low cytotoxic activity. The findings indicate that this fraction has minimal potential as a chemotherapeutic agent for colon cancer.	(Rohima et al., 2011)
In vivo	To investigate the capacity of *S. arvensis* leaf ethanol extract to inhibit platelet aggregation in male Swiss Webster mice.	Indonesia	Leaves	Reflux/ 95% ethanol	NR	Anti-aggregation activity of platelet	Administration of *S. arvensis* leaf ethanol extract at 50 mg/kg BW significantly extended bleeding time in mice, especially on day 28 of treatment. In contrast, coagulation time showed no notable change following the administration of the extract.	(Ningsih et al., 2017)

Table 1. Summary of included studies on *Sonchus arvensis* L.: Study type, objectives, and key outcomes (continued...)

Type of study	Study objectives	Country	Plant part used	Extraction solvent and method	Compound identified	Bioactivity	Outcomes of study	Reference
In vitro	To determine the antioxidant potential of flavonoid compounds isolated and identified from the ethyl acetate extract of *S. arvensis* leaves.	Indonesia	Leaves	Maceration/ n-hexane, 96% ethanol, ethyl acetate	Flavonoid	Antioxidant activity	The antioxidant assay showed IC_{50} values of 473.28 µg/mL for the ethyl acetate extract and 421.03 µg/mL for the isolated flavonoids. In comparison, the reference compound quercetin exhibited an IC_{50} of 64.06 µg/mL.	(Ramadhani et al., 2013)
In vitro	To evaluate the effect of different solvent concentrations and extraction durations on extract yield.	Indonesia	Leaves	NR/ 96% ethanol	Flavonoid, phenolic, tannin, saponin	Antioxidant activity	The extract yield reached a maximum of 12.27%. Optimal extraction was achieved using 50% solvent concentration for 45 min. This condition produced a total phenolic content of approximately 9.6166 mg/g of leaf weight.	(Laksono, 2020)
In vivo	To evaluate the anti-hyperuricemic potential of *Asteraceae* family in *Mus musculus*.	Indonesia	Leaves	Maceration/ 70% ethanol	Flavonoid	Anti-hyperuricemia activity	*S. arvensis* exhibited the strongest anti-hyperuricemic effect at a dose of 500 mg/kg BW, reducing blood uric acid levels by 52 ± 0.2%.	(Amal et al., 2021)
In vitro	To determine tannin and total phenolic content, antioxidant potential, inhibition score, and sensory profile.	Indonesia	Leaves	NR/water	Phenolic, tannin	Antioxidant activity	The highest tannin content was observed in the 25 g/200 mL sample. Total phenolic content peaked at 20 g/200 mL and decreased with higher concentrations. Antioxidant capacity was highest in the 25 g/200 mL sample, while an inhibition concentration (IC) score of 50% was achieved at 13.3 g/200 mL.	(Sudewi, 2015)
In vivo	To assess the influence of *S. arvensis* leaf ethanol extract on diuresis and serum potassium and sodium levels relative to furosemide in male Wistar rats.	Indonesia	Leaves	Maceration/ 70% ethanol	NR	Diuretic	The ethanolic extract of *S. arvensis* demonstrated a diuretic effect in male Wistar rats. At a dose of 300 mg/kg BW, the extract exhibited stronger diuretic activity than furosemide at 0.72 mg/kg BW.	(Rustam et al., 2006)

Table 1. Summary of included studies on *Sonchus arvensis* L.: Study type, objectives, and key outcomes (continued...)

Type of study	Study objectives	Country	Plant part used	Extraction solvent and method	Compound identified	Bioactivity	Outcomes of study	Reference
In vivo	To evaluate the acute toxic effects of *S. arvensis* leaf ethanol extract in female mice based on clinical signs, body weight changes, organ indices, gross pathological observations, LD_{50}, and toxicity categorization.	Indonesia	Leaves	Maceration/ ethanol	Flavonoid	NR	Ethanol extract of *S. arvensis* leaves caused clinical toxicity signs in female mice, with no significant changes in body or organ weights up to 2000 mg/kg BW. A 5000 mg/kg BW dose led to 80% mortality and liver yellowing, indicating an LD_{50} > 2000 mg/kg BW and slight toxicity.	(Amal et al., 2022)
In vitro	To determine the total flavonoid levels and relevant parameters in both hydrolyzed and non-hydrolyzed *S. arvensis* leaf extracts.	Indonesia	Leaves	Reflux/ 70% ethanol	Flavonoid	NR	The study found that acid-hydrolyzed *S. arvensis* extract contained a total flavonoid content of 0.532%. In comparison, the non-hydrolyzed extract had a total flavonoid content of 0.388%.	(Sari, 2020)
In vitro	To determine the physicochemical properties and identify major secondary metabolites in *S. arvensis* leaves.	Indonesia	Leaves	NR/ NR	Flavonoid, alkaloid, terpenoid, steroid, tannin, quinone, saponin, glycoside	NR	The characterization of *S. arvensis* leaves met quality standards, with 5.33% water content, 28.27% water-soluble extract, 9.42% ethanol-soluble extract, 16.44% total ash, and 0.61% acid-insoluble ash. Phytochemical screening revealed the presence of flavonoids, alkaloids, tannins, anthraquinones, glycosides, steroids/terpenoids, and saponins.	(Harahap, 2020)
In vivo	To investigate the impact of *S. arvensis* leaf extract on total and differential leukocyte counts and IL-2 concentration in male Wistar rats.	Indonesia	Leaves	Reflux/ ethanol	Flavonoid, terpenoid, saponin, quinone	Immunomodulatory activity	Ethanol extract of *S. arvensis* leaves enhanced total leukocyte count, leukocyte subsets, and Interleukin-2 (IL-2) levels.	(Sukmayadi et al., 2014)

Table 1. Summary of included studies on *Sonchus arvensis* L.: Study type, objectives, and key outcomes (continued...)

Type of study	Study objectives	Country	Plant part used	Extraction solvent and method	Compound identified	Bioactivity	Outcomes of study	Reference
In vitro	To investigate the flavonoid content of *S. arvensis* leaves processed using various combined drying approaches in highland areas.	Indonesia	Leaves	NR/ 96% ethanol	Flavonoid	NR	The sunlight-drying method yielded the highest total flavonoid content in S. arvensis at 0.043%, followed by room-temperature oven drying. Statistical analysis showed that combining different drying methods did not significantly influence the total flavonoid content.	(Safrina et al., 2020)
In vitro	To determine the phytochemical composition of *S. arvensis* callus.	Indonesia	Leaves	Soxhlet/ 80% ethanol	Flavonoid, tannin, bufadianol	NR	Flavonoid compounds in the ethanolic extracts of *S. arvensis* leaves and callus were found to be the same.	(Katno & Widiyastuti, 2004)
In vitro	To investigate the antioxidant activity of *S. arvensis* leaf extract using the 2,2-diphenyl-1-picrylhydrazyl (DPPH) method.	Indonesia	Leaves	Maceration/ methanol, ethanol, water	Flavonoid, phenolic	Antioxidant activity	Methanol extract showed the strongest activity with IC_{50} values of 55.53, 93.21, and 238.71 µg/mL, followed by ethanol extract at 247.09–512.11 µg/mL, while water extract exhibited the weakest activity with an IC_{50} of 4071.25 µg/mL.	(Ediningsih et al., 2016)
In vivo	To assess how *S. arvensis* leaf extract influences osteoblast proliferation in healing tooth extraction sites in white rats.	Indonesia	Leaves	Maceration/ 96% ethanol	Flavonoid, terpenoid	Wound healing	*S. arvensis* leaf extract increased osteoblast numbers in post-extraction sockets of rats. Longer administration further enhanced osteoblast proliferation, supporting improved bone healing.	(Rahmaniar, 2018)
In vitro	To assess the ability of ethanolic *S. arvensis* leaf extract to inhibit *Salmonella typhi* and determine its minimum inhibitory concentration (MIC).	Indonesia	Leaves	Maceration/ 96% ethanol	Flavonoid, terpenoid	Antibacterial activity	Ethanolic extract of *S. arvensis* leaves inhibited *Salmonella typhi* growth in a dose-dependent manner. The extract showed MIC values of 10 µg/disc qualitatively and 4.43 µg/disc quantitatively, indicating strong antibacterial activity.	(Yanuarisa et al., 2016)

Table 1. Summary of included studies on *Sonchus arvensis* L.: Study type, objectives, and key outcomes (continued...)

Type of study	Study objectives	Country	Plant part used	Extraction solvent and method	Compound identified	Bioactivity	Outcomes of study	Reference
In vivo	To evaluate the effect of *S. arvensis* root infusion on lowering serum uric acid levels in rats compared with allopurinol.	Indonesia	Root	Infusion/ NR	Flavonoid	Anti-hyperuricemia	*S. arvensis* root infusion reduced serum uric acid levels in potassium ozonate-induced white rats in a dose-dependent manner, with 1.25, 2.5, and 5 g/kg BW (10–40% concentrations) showing progressively stronger effects.	(Retnowati et al., 2014)
In vivo	To evaluate the potential of *S. arvensis* leaves in lowering uric acid levels.	Indonesia	Leaves	NR/ 70% ethanol	Flavonoid, alkaloid, tannin, saponin	Anti-hyperuricemia	Ethanol extract of *S. arvensis* leaves demonstrated significant uric acid–reducing potential, lowering levels by 64.27% in rats at a dose of 12.8 mg/20 g BW.	(Lailli & Savitri, 2021)
In vitro	To evaluate the total flavonoid content of *S. arvensis* ethanol extract using UV-Vis spectrophotometry.	Indonesia	Leaves	Maceration/ ethanol 70%	Flavonoid	NR	Ethanol extract of *S. arvensis* contained total flavonoids at 3.3671 mg QE/g extract (0.33671%) measured at 430 nm, indicating the presence of bioactive compounds.	(Syarifuddin et al., 2022)
In vitro	To assess the free radical–scavenging activity of *S. arvensis* leaf ethanol extract via DPPH and ABTS assays.	Indonesia	Leaves	Maceration/ ethanol 70%	Flavonoid, phenolic	Antioxidant activity	*S. arvensis* leaf ethanol extract exhibited antioxidant activity, with IC_{50} values of 138.26 µg/mL against ABTS and 64.97 µg/mL against DPPH, indicating a stronger radical-scavenging effect on DPPH.	(Istikharah, 2015)
In vitro	To investigate the cytotoxic potential of *S. arvensis* leaf chloroform extract against *Artemia salina* L. larvae and to characterize the chemical composition of its active fraction using GC-MS.	Indonesia	Leaves	Maceration/ chloroform	Fatty acids	Larvicidal effect	Fraction B from the chloroform extract column showed strong cytotoxicity with an LC_{50} of 7.86 µg/mL. Chemical analysis identified 29 compounds, with dibutyl phthalate, palmitic acid, 8,11,14-eicosatrienoic acid, dioctyl adipate, and dioctyl phthalate as the most abundant.	(Azifa et al., 2014)

Table 1. Summary of included studies on *Sonchus arvensis* L.: Study type, objectives, and key outcomes (continued...)

Type of study	Study objectives	Country	Plant part used	Extraction solvent and method	Compound identified	Bioactivity	Outcomes of study	Reference
In vivo	To evaluate the optimal dose of *S. arvensis* leaf extract for reducing serum uric acid levels in hyperuricemic male white rats.	Indonesia	Leaves	NR/ NR	Flavonoid	Anti-hyperuricemia	Administration of *S. arvensis* extract at 0.35 mg/g BW significantly lowered serum uric acid levels in hyperuricemic male mice, with an average reduction of 6.271 mg/dL.	(Brajawikalpa et al., 2018)
In vitro	To extract and characterize antioxidant compounds from the ethyl acetate fraction of *S. arvensis* and evaluate their free radical–scavenging potential.	Indonesia	Leaves	Maceration/ ethyl acetate	Flavonoid	Antioxidant activity	The active antioxidant compound isolated from *S. arvensis* ethyl acetate fraction was identified as a chalcone-type flavonoid. Antioxidant testing showed weak activity, with an IC_{50} of 353.41 µg/mL, indicating low radical-scavenging potential.	(Putra et al., 2013)
In vitro	To determine the size effect of raw material and the extraction time on the yield and quality of the extract.	Indonesia	Leaves	Maceration/ ethanol and Water	Flavonoid, alkaloid, terpenoid, steroid, tannin, saponin, glycoside	NR	Water extract of *S. arvensis* yielded more than the ethanol extract. The drying method did not affect extract quality, while particle fineness and extraction time influenced overall yield.	(Manoi, 2017)
In vitro	To assess the impact of solvent selection on the quality characteristics of *S. arvensis* leaf extracts.	Indonesia	Leaves	Maceration/ water and ethanol	Flavonoid, phenolic, saponin	NR	Across all extraction solvents (water, 25% ethanol, and 50% ethanol), *S. arvensis* leaf extracts were characterized by the presence of flavonoids and tannins as the dominant phytochemicals.	(Rosandi & Oktavia, 2018)
In vitro	To identify the specific flavonoid compound present in *S. arvensis* leaves.	Indonesia	Leaves	Maceration/ n-butanol	Flavonoid	NR	Analysis by IR spectrophotometry revealed characteristic OH, CH, aromatic C=C, CC, and out-of-plane CH functional groups in flavonoids isolated from *S. arvensis* leaves. UV spectral data with a maximum absorption at 329.10 nm further indicated that these compounds were classified as flavanols (2-phenylbenzopyran).	(Syarifuddin & Yusriyani, 2021)

Table 1. Summary of included studies on *Sonchus arvensis* L.: Study type, objectives, and key outcomes (continued...)

Type of study	Study objectives	Country	Plant part used	Extraction solvent and method	Compound identified	Bioactivity	Outcomes of study	Reference
In vitro	To investigate and isolate antibacterial agents from the n-hexane leaf extract of *S. arvensis.*	Indonesia	Leaves	Maceration/ n-hexane	Terpenoid	Antibacterial activity	The concentrated n-hexane extract contained at least seven distinct compounds. Among these, bis(2-ethylhexyl) esters and a triterpenoid with the molecular formula $C_{32}H_{66}O_6$ demonstrated antibacterial activity.	(Sukadana & Santi, 2011)
In vitro	To design and validate an RP-HPLC–PDA analytical method for concurrent quantification of several compounds in *S. arvensis* leaves.	India	Leaves	Maceration/ chloroform, methanol, water, acetic acid	Flavonoid, phenolic, vitamin	NR	A validated HPLC method was successfully established for the simultaneous quantification of target compounds. *S. arvensis* and *Oenanthe linearis* showed high levels of ascorbic acid (1.2% and 2.3%) and gallic acid (0.02% and 0.06%), particularly in the 1% aqueous acetic acid extract. Method performance was confirmed by high recovery (96–103%), low coefficient of variation, and low LOD and LOQ, indicating strong accuracy and precision.	(Seal, 2016)
In vitro	To assess the xanthine oxidase inhibitory potential of *S. arvensis* leaf ethanol extract *in vitro* for anti-hyperuricemic application.	Indonesia	Leaves	Maceration/ 96% ethanol	Flavonoid, alkaloid, terpenoid, quinone	Anti-hyperuricemia	Ethanol extract of *S. arvensis* leaves exhibited strong xanthine oxidase inhibition with an IC_{50} of 23.37 µg/mL, compared to allopurinol (as reference drug) at 17.16 µg/mL. These results indicate the potential of tempuyung leaf ethanol extract as a natural anti-hyperuricemic agent.	(Parisa et al., 2024)
In vitro	To analyse drought stress–induced expression of PAL, C4H, 4CL, HCT, HQT, and C3'H genes in *S. arvensis* and correlate these patterns with anticancer-related metabolite levels.	Iran	Leaves	Methanol, ethanol, or aqueous methanol/ ethanol	Phenolic	Anticancer	Exposure of the middle leaves to 50% field capacity resulted in maximal upregulation of all targeted genes and the highest accumulation of chicoric, chlorogenic, and 2,5-dihydroxybenzoic acids. HQT expression showed the strongest correlation with chlorogenic acid levels, supporting an HQT-dependent biosynthetic pathway. In addition, partial coding sequences of C4H, HCT, C3'H, and actin were identified and submitted to the GenBank database.	(Azizyan & Mandoulakani, 2024)

Table 1. Summary of included studies on *Sonchus arvensis* L.: Study type, objectives, and key outcomes (continued...)

Type of study	Study objectives	Country	Plant part used	Extraction solvent and method	Compound identified	Bioactivity	Outcomes of study	Reference
In vitro	To assess xanthine oxidase inhibition by quercetin isolated from *S. arvensis* leaves using *in vitro* assays and *in silico* molecular docking.	Indonesia	Leaves	Maceration method for extraction, employing 96% ethanol	Flavonoid	Anti-hyperuricemia	The ethyl acetate fraction showed the strongest xanthine oxidase inhibition among the tested solvents, with an IC_{50} of 16.20 µg/mL, and quercetin was identified as the active compound. Molecular docking analysis demonstrated that quercetin had a higher binding affinity (–7.71 kcal/mol) than allopurinol (–5.63 kcal/mol). These results highlight quercetin from *S. arvensis* leaves as a promising natural anti-hyperuricemic agent.	(Hendriani et al, 2017)
In vitro	To perform a comparative assessment of antioxidant capacity in seven Indonesian plant extracts (*Orthosiphon stamineus*, *Centella asiatica*, *Apium graveolens*, *Curcuma domestica*, *Curcuma xanthorrhiza*, *Sonchus arvensis*, and *Phyllanthus niruri*) using multiple radical scavenging and reducing power assays (DPPH, ABTS, and FRAP).	Indonesia	Leaves	NR/ 80% ethanol	Flavonoid, phenolic	Antioxidant	Antioxidant screening revealed clear differences among the seven herbal extracts. *P. niruri* and *O. stamineus* showed the strongest activity across DPPH (IC_{50} 102 and 132 µg/mL), ABTS (IC_{50} 20 and 22 µg/mL), and FRAP assays, with *P. niruri* exhibiting the highest reducing power (17.41 µg/mL AEAC/ µg/mL extract at 20 µg/mL). These results were consistent with total phenolic and flavonoid contents, identifying *P. niruri* and *O. stamineus* as the most potent antioxidants among the tested herbs.	(Sukweenadhi et al.,2020)
In vitro	To investigate the antihypertensive potential of single and combined *Anredera cordifolia* and *S. arvensis* leaf extracts in an angiotensin II–induced hypertension model.	Indonesia	Leaves	Maceration/ ethanol and methanol	NR	Anti-hypertensive	Significant blood pressure reduction was observed with *A. cordifolia* at 50 mg/kg BW and with the combined *A. cordifolia–S. arvensis* treatment at 25–25 mg/kg BW, while *S. arvensis* alone at 50 mg/kg BW was ineffective. Notably, the 25–25 mg/kg BW combination showed the greatest protective effect, suppressing elevations in systolic and diastolic blood pressure by 54.77% and 67.6%, respectively.	(Suliska et al., 2021b)

Table 1. Summary of included studies on *Sonchus arvensis* L.: Study type, objectives, and key outcomes (continued...)

Type of study	Study objectives	Country	Plant part used	Extraction solvent and method	Compound identified	Bioactivity	Outcomes of study	Reference
In vitro	To evaluate the antioxidant activity of Indonesian herbal extracts to identify suitable materials for green synthesis of silver nanoparticles applicable in diabetic foot ulcer therapy.	Indonesia	Leaves	Maceration/ ethanol and methanol	Flavonoid, phenolic	Antioxidant	Comparative evaluation revealed that *P. niruri* (IC_{50} = 102 µg/mL) and *O. stamineus* (IC_{50} = 133 µg/mL) exhibited the highest antioxidant activity, followed by *C. domestica, S. burahol,* and *C. xanthorrhiza*, whereas *S. arvensis*, *A. graveolens*, and *C. asiatica* showed negligible effects. Consistent with phenolic and flavonoid contents, *O. stamineus* was identified as the most suitable bioreductant for green synthesis of silver nanoparticles intended for diabetic wound healing applications.	(Kartini et al., 2020)
In vitro	To determine the chemical profiles of essential oils from *S. arvensis* (aerial parts) and *E. spectabilis* (roots) via GC–MS and examine antibacterial activity of their methanol extracts against representative bacterial strains.	Iran	Leaves	Hydro-distillation	Essential oils	Antibacterial	Profiling of essential oils revealed 35 constituents in *S. arvensis*, accounting for 99.82% of the total composition, with n-octane (29.82%) and n-decane (11.09%) as the dominant components. Antibacterial evaluation indicated minimum inhibitory concentrations of 12.5–100 mg/mL and minimum bactericidal concentrations of 100 to >400 mg/mL, with *Staphylococcus aureus* showing the highest sensitivity (MIC 12.5 mg/mL; MBC 100 mg/mL). Overall activity patterns showed that both *S. arvensis* and *E. spectabilis* extracts inhibited Gram-positive and Gram-negative bacteria, with stronger effects against Gram-positive strains.	(Kanaani & Mohamadi, 2015)
In vitro	To evaluate traditional Indonesian medicinal plants for gout treatment based on their inhibitory potential activity against xanthine oxidase *in vitro*.	Indonesia	Leaves	Maceration method for extraction, employing 96% ethanol	NR	Enzyme inhibition	Screening results indicated that the stem ethanol extract of *S. rhombifolia* showed the strongest xanthine oxidase inhibition (IC_{50} = 21.43 µg/mL), followed by the leaf extract of *S. arvensis* (IC_{50} = 23.64 µg/mL). Other tested extracts also demonstrated inhibitory activity with variable IC_{50} values. Overall, these outcomes highlight *S. rhombifolia* and *S. arvensis* as promising natural candidates for the management of hyperuricemia and gout.	(Hendriani et al., 2016)

Table 1. Summary of included studies on *Sonchus arvensis* L.: Study type, objectives, and key outcomes (continued...)

Type of study	Study objectives	Country	Plant part used	Extraction solvent and method	Compound identified	Bioactivity	Outcomes of study	Reference
In vitro	To investigate the antibacterial and antifungal effects of *S. arvensis* L. plant part extracts on *Escherichia coli* and *Candida utilis*.	Indonesia	Leaves	NR/ NR	NR	Antimicrobial	Evaluation of methanolic extracts at concentrations of 10–100% revealed no inhibition zones against *Escherichia coli* or *Candida utilis.* This lack of antimicrobial activity suggests that the solvent choice or extraction duration was inadequate, indicating that methanol extraction under these conditions failed to isolate effective antibacterial or antifungal compounds from *S. arvensis*.	(Pasaribu et al., 2024)
In vitro	To assess the *in vitro* inhibitory activity of ethanol extract of *S. arvensis* leaves against angiotensin-converting enzyme involved in hypertension.	Indonesia	Leaves	Maceration method with ethanol 96% as solvent	NR	Anti-hypertensive	*In vitro* evaluation demonstrated that *the S. arvensis* leaf ethanol extract inhibited ACE activity with an IC_{50} of 46.71 µg/mL, whereas captopril exhibited a lower IC_{50} of 1.26 µg/mL. Although less potent than the reference drug, the extract exhibited measurable ACE inhibitory activity, supporting its potential as a natural antihypertensive candidate for further development.	(Suryani et al., 2017)
In vitro	To investigate the antibacterial activity of tetracycline combined with *Curcuma xanthorrhiza* or *S. arvensis* extracts against *Shigella flexneri* as potential anti-dysentery agents *in vitro* and *in vivo*.	Indonesia	Leaves	Reflux method with ethanol 96% as solvent	Flavonoid, phenolic, alkaloid, steroid, tannin, saponin	Antibacterial, anti-dysentery	Combination of tetracycline with *S. arvensis* or *C. xanthorrhiza* enhances antibacterial activity against *Shigella flexneri*, with MIC values of 4 mg/100 µL (tetracycline), 128 mg/100 µL (*C. xanthorrhiza*), and 512 mg/100 µL (*S. arvensis*). The interaction shows additive-to-synergistic effects, characterized by reductions in MIC and significant decreases in fecal bacterial counts after 7 days of oral administration *in vivo*. These results indicate that plant extract–tetracycline combinations improve anti-dysentery efficacy compared with tetracycline alone.	(Sukandar et al., 2016)

Table 1. Summary of included studies on *Sonchus arvensis* L.: Study type, objectives, and key outcomes (continued...)

Type of study	Study objectives	Country	Plant part used	Extraction solvent and method	Compound identified	Bioactivity	Outcomes of study	Reference
In vitro	To evaluate the protective activity of phenolic compounds from *S. arvensis* and *Hemerocallis citrina* in *Caenorhabditis elegans* under physiological and diet-induced stress conditions.	China	Leaves	NR/ NR	Phenolic	Anti-helminthic	Phenolic compounds from *S. arvensis* and *H. citrina* exhibit protective effects in *C. elegans* by enhancing lifespan, reproduction, and growth under sucrose- and stearic-acid stress. The mechanism is mediated by TGF-β signaling, with SKN-1–associated antioxidant activity specifically linked to *S. arvensis*. These results indicate that phenolic-driven pathways contribute to stress resistance.	(An et al., 2023)
In vitro	To examine the phytochemical composition and associated antioxidant and antibacterial activities of six wild *Sonchus* species in China, including *S. arvensis*.	China	Leaves	NR/ NR	Flavonoid, phenolic	Antioxidant and antibacterial	*S. arvensis* extract exhibits the highest phenolic content and strongest antioxidant activity, as evidenced by DPPH, $ABTS^{+}$, lipid peroxidation inhibition, and reducing power assays, while *S. oleraceus* shows the most potent antibacterial activity against both Gram-negative and Gram-positive bacteria. Evidence suggests that Sonchus species, particularly *S. arvensis* and *S. oleraceus*, are promising natural sources of antioxidants and antimicrobial agents.	(Xia et al., 2011)
In vitro	To investigate secondary metabolites from *Salacca zalacca*, *S. arvensis*, and *Carica papaya* as biolarvicidal agents targeting *Aedes aegypti* larvae.	Indonesia	Leaves	Macerated with 70% ethanol	Flavonoid, alkaloid, tannin, saponin	Larvicidal effect	*C. papaya* extract shows the highest larvicidal activity against *A. aegypti* larvae compared with *S. zalacca* and *S. arvensis*. At 24 h, larvicidal potency is indicated by LC_{50} and LC_{90} values of 2.62% and 5.49%, respectively. The activity is attributed to secondary metabolites present in the extract.	(Astuti et al., 2023)
In vitro	To evaluate the standardization of *Strobilanthes crispus* and *S. arvensis* leaf extracts for preclinical applications based on chemical, biochemical, and biological characterization.	Malaysia	Leaves	NR/ NR	Steroid	Antioxidant	*S. crispus* and *S. arvensis* leaf extracts exhibit inhibition of calcium oxalate crystal growth and antioxidant activity. Antioxidant effects are associated with phenolic content, with stronger activity observed in *S. arvensis*. Extract stability at room temperature and shelf-life assessment indicate greater stability for *S. arvensis* than *S. crispus*, alongside preliminary antiangiogenic activity in both species.	(Afrizal, 2008)

Table 1. Summary of included studies on *Sonchus arvensis* L.: Study type, objectives, and key outcomes (continued...)

Type of study	Study objectives	Country	Plant part used	Extraction solvent and method	Compound identified	Bioactivity	Outcomes of study	Reference
In vitro	To examine solvent-dependent differences in antioxidant activity, phenolic composition, and phytochemical profiles of *S. arvensis* root and leaf extracts.	India	Leaves	Ethyl acetate and n-hexane	Phenolic, alkaloid, tannin, terpenoid, glycoside	Antioxidant	Successive extraction of *S. arvensis* leaves yields the highest extract in petroleum ether (84.8%), followed by methanol (43.2%) and water (17.9%). Antioxidant activity is strongest in methanol extracts (IC_{50}: 0.501, 0.869, and 0.769 µg/mL) and petroleum ether extract (IC_{50}: 0.501 µg/mL). TLC profiling shows petroleum ether extracts provide the best compound separation using ethyl acetate–n-hexane as the mobile phase.	(Ghosal et al., 2023)
In vitro	To evaluate the capacity of *S. arvensis* leaf extract to inhibit xanthine oxidase for gout management.	Indonesia	Leaves	Ethanol, maceration	Flavonoid, steroid	Anti-gout, anti-inflammatory	Ethanolic leaf extract of *S. arvensis* exhibits significant *in vitro* xanthine oxidase inhibitory activity. The activity is mediated by enzyme inhibition, resulting in reduced uric acid production.	(Hendriani et al., 2014)
In vitro	To examine the antibacterial potential of 96% ethanol *S. arvensis* leaf extract against *Staphylococcus epidermidis* and *Pseudomonas aeruginosa* and identify metabolites associated with the activity.	Indonesia	Leaves	Ethanol, maceration and evaporation	Flavonoid, alkaloid, terpenoid, glycoside	Antibacterial	Ethanolic (96%) leaf extract of *S. arvensis* demonstrates significant concentration-dependent inhibitory activity against *S. epidermidis* and *P. aeruginosa*. Larger inhibition zones are observed with increasing extract concentrations.	(Taris, 2021)
In vitro	To examine the impact of different drying methods on the antioxidant activity of *S. arvensis* leaves.	Indonesia	Leaves	NR/ NR	Flavonoid	Antioxidant	Flavonoid-containing extracts obtained via water bath and combined water bath–oven (40 °C) drying exhibit antioxidant activity. IC_{50} values are 72.37 ± 37.78 µg/mL for water bath and 79.6 ± 8.39 µg/mL for the combined method, compared with 5.46 ± 7.87 µg/mL for vitamin C. ANOVA analysis ($p<0.05$) indicates no significant difference in antioxidant activity between the two drying approaches.	(Harun & Khairunissa, 2022)

NR: not reported.

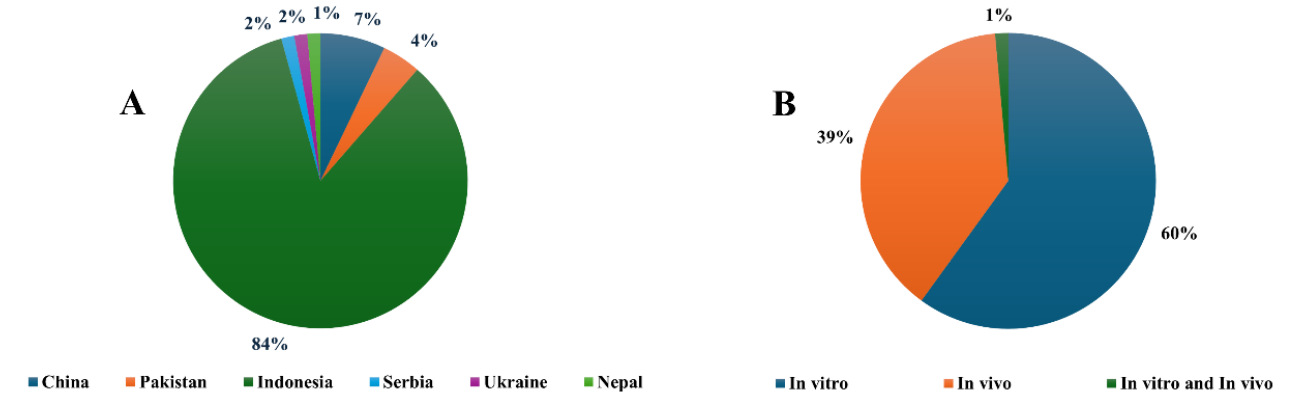


Figure 2. (A) Geographic origin of included studies on *S. arvensis* (2004–2024), **(B)** Distribution of study types (*in vitro*, *in vivo*, combined).



Figure 3. **(A)** Frequency of plant parts used in pharmacological studies of *S. arvensis*, **(B)** Common extraction techniques applied in *S. arvensis* research.

Plant part and extraction methods

Leaf extracts were most frequently studied (72%), followed by whole plants (17%), seeds (3%), roots (3%), and aerial parts (1%), as shown in Fig. 3A. Maceration was the predominant extraction method (49%), followed by reflux (12%), Soxhlet (4%), and hydrodistillation (1%) as shown in Fig. 3B. Ethanol, methanol, ethyl acetate, and water were the primary solvents used.

Phytochemical findings

Phytochemical analyses across the studies revealed that *S. arvensis* contains several major secondary metabolites, including flavonoids, alkaloids, terpenoids, saponins, and phenolic acids. Among these, flavonoids were predominantly represented by derivatives of luteolin, kaempferol, and apigenin (Fig. 4).

Pharmacological activities

Studies consistently reported significant antioxidant activity, with IC_{50} values ranging from 2.92 to 64.97 µg/mL, depending on the extract and assay. Anti-inflammatory activity was demonstrated through modulation of cytokine levels (e.g., TNF-α, IL-1β). Antidiabetic effects were reflected by lowered blood glucose levels and enhanced insulin sensitivity in streptozotocin-induced models. Antiplasmodial and antimicrobial effects were also confirmed in both *in vitro* and *in vivo* settings (Fig. 5).

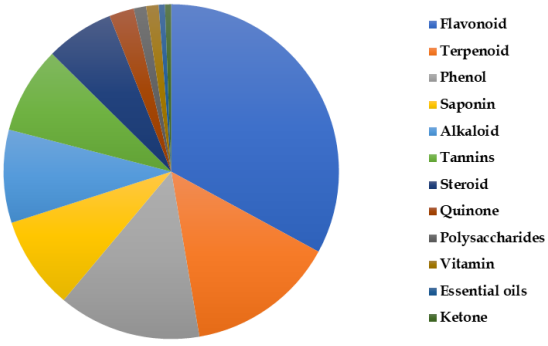


Figure 4. Distribution of phytochemical classes identified across reviewed studies.

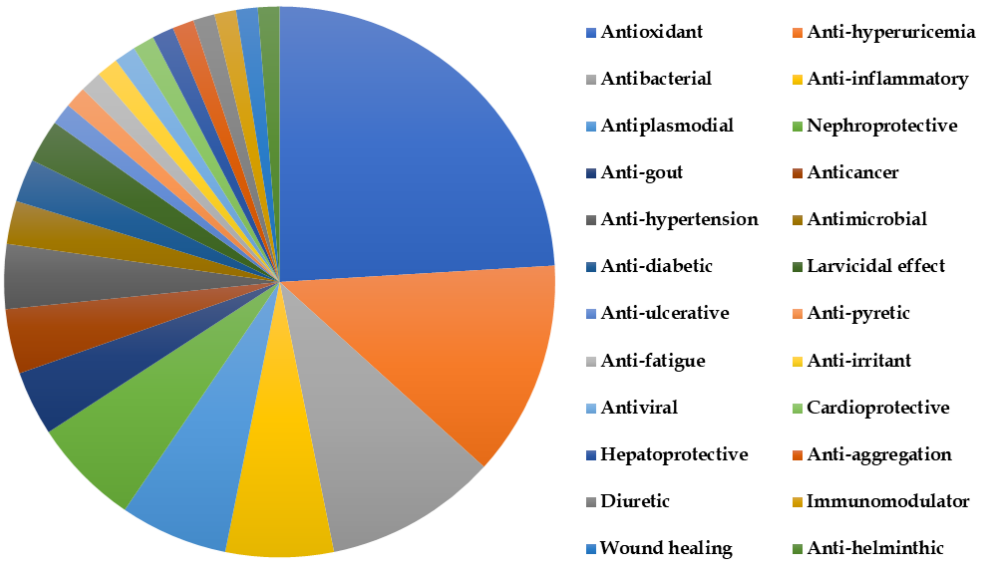


Figure 5. Prevalence of reported bioactivities across reviewed studies.

DISCUSSION

Most studies on *S. arvensis* were conducted in Indonesia, China, and Pakistan, reflecting strong regional interest in its medicinal uses. The majority of studies used an *in vitro* and *in vivo* approach, reflecting sustained and increasing scientific interest over the past two decades. The use of ethyl acetate and ethanol as extraction solvents yielded higher bioactivity, consistent with the solvent polarity influencing phytoconstituent solubility. Overall, the available evidence indicates the potential of *S. arvensis* as a promising candidate for drug development and integrative medicine. It is supported by its phytochemical profile, which is rich in flavonoids and phenolic compounds exhibiting antioxidant activity. Flavonoids emerged as the dominant phytocompound identified to exert antioxidant effects through free radical scavenging, inhibit oxidative enzymes, chelate metals, and modulate redox-related pathways (Bodewes et al., 2011; Vo et al., 2019).

Phytochemical composition

S. arvensis, a Eurasian native, contains various phytochemical compounds. Reports across studies show that flavonoids were the most frequently identified class in *S. arvensis*, including quercetin, kaempferol, luteolin, orientin, and luteolin-7-O-glucoside (Khan, 2012). Flavonoids have a 15-carbon core with a C6-C3-C6 configuration, consisting of two aromatic rings connected by a three-carbon bridge (Tandi et al., 2020). It can be found in most solvents used, including distilled water, alcohol (methanol or ethanol), ethyl acetate, and n-hexane, but not in chloroform. Detailed phytochemical analysis revealed that the ethanol extract of *S. arvensis* included flavonoids, alkaloids, terpenoids, saponins, and polyphenols. The ethyl acetate extract comprised flavonoids, alkaloids, terpenoids, and polyphenols, whereas the n-hexane extract comprised flavonoids, alkaloids, and terpenoids. Notably, polyphenols were predominantly present in the ethanol extract, whereas the ethyl acetate and n-hexane extracts were relatively rich in terpenoids (Wahyuni et al., 2023c).

Based on the reported studies, antioxidant activity was the most frequently evaluated bioactivity and was tested using the widest variety of solvents, including water, alcohol, ethyl acetate, and n-hexane. Among these, alcohol-based extracts were the most commonly used solvent. Similarly, anti-hyperuricemic effects were mostly investigated using alcohol extracts. Alcohol was also the most commonly used solvent in antibacterial studies, with n-hexane extracts also applied in a few cases. Antiplasmodial activity was examined using alcohol, ethyl acetate, and n-hexane extracts, while antiviral activity was reported only for n-hexane extracts. Cardioprotective effects were observed across all solvents except chloroform, which exhibited only anti-larvicidal activity.

Anti-inflammatory activities

Studies investigating *S. arvensis* in inflammation-related models consistently point to a shared mechanism that modulates immune responses and microbial balance. In the context of gastrointestinal inflammation, *S. arvensis* demonstrated the ability to attenuate dextran sulfate sodium–induced colitis through interaction with the gut microbiota, promoting beneficial bacterial populations and suppressing harmful strains (Ren et al., 2023). This observation aligns with the broader

understanding that reduced microbial diversity is associated with inflammatory pathologies, as reported by Walker et al. (2011). Histopathological evidence further supports this protective role, showing markedly improved tissue architecture in DSS-induced ulcerative conditions following *S. arvensis* administration (Khuluk et al., 2021). Taken together, these findings suggest that regulation of the gut–immune axis may represent a key mechanism underlying the anti-colitic potential of *S. arvensis*.

A similar immunomodulatory pattern is also evident in systemic and joint-related inflammatory conditions. Monosodium urate (MSU) exposure was shown to significantly increase TNF-α and IL-1β, which are also known as pro-inflammatory cytokines. However, treatment with *S. arvensis* extract effectively reduced the expression of these mediators, thereby mitigating crystal-induced inflammatory responses (Hidayat et al., 2020). This anti-gout arthritis activity is consistent with the modulation of inflammatory processes observed at the tissue level in synovial joints. In parallel, Wahyuni et al. (2023c) reported that *the S. arvensis* ethyl acetate extract could increase serum IL-10 levels, with the highest activity observed at a 200 mg/kg BW dose (119.64 ± 2.84 µg/mL), while also altering TNF-α levels. These changes collectively indicate a broader anti-inflammatory and immunoregulatory capacity that may underline other bioactivities observed in *P. berghei*-infected mice.

Antioxidant properties

Antioxidant potential of *S. arvensis* is strongly influenced by solvent polarity and total phenolic content. Higher phenolic concentrations consistently correlate with stronger free-radical-scavenging activity across different extraction methods. Among the fractions evaluated, the highest total phenolic content was observed in the methanolic extract (420 ± 6.9 mg GAE/g), followed by chloroform, ethyl acetate, and n-hexane (Khan et al., 2012). This pattern is consistent with the previously reported linear relationship between phenolic content and antioxidant capacity (Maisuthisakul et al., 2007).

Comparable trends are evident in radical scavenging assays, particularly when the activity of the *S. arvensis* extracts is benchmarked against the pure reference compound (ascorbic acid). Ascorbic acid was reported to have an IC_{50} value of 3.9 ± 0.7 µg/mL in the 2,2-diphenyl-1-picrylhydrazyl (DPPH) test (Khan et al., 2012). All *S. arvensis* extracts demonstrated measurable antioxidant activity, although the level of potency varied according to the solvent used. Strongest antioxidant activity was observed in ethyl acetate extract (8.27 ± 4.93 µg/mL), followed by ethanol (12.36 ± 10.40 µg/mL), methanol (31.35 ± 3.27 µg/mL), and n-hexane (108.59 ± 11.24 µg/mL) extracts (Wahyuni et al., 2023c). Notably, the IC_{50} values for the most potent extracts, ethyl acetate and ethanol, are in a range that shows comparable pharmacological significance to the pure ascorbic acid standard. Complementary *in vivo* findings revealed that *S. arvensis* extract has total phenolic content ranging from 60 to 270 mg GAE/g, with the ethanol extract exhibiting the strongest antioxidant effect (IC_{50} = 22 µg/mL) (Rafi et al., 2021). These observations further support the conclusion that phenolic groups are associated with antioxidant effect (Meenakshi et al., 2009).

These findings show that solvent selection has a great role in determining the antioxidant potency of *S. arvensis* extracts. Polar solvents, particularly methanol and ethanol, consistently yield extracts with superior radical-scavenging capacity, which supports the identification of *S. arvensis* as a promising raw material for antioxidant-based dietary supplement applications. Beyond its antioxidant properties, *S. arvensis* has also been traditionally used in garden-based medicinal practices as a diuretic (Delyan, 2016), underscoring its broader functional relevance.

Antimicrobial activities

Antimicrobial medication resistance poses a worldwide concern. Plants, however, constantly provide us with a variety of bioactive substances that can be utilized to create novel medications, such as antibiotics (Abu-Odeh et al., 2023). Studies have been conducted on the antibacterial properties of plant extracts and volatile oils from *S. arvensis*. An *in vitro* study was conducted to assess the antimicrobial effect of the *S. arvensis* ethyl acetate fraction. Findings showed that fraction IV (50%) exhibited very potent antimicrobial activity against *Staphylococcus aureus* (15.17 ± 1.04 mm) and *Escherichia coli* (19.22 ± 0.07 mm), with inhibition zones exceeding 8 mm (Wahyuni et al., 2023a). The antimicrobial efficacy of the *S. arvensis* extract is comparable to the commercial standard, chloramphenicol. Specifically, the inhibition zone diameter for the plant subfraction against *E. coli* is very close to that of chloramphenicol (20.43 ± 1.11 mm), and its activity against *S. aureus* is also strong and approaches that of the standard (20.67 ± 0.31 mm) (Wahyuni et al., 2023a). This close comparison suggests that the active compounds within the ethyl acetate sub-fraction of *S. arvensis* possess significant broad-spectrum antimicrobial potential. This calls for further research to identify the specific active phytoconstituents responsible for this potency and to investigate their potential as natural substitutes for synthetic antibiotics.

Additional research has assessed the antibacterial activity of sesquiterpene lactones isolated from *S. arvensis* against *Streptococcus mutans* ATCC 25175.

Selected compounds demonstrated strong antibacterial activity against S. mutans ATCC, with MIC values of 15.6 and 62.5 µg/mL, respectively. This result further revealed that the plant can biosynthesize sulphated sesquiterpene lactones, which may play an important role in plant defense mechanisms (Xia et al., 2010). However, compared with established clinical antimicrobials, these values show differences in potency. *In vitro* susceptibility testing of 424 clinical isolates of *S. mutans* showed that commonly used agents (chlorhexidine, amoxicillin, penicillin, and tetracycline) exhibited MICs of <4 µg/mL (Järvinen et al., 1993). Given that a lower MIC value indicates greater antibacterial potency, the standard clinical agents generally demonstrate superior activity compared to the most effective plant-derived sesquiterpene lactones tested (15.6 µg/mL). While the purified plant compounds are undeniably active and hold promise as natural antimicrobial leads, their current MIC values suggest that structural modification of the lead compounds may be necessary to match the high potency of existing, pure, clinically relevant antibiotics.

Antiplasmodial activities

The antiplasmodial activity of *S. arvensis* demonstrates consistent potency across different extract types, plant materials, and experimental models. *In vitro* evaluation using *Plasmodium falciparum* strain 3D7 revealed that both leaf extracts and callus-derived extracts exhibited inhibitory activity at pharmacologically relevant concentrations. The methanolic and ethanolic leaf extracts showed IC_{50} values of 17.78 and 27.09 µg/mL. In contrast, callus grown in the control medium (1 mg/L 2,4-D + 0.5 mg/L BAP) exhibited lower IC_{50} values of 12.47 µg/mL (methanolic extract) and >10 µg/mL (ethanolic extract). Meanwhile, callus treated with 150 mg/L dolomite exhibits even lower IC_{50} values of 5.037 µg/mL (methanolic extract) and 5.944 µg/mL (ethanolic extract) (Wahyuni et al., 2021). These IC_{50} values are within the threshold regarded as effective for antimalarial candidates (1-10 µg/mL) (Upadhyay et al., 2013), and extracts with IC_{50} values ranging from 0.008 to 15.38 µg/mL have previously been utilized as malaria drug components in China (Aryanti et al., 2006). Further evidence from combined *in vitro* and *in vivo* studies reinforces the strong antiplasmodial potential of *S. arvensis*. Ethyl acetate fraction showed the most potent *in vitro* antimalarial activity among all extracts tested (IC_{50} = 2.92 ± 3.27 µg/mL) (Wahyuni et al., 2023c). This potency was further supported by *in vivo* findings, in which parasitemia levels decreased in a clear dose-dependent manner. The lowest parasitemia inhibition percentage was observed at the 0 mg/kg BW dose (0%), and the highest inhibition percentage was observed at the 200 mg/kg BW dose (77.48 ± 2.93%). Collectively, these findings confirm that *S. arvensis* ethyl acetate is the most promising candidate for an antiplasmodial agent (Wahyuni et al., 2023c).

Antidiabetic activities

The antihyperglycemic activity of *S. arvensis* leaf extract has been demonstrated through consistent *in vivo* findings in diabetic animal models. A 14-day intervention showed significant differences in blood glucose levels between groups from day 7 through day 14. Significant differences were observed across all experimental groups, except the negative control, which received distilled water (Haryta et al., 2021). The administration of *S. arvensis* leaf extract reduces blood glucose levels, with the greatest effect observed at 150 mg/kg BW. This antihyperglycemic activity is attributable to the primary flavonoid compounds in the extract, which protect pancreatic β-cells from damage and enhance insulin sensitivity.

Additional *in vivo* evidence further supports the glucose-lowering potential of *S. arvensis* extracts. *S. arvensis* leaves ethanol extract significantly reduces blood glucose with a 300 mg/kg BW dose, demonstrating the highest efficacy relative to glibenclamide as a positive control (Tandi et al., 2020). Concurrently, all extract-treated groups showed lower tubular injury scores, indicating a potential restorative effect on renal tubular cells. The greatest improvement was observed at the 300 mg/kg BW dose, with an average damage score of 0.28, highlighting its potential nephroprotective effects alongside its antihyperglycemic effects.

Anticancer properties

Recent studies have further examined the anticancer potential of *S. arvensis*. A recent study of endometrial carcinoma cells reported that steroidal compounds isolated from *S. arvensis* induced marked morphological changes, including cell shrinkage, reduced cell size, and decreased adhesion, suggesting cytotoxic activity (Xia et al., 2020). These morphological changes are consistent with apoptosis-related cellular responses, suggesting that *S. arvensis* may interfere with tumor cell survival mechanisms. Another research on WiDr colon cancer cells reported that the ethanolic fraction of *S. arvensis* exhibited very low anticancer activity with a high IC_{50} value (2865.5 µg/mL) (Rohima et al., 2011). This IC_{50} value is dramatically higher than that of the cytotoxic standard drug, doxorubicin (3.49 µg/mL) (Fathani & Miladiyah, 2021). This disparity immediately establishes that the fraction's current potency does not meet the high-activity criteria ($IC_{50} \leq 20$ µg/mL) set by the U.S. National Cancer Institute, which classifies doxorubicin's activity as high (Fathani & Miladiyah, 2021). This low potency suggests that the active cytotoxic compounds in the ethanolic fraction

are present at very low concentrations. In addition, more recent phytochemical investigations identified chlorogenic and chicoric acids as major constituents of *S. arvensis*. Both compounds are known for their anticancer potential, although their activities were not specifically assessed in that study, leaving an important gap for future exploration (Azizyan & Mandoulakani, 2024). These metabolites are widely recognized for their antioxidant and antiproliferative effects, highlighting the need for dedicated assays to confirm their therapeutic value against cancer.

Other medicinal properties

Investigations into *S. arvensis* have unveiled a wide array of pharmacological activities that extend well beyond its established antioxidant and anti-inflammatory roles. For instance, studies have documented its hepatoprotective function, in which extracts have been shown to mitigate liver damage induced by toxins such as carbon tetrachloride (Alkreathy et al., 2014). Similarly, its nephroprotective potential was observed in models of gentamicin-induced renal injury, suggesting a shielding effect on kidney tissues (Imelda et al., 2018). Beyond protection, *S. arvensis* appears to contribute to tissue regeneration and homeostasis. In preclinical models of ulcerative colitis, its administration was associated with amelioration of pathological changes, an effect attributed to its capacity to modulate gut microbiota diversity (Ren et al., 2023). Another study highlighted its role in bone repair, in which extracts were found to increase the osteoblast population in post-extraction dental sockets, thereby facilitating healing (Rahmaniar, 2018). The plant's influence extends to the cardiovascular system. Its antihypertensive properties have been investigated, with evidence suggesting a mechanism involving beta-receptor blockade, which could reduce cardiac output (Suryani et al., 2020). Furthermore, its extracts have been shown to inhibit platelet aggregation, a finding relevant for thrombosis prevention (Ningsih et al., 2017), and to produce a diuretic effect (Rustam et al., 2006). At a cellular and systemic level, the scope of its bioactivity is equally broad. Preliminary research has indicated cytotoxic activity against specific cancer cell lines, including endometrial and colon cancer (Rohima et al., 2011; Xia et al., 2020). Another study also documented immunomodulatory activity via enhancement of leukocyte counts and IL-2 levels (Sukmayadi et al., 2014), anti-fatigue properties that improve physical endurance (Yuan et al., 2019), antipyretic (fever-reducing) effects (Mbaubedari et al., 2020), and anti-rheumatic potential relevant to gout management (Parisa et al., 2021). Finally, specific compounds have been assessed for their anti-irritant properties (Asif & Saeed, 2020). This evidence provides a scientific basis for its diverse applications in traditional medicine and highlights specific avenues for future clinical investigation into its complex phytochemical profile.

Limitation

The findings of this review provided a representative overview of *S. arvensis*, with 94 studies included. However, several limitations of the evidence base should be noted. The databases searched were restricted to three, excluding broader platforms such as Web of Science or ProQuest, while access to institutional, governmental, and industrial repositories was limited. Another notable limitation of this review is the heavy reliance on Indonesian and local studies, with approximately 84% of the included articles originating from Indonesia. This regional focus may constrain the generalizability of the findings towards the global population. Future studies should consider incorporating a wider range of global data to provide a more comprehensive and internationally representative perspective on *S. arvensis*. In addition, the scarcity of preclinical animal studies and the near absence of human trials constrain the generalizability of reported pharmacological activities. Furthermore, variability in extraction techniques, dosage, and outcome measures hampers direct comparison across studies. Mechanistic studies, clinical trials, and standardization of extraction protocols are necessary to translate these findings into clinical applications.

CONCLUSION

This review provides a comprehensive summary of the phytochemical profile and pharmacological activities of *Sonchus arvensis* L. over the past two decades. The findings highlight its potential as an antioxidant, anti-inflammatory, antiplasmodial, antidiabetic, and antimicrobial effects in preclinical models, largely attributed to its high flavonoid and polyphenol content. However, most available evidence was primarily preclinical, highlighting the necessity for comprehensive pharmacological, toxicological, and clinical investigations to confirm these effects. Further research in this area may support the development of novel therapeutic agents derived from this medicinal plant.

CONFLICT OF INTEREST

The research was conducted entirely free from any involvement in commercial, financial, or personal matters that might be perceived as a possible conflict of interest or that could have influenced the outcomes or interpretation of the study.

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GENERATIVE ARTIFICIAL INTELLIGENCE (AI)

The authors used ChatGPT (OpenAI) to improve the language and readability of the manuscript. The authors reviewed and edited the content and take full responsibility for its accuracy. No images were generated or manipulated using AI tools.

REFERENCES

Abu-Odeh A, Fino L, Al-Absi G, Alnatour D, Al-Darraji M, Shehadeh M, Suaifan G (2023) Medicinal plants of Jordan: Scoping review. Heliyon 9(6): e17081. https://doi.org/10.1016/j.heliyon.2023.e17081

Afrizal (2008) Analytical, bioactivity and stability studies on *Strobilanthes crispus* L. Bremek and *Sonchus arvensis* L. extracts. Ph.D. Thesis, Universiti Sains Malaysia, Penang, Malaysia.

Alkreathy HM, Khan RA, Khan MR, Sahreen S (2014) CCl_4 induced genotoxicity and DNA oxidative damages in rats: hepatoprotective effect of *Sonchus arvensis*. BMC Complement Altern Med 14: 452. https://doi.org/10.1186/1472-6882-14-452

Amal S, Gunarti NS, Lullael K, Soebakti KP, Mahdalena DG, Fadhillah NN, Hidayah H (2021) Uji aktivitas antihiperurisemia ekstrak etanol beberapa tumbuhan famili Asteraceae. Majalah Farmasetika 6(1): 32–41. https://doi.org/10.24198/mfarmasetika.v6i0

Amal S, Gunarti NS, Saragih DS, Hidayah H (2022) Uji toksisitas akut ekstrak etanol daun tempuyung (*Sonchus arvensis* L.) pada mencit betina dengan metode fixed dose. J Pharmacopolinum 5(2): 190–198.

An Q, Zhang L, Qin X, Wang X, Wang W, Meng Q, Zhang Y (2023) Phenolic compounds from *Sonchus arvensis* Linn. and *Hemerocallis citrina* Baroni. inhibit sucrose and stearic acid induced damage in *Caenorhabditis elegans*. Molecules 28(4): 1707. https://doi.org/10.3390/molecules28041707

Arksey H, O'Malley L (2005) Scoping studies: towards a methodological framework. Int J Soc Res Methodol 8(1): 19–32. https://doi.org/10.1080/1364557032000119616

Aryanti TME, Kartika IP, Rita MD (2006) Uji daya antimalarial *Artemisia* spp. terhadap *Plasmodium falciparum*. Majsl Farm Indones 17(2): 81–84.

Asif A, Saeed MA (2020) Exploring irritant activity of some of the phytochemical components from wild *Sonchus arvensis* (L.) ssp arvensis (DC) kirp herb. Acta Pharm Sci 58(3): 305–319. http://dx.doi.org/10.23893/1307-2080.APS.05817

Astuti RRUNW, Illahi AN, Umri WNS, Falah AA (2023) Potency of secondary metabolites from *Salacca zalacca*, *Sonchus arvensis*, and *Carica papaya* against *Aedes aegypti* L. J Penelit Pendidik IPA 9(7): 4931–4937. https://doi.org/10.29303/jppipa.v9i7.4129

Azifa AN, Kusrini D, Fachriyah E (2014) Identifikasi senyawa sitotoksik dalam ekstrak kloroform daun tempuyung (*Sonchus arvensis* L.) menggunakan GC-MS. J Kim Sains Apl 17(1): 23–26. https://doi.org/10.14710/jksa.17.1.23-26

Azizyan R, Mandoulakani BA (2024) Partial coding sequence identification, gene expression analysis, and content of anticancer phenolic compounds in *Sonchus arvensis* L. under drought stress conditions. Ind Crops Prod 209: 118030. https://doi.org/10.1016/j.indcrop.2024.118030

Bodewes TCF, Luttikhold J, van Stijn MFM, Visser M, van Norren K, Vermeulen MAR, van Leeuwen PAM (2011) Antioxidative properties of flavonoids. Currt Org Chem 15(15): 2616–2626. https://doi.org/10.2174/138527211796367282

Brajawikalpa RS, Basyir PBS, Nirmala N (2018) Uji efektifitas ekstrak daun tempuyung (*Sonchus arvensis* L.) untuk menurunkan kadar asam urat pada tikus putih Wistar jantan yang dibuat hiperurisemia. J Kedokt Kesehat 4(2): 97–100. https://doi.org/10.33603/tumed.v4i2.1714

Delyan E (2016) Analysis of component composition of volatile compounds of field sow thistle (*Sonchus arvensis* L.) leaves using the method of gas chromatography with mass-detection. Pharma Innov J 5(10): 118–121.

Ediningsih, Nurhayati H, Rubiana R (2016) Uji aktivitas antioksidan ekstrak daun tempuyung (*Sonchus arvensis* L.). Proceeding of Seminar Nasional 2016: Membangun Pertanian Modern Dan Inovatif Berkelanjutan Dalam Rangka Mendukung MEA, pp. 1468–1474.

Fathani IJ, Miladiyah I (2021) Cytotoxicity of ethanolic extract of fruit shells and seeds of Nyamplung (*Calophyllum inophyllum* L.) on WiDr colorectal cancer cells. J Kedokt Kesehat Indones 12(2): 166–174. https://doi.org/10.20885/JKKI.Vol12.Iss2.art10

Fauziah S, Melati P, Mulyati AH, Rafi M, Rohaeti E (2023) Thin layer chromatography fingerprint analysis of tempuyung (*Sonchus arvensis* L.). J Kim Sains Apl 26(5): 187–193. https://doi.org/10.14710/jksa.26.5.187-193

Ghosal P, Chandra S, Choudhary A, Saklani S (2023) *Sonchus arvensis*: Antioxidant activity, phenolic profile, and phytochemical screening. Kariri Sci 1(1): 8. https://doi.org/10.29327/2256856.2023.1-8

Hapsari AM, Masrifa, Dalimunthe A (2018) Total phenol content determination in tempuyung (*Shoncus arvensis* L.) ethanol extract. TALENTA Conf Ser Trop Med 1: 284–290. https://doi.org/10.32734/tm.v1i1.75

Harahap NI (2020) Skrining dan karakterisasi simplisia daun tempuyung (*Sonchus arvensis* L.) Imelda Pekerja Indonesia. Jurnal Ilmiah Farmasi Imelda 3(2): 42–47. https://doi.org/10.52943/jifarmasi.v3i2.212

Harun N, Indriastuti M, Fatimah A, Ega D, Safitri YE, Rosmayanti M (2019) Effect of ethanol extract *Sonchus arvensis* Linn leaf on BUN, SCr, ALT, AST in healthy male albino mice (*Rattus norvegicus*). J Phys Conf Ser 1179(1): 012188. https://doi.org/10.1088/1742-6596/1179/1/012188

Harun N, Khairunissa M (2022) Antioxidant potential of tempuyung (*Shoncus arvensis* L.) leaf extract in two drying methods. Jurkes 9(2): 38–44. https://doi.org/10.52221/jurkes.v9i2.125

Haryta FS, Listyawati S, Pangastuti A (2021) The effect of perennial sow-thistle (*Sonchus arvensis*) leaf extract on blood glucose and plasma insulin levels of diabetic mice. Cell Biol Dev 5(2): 63–69. https://doi.org/10.13057/cellbioldev/v050202

Hendriani R, Nursamsiar, Tjitraresmi A (2017) *In vitro* and *in silico* evaluation of xanthine oxidase inhibitory activity of quercetin contained in *Sonchus arvensis* leaf extract. Asian J Pharm Clin Res 10(14): 50–53. https://doi.org/10.22159/ajpcr.2017.v10s2.19486

Hendriani R, Sukandar EY, Anggadiredja K, Sukrasno (2016) *In vitro* evaluation of xanthine oxidase inhibitory activity of selected medicinal plants. Int J Pharm Clin Res 8(4): 235–238.

Hendriani R, Sukandar EY, Kusnandaranggadiredja, Sukrasno (2014) *In vitro* evaluation of xanthine oxidase inhibitory activity of *Sonchus arvensis* leaves. Int J Pharm Pharm Sci 6(2): 501–503.

Hidayat R, Reagan M, Hayati L (2020) Tempuyung leaves (*Sonchus arvensis*) ameliorates monosodium urate crystal-induced gouty arthritis in rats through anti-inflammatory effects. Open Access Maced J Med Sci 8(A): 220–224. https://doi.org/10.3889/oamjms.2020.3801

Hong QN, Fàbregues S, Bartlett G, Boardman F, Cargo M, Dagenais P, Gagnon MP, Griffiths F, Nicolau B, O'Cathain A (2018) The Mixed Methods Appraisal Tool (MMAT) version 2018 for

information professionals and researchers. Educ Inf 34(4): 285–291. https://doi.org/10.3233/EFI-180221

Imelda I, Azaria C, Lucretia T (2017) Protective effect of ethanol extract of *Sonchus arvensis* leaf (tempuyung) against gentamicin-induced renal injury based on blood urea levels. J Med Health 1(6): 575–582. https://doi.org/10.28932/jmh.v1i6.555

Imelda, Achadiyani, Sekarwana N (2018) Protective effect of ethanolic extract *Sonchus arvensis* L. in gentamicin-induced acute tubular necrosis on Wistar rats. Indones J Pharm 29(2): 86–93. http://dx.doi.org/10.14499/indonesianjpharm29iss2pp86

Istikharah R (2015) Aktivitas antioksidan ekstrak etanol daun *Sonchus arvensis* L. J Ilmiah Farm 11(2): 30–65.

Itam A, Majid AMSA, Ismail Z (2013) Kestabilan ekstrak metanol daun *Sonchus arvensis* pada penyimpanan. Prosiding Semirata FMIPA Universitas Lampung 2013, pp. 11–16.

Järvinen H, Tenovuo J, Huovinen P (1993) *In vitro* susceptibility of *Streptococcus mutans* to chlorhexidine and six other antimicrobial agents. Antimicrob Agents Chemother 37(5): 1158–1159. https://doi.org/10.1128/AAC.37.5.1158

Kanaani S, Mohamadi SA (2015) Chemical composition of essential oils and *in vitro* antibacterial activity of methanolic extract of *Sonchus arvensis* and *Eremurus spectabilis* against food-borne pathogenic bacteria. J Essent Oil Bear Plants 18(5): 1093–1099. https://doi.org/10.1080/0972060X.2014.989185

Kartini K, Setiawan F, Sukweenadhi J, Yunita O, Avanti C (2020) Selection of potential Indonesian plant species for antioxidant. IOP Conf Ser Earth Environ Sci 457(1): 012040. https://doi.org/10.1088/1755-1315/457/1/012040

Katno, Widiyastuti Y (2004) Analisis kualitatif kandungan kimia kalus *Sonchus arvensis* L. hasil pertumbuhan secara kultur jaringan. Media Litbangkes XIV(1): 37–40. https://doi.org/10.22435/mpk.v14i1%20Mar.1101

Khan RA (2012) Evaluation of flavonoids and diverse antioxidant activities of *Sonchus arvensis*. Chem Central J 6: 126. https://doi.org/10.1186/1752-153X-6-126

Khuluk RH, Yunita A, Rohaeti E, Syafitri UD, Linda R, Lim LW, Takeuchi T, Rafi M (2021) An HPLC-DAD method to quantify flavonoids in *Sonchus arvensis* and able to classify the plant parts and their geographical area through principal component analysis. Separations 8(2): 12. https://doi.org/10.3390/separations8020012

Kurniati NF, Sukandar EY, Pardilah R, Suliska N, Ayuningtyas DK (2018) Cardioprotective potential of ethanol extract of *Sonchus arvensis* L. leaves on isoproterenol-induced myocardial infarction in rat. J Ilmu Kefarmasian Indones 16(1): 20–24. https://doi.org/10.35814/jifi.v16i1.434

Lailli NF, Savitri L (2021) Potensi daun tempuyung (*Sonchus arvensis* L.) sebagai antihiperurisemia pada mencit putih jantan. J Ilm Univ Batanghari Jambi 21(2): 609–611. http://dx.doi.org/10.33087/jiubj.v21i2.1434

Laksono J (2020) Ekstraksi senyawa antioksidan daun tempuyung (*Sonchus arvensis* L.) dengan menggunakan metode ultrasound-assisted extraction, Thesis, Universitas Pertamina, Indonesia.

Liu Y, Feng Z, Hu Y, Xu X, Kuang T, Liu Y (2024) Polysaccharides derived from natural edible and medicinal sources as agents targeting exercise-induced fatigue: A review. Int J Biol Macromol 256: 128280. https://doi.org/10.1016/j.ijbiomac.2023.128280

Maisuthisakul P, Suttajit M, Pongsawatmanit R (2007) Assessment of phenolic content and free radical-scavenging capacity of some Thai indigenous plants. Food Chem 100(4): 1409–1418. https://doi.org/10.1016/j.foodchem.2005.11.032

Manoi F (2017) Pengaruh kehalusan bahan dan lama ekstraksi terhadap mutu ekstrak tempuyung (*Sonchus arvensis* L.). J Penelit Pertan Terap 15(2): 156–161. https://doi.org/10.25181/jppt.v15i2.123

Mbaubedari AH, Mongie J, Sambou CN, Palandi RR (2020) Uji efektivitas infusa daun tempuyung (*Sonchus arvensis* L.) sebagai antipiretik pada tikus putih jantan (*Rattus norvegicus*). J Biofarm Trop 3(2): 34–39. https://doi.org/10.55724/j.biofar.trop.v3i2.282

Meenakshi S, Gnanambigai DM, Mozhi ST, Arumugam M, Balasubramanian T (2009) Total flavonoid and *in vitro* antioxidant activity of two seaweeds of Rameshwaram coast. Glob J Pharmacol 3(2): 59–62.

Mohammed MS, Osman WJA, Garelnabi EAE, Osman Z, Osman B, Khalid HS, Mohamed MA (2014) Secondary metabolites as anti-inflammatory agents. J Phytopharmacol 3(4): 275–285.

Mukaromah AH, Anggraini YH (2009) Pengaruh frekuensi penggunaan teh daun tempuyung kering (*Sonchus arvensis*) terhadap daya larut kalsium oksalat (CaC_2O_4). J Kesehat 2(2): 30–37.

Mulisa E, Asres K, Engidawork E (2015) Evaluation of wound healing and anti-inflammatory activity of the rhizomes of *Rumex abyssinicus* J. (Polygonaceae) in mice. BMC Complement Altern Med 15: 341. https://doi.org/10.1186/s12906-015-0878-y

Nigussie D, Makonnen E, Tufa TB, Brewster M, Legesse BA, Fekadu A, Davey G (2021) Systematic review of Ethiopian medicinal plants used for their anti-inflammatory and wound healing activities. J Ethnopharmacol 276: 114179. https://doi.org/10.1016/j.jep.2021.114179

Ningsih DSL, Mulqie L, Hazar S (2017) Uji aktivitas antiagregasi platelet ekstrak etanol daun tempuyung (*Sonchus arvensis* L.) pada mencit Swiss Webster jantan. Pros Farm 3(2): 329–336.

Parisa N, Hidayat R, Fatmawati F (2024) Extract ethanol of tempuyung (*Sonchus arvensis*) leaves as anti-hyperuricemia: *In vitro* studies. Med Lab Technol J 10(1): 63–72. https://doi.org/10.31964/mltj.v10i1.594

Parisa N, Hidayat R, Maritska Z, Prananjaya BA (2021) Evaluation of the anti-gout effect of *Sonchus arvensis* on monosodium urate crystal-induced gout arthritis via anti-inflammatory action-an *in vivo* study. Med Pharm Rep 94(3): 358. https://doi.org/10.15386/mpr-1959

Pasaribu T, Altandjung RI, Kostaman T, Tresia GE, Purba M (2024) The influence of *Sonchus arvensis* extract against *Escherichia coli* and *Candida utilis*. AIP Conf Proc 2857: 090037. https://doi.org/10.1063/5.0184019

Poudel BK, Sah JP, Subedi SR, Amatya MP, Amatya S, Shrestha TM (2015) Pharmacological studies of methanolic extracts of *Sonchus arvensis* from Kathmandu. J Pharmacogn Phytochem 7(11): 263-267. https://doi.org/10.5897/JPP2015.0359

Putra BR, Kusrini D, Fachriyah E (2013) Isolasi senyawa antioksidan dari fraksi etil asetat daun tempuyung (*Sonchus arvensis* L.). J Kim Sains Apl 16(3): 69–72. https://doi.org/10.14710/jksa.16.3.69-72

Putri DP, Widyastuti Y, Dewi WS, Yunus A (2018) The effect of shade and vermicompost application on yield and flavonoid levels of Tempuyung (*Sonchus arvensis*). IOP Conf Ser Earth Environ Sci 142(1): 12055. https://doi.org/10.1088/1755-1315/142/1/012055

Radulović N, Blagojević P, Palić R (2009) Fatty acid derived compounds–the dominant volatile class of the essential oil poor *Sonchus arvensis* subsp. uliginosus (Bieb.) Nyman. Nat Prod Commun 4(3): 405–410.

Rafi M, Hasanah T, Karomah AH, Mulyati AH, Trivadila, Rahminiwati M, Achmadi SS, Iswantini D (2022a) FTIR- and UHPLC-Q-Orbitrap HRMS-based metabolomics of *Sonchus arvensis* extracts and evaluation of their free radical scavenging

activity. Sains Malays 51(10): 3261–3269. http://dx.doi.org/10.17576/jsm-2022-5110-12

Rafi M, Rismayani W, Sugiarti RM, Syafitri UD, Wahyuni WT, Rohaeti E (2021) FTIR-based fingerprinting combined with chemometrics for discrimination of *Sonchus arvensis* leaves extracts of various extracting solvents and the correlation with its antioxidant activity. Indones J Pharm 32(2): 132–140. https://doi.org/10.22146/ijp.755

Rafi M, Suwartiny NL Rohaeti E (2022b) Traditional use, phytochemical composition, and biological activities of *Sonchus arvensis*. Indones J Pharm 33(4): 540–553. https://doi.org/10.22146/ijp.3823

Rahmaniar AA (2018) Pengaruh ekstrak daun tempuyung (*Sonchus arvensis* L.) terhadap jumlah osteoblas pada penyembuhan soket pasca pencabutan gigi tikus putih (*Rattus norvegicus*). Thesis, Brawijaya University, Indonesia.

Raisawati T, Melati M, Aziz SA, Rafi M (2020) Total flavonoid content and antioxidant activity in leaves of ten cultivated *Sonchus arvensis* L. accessions. Plant Arch 20(1): 1785–1792. https://www.plantarchives.org/20-1/1785-1792%20(5984).pdf [Consulted 21 March, 2026].

Raisawati T, Melati M, Aziz SA, Rafi M (2023) Harvest methods determine the yield and quality of *Sonchus arvensis* accessions cultivated in organic way. Biodiversitas 24(7): 4110–4119. https://doi.org/10.13057/biodiv/d240749

Ramadhani RA, Kusrini D, Fachriyah E (2013) Isolasi, identifikasi dan uji antioksidan senyawa flavonoid dari ekstrak etil asetat daun tempuyung (*Sonchus arvensis* L.). Chem Info 1(1): 247–255.

Ren Y, Hou S, Sui Y, Chang N, Zhou Y, Sun C (2023) *Sonchus arvensis* L. water extract attenuates dextran sulfate sodium-induced colitis by adjusting gut microbiota. Heliyon 9(3). https://doi.org/10.1016/j.heliyon.2023.e14168

Retnowati K, Sutrisna E, Mahmuda INN (2014) Efek infusa akar tempuyung (*Sonchus arvensis*) terhadap penurunan kadar asam urat pada tikus putih (*Rattus norvegicus*). Biomedika 6(2): 1–4. https://doi.org/10.23917/biomedika.v6i2.274

Rohima BN, Astuti I, Ghufron M (2011) Efikasi fraksi etanolik akar tempuyung (*Sonchus arvensis* L.) sebagai kemoterapi kanker kolon berdasarkan ekspresi caspase-9. Mutiara Med 11(1): 55–61. https://doi.org/10.18196/mmjkk.v11i1.931

Rosandi MJ, Oktavia A (2018) Pengaruh variasi jenis pelarut terhadap kualitas ekstrak daun tempuyung (*Sonchus arvensis* L.) dengan metode maserasi. Thesis, Akademi Farmasi Putera Indonesia Malang, Indonesia.

Ruiz-Rocamora A, Obón C, Ríos S, Alcaraz F, Rivera D (2025) Sonchus species of the Mediterranean Region: From wild food to horticultural innovation—Exploring taxonomy, cultivation, and health benefits. Horticulturae 11(8): 893. https://doi.org/10.3390/horticulturae11080893

Rustam E, Imelda F, Andani EP (2006) Perbadingan efek diuretika serta kadar natrium dan kalium darah antara pemberian ekstrak etanol daun tempuyung (*Sonchus arvensis* Linn) dengan furosemida. J Sains Teknol Farm 11(2): 76–80.

Safrina D, Susanti D, Dewi TF, Dita M (2020) Kadar flavonoid total simplisia tempuyung (*Sonchus arvensis* L.) dengan metode pengeringan kombinasi di dataran tinggi. Proceeding of Seminar Nasional Dalam Rangka Dies Natalis Ke-44 UNS Tahun 2020 "Strategi Ketahanan Pangan Masa New Normal Covid-19", pp. 95–102.

Sari EP (2020) Penetapan parameter dan penetapan kadar flavonoid total pada ekstrak daun tempuyung (*Sonchus arvensis* L.). J Ilm Farm Imelda 3(2): 48–51. https://doi.org/10.52943/jifarmasi.v3i2.213

Seal T (2016) Quantitative HPLC analysis of phenolic acids, flavonoids and ascorbic acid in four different solvent extracts of two wild edible leaves, *Sonchus arvensis* and *Oenanthe linearis* of North-Eastern region in India. J Appl Pharm Sci 6(2): 157–166. https://dx.doi.org/10.7324/JAPS.2016.60225

Sudewi NKY (2015) Potensi antioksidan dan uji organoleptik loloh daun tempuyung (*Sonchus arvensis* L.). J Virgin 1(2): 142–153.

Sukadana IM, Santi SR (2011) Antibacterial compounds present on n-hexane extract of tempuyung leaves (*Sonchus arvensis* L.). Maj Obat Tradis 16(1): 1–6.

Sukandar EY, Kurniati NF, Purnama AB (2016) Anti-dysentery activity of tetracycline in combination with *Curcuma xanthorrhiza* Roxb. or *Sonchus arvensis* L. Asian J Pharm Clin Res 9(6): 176–178. https://doi.org/10.22159/ajpcr.2016.v9i6.14033

Sukmayadi A E, Sumuwi SA, Barliana MI, Aryanti AD (2014) The immunomodulatory activity of ethanol extract of tempuyung leaves (*Sonchus arvensis* Linn.). Indones J Pharm Sci Technol 1(2): 65–72. https://doi.org/10.15416/ijpst.v1i2.7515

Sukweenadhi J, Yunita O, Setiawan F, Kartini K, Siagian MT, Danduru AP, Avanti C (2020) Antioxidant activity screening of seven Indonesian herbal extract. Biodiversitas 21(5): 2062–2067. https://doi.org/10.13057/biodiv/d210532

Suliska N, Kurniati N, Sukandar EY (2021c) *Anredera cordifolia* (Ten.) Steenis and *Sonchus arvensis* L. inhibit gentamicin-induced nephrotoxicity: The role of urinary N-acetyl beta-D-glucosaminidase. J Rep Pharm Sci 10(2): 256–260. https://doi.org/10.4103/jrptps.JRPTPS_6_21

Suliska N, Praviska M, Kurniati NF, Sukandar EY (2021a) Nephroprotective effect of ethanol extract of *Sonchus arvensis* L. leaves in gentamicin-piroxicam induced rat renal failure. J Res Pharm 25(4): 441–449. https://doi.org/10.29228/jrp.35

Suliska N, Suryani, Insanu M, Sukandar EY (2021b) Antihypertensive activity of combination of *Anredera cordifolia* (Ten.) V. Steenis and *Sonchus arvensis* L. leaves on epinephrine induced male Wistar rat. J Adv Pharm Technol Res 12(4): 384–388. https://doi.org/10.4103/japtr.japtr_91_21

Suryani, Sukandar EY, Insanu M, Kurniati NF (2020) Evaluation effect of polarity of the compound from *Sonchus arvensis* (Linn.) leaves as hypertention inhibition. Rasayan J Chem 13(03): 1807–1816. https://doi.org/10.31788/RJC.2020.1335843

Suryani, Sukandar EY, Sutjiatmo AB, Vikasari SNAR (2017) Angiotensin converting enzyme inhibitor activity of ethanol extract of *Sonchus arvensis* (Linn.) leaves. ACM International Conference Proceeding Series Part F130950: 124–128. https://doi.org/10.1145/3121138.3121195

Syarifuddin K, Yusriyani (2021) Isolasi dan identifikasi senyawa flavonoid ekstrak n-butanol daun tempuyung (*Sonchus arvensis* L.) secara spektrofotometri infra merah. Fito Med J Pharm Sci 12(2): 95–102.

Syarifuddin K, Yusriyani, Dewi A (2022) Analisis kadar flavonoid total ekstrak etanol tempuyung (*Sonchus arvensis*) dengan menggunakan metode spektrofotometri UV-Vis. Fito Med J Pharm Sci 12(2): 69–76.

Tandi J, Sutrisna INE, Pratiwi M, Handayani TW (2020) Potential test of nephropathy *Sonchus arvensis* L. leaves on male rats (*Rattus norvegicus*) diabetes mellitus. Pharmacogn J 12(5): 1115–1120. https://doi.org/10.5530/pj.2020.12.158

Taris AFKJ (2021) Prediksi senyawa aktif antibakteri dari ekstrak etanol 96% daun tempuyung (*Sonchus arvensis* L.) terhadap *Staphylococcus epidermidis* dan *Pseudomonas aeruginosa* secara *in vitro*. Thesis, Universitas Islam Negeri Malang, Indonesia.

Tricco AC, Lillie E, Zarin W, O'Brien KK, Colquhoun H, Levac D, Moher D, Peters MDJ, Horsley T, Weeks L, Hempel S, Akl EA, Chang C, McGowan J, Stewart L, Hartling L, Aldcroft A, Wilson MG, Garritty C, Lewin S, Godfrey CM, Macdonald MT, Langlois EV, Soares-Weiser K, Moriarty J, Clifford T, Tunçalp Ö, Straus SE (2018) PRISMA extension for scoping reviews (PRISMA-ScR): Checklist and explanation. Ann Intern Med 169(7): 467–473. https://doi.org/10.7326/M18-0850

Upadhyay HC, Sisodia BS, Cheema HS, Agrawal J, Pal A, Darokar MP, Srivastava SK (2013) Novel antiplasmodial agents from *Christia vespertilionis*. Nat Prod Commun 8(11): 1591–1594. https://doi.org/10.1177/1934578X1300801123

Vo QV, Nam PC, Bay MV, Thong NM, Cuong ND, Mechler A (2019) Antioxidant motifs in flavonoids: O–H versus C–H bond dissociation. ACS Omega 4(5): 8935–8942. https://doi.org/10.1021/acsomega.9b00677

Wahjono TE, Jusniarti, Wahyuno D (2021) Buku Saku Tanaman Obat: Warisan Tradisi Nusantara untuk Kesejahteraan Rakyat. Jakarta: Pusat Penelitian dan Pengembangan Perkebunan, Kementerian Pertanian Republik Indonesia.

Wahyuni DK, Lestari S, Kuncoro EP, Purnobasuki H (2020b) Callus induction and its metabolite profiles of *Sonchus arvensis* L. Under temperature treatment. Ann Biol 36(2): 299–303.

Wahyuni DK, Nariswari A, Supriyanto A, Purnobasuki H, Punnapayak H, Bankeeree W, Prasongsuk S, Ekasari W (2023a) Antioxidant, antimicrobial, and antiplasmodial activities of *Sonchus arvensis* L. leaf ethyl acetate fractions. Pharmacogn J 14(6): 993–998. http://dx.doi.org/10.5530/pj.2022.14.202

Wahyuni DK, Pradana RAP, Wahyuningsih SPA, Purnobasuki H, Pramudya M, Prasongsuk S, Wacharasindhu S, Atere TG (2023b) Effect of tempuyung (*Sonchus arvensis* L.) leaf extract on kidney histology of mice exposed to *Plasmodium berghei*. Res J Pharm Technol 16(12): 5684–5690. https://doi.org/10.52711/0974-360X.2023.00919

Wahyuni DK, Purnobasuki H, Kuncoro EP, Ekasari W (2020a) Callus induction of *Sonchus arvensis* L. and its antiplasmodial activity. Afr J Infect Dis 14(1): 1–7. https://doi.org/10.21010/ajid.v14i1.1

Wahyuni DK, Rahayu S, Purnama PR, Saputro TB, Wijayanti N, Purnobasuki H (2019) Morpho-anatomical structure and DNA barcode of *Sonchus arvensis* L. Biodiversitas 20(8): 2417–2426. https://doi.org/10.13057/biodiv/d200841

Wahyuni DK, Rahayu S, Zaidan AH, Ekasari W, Prasongsuk S, Purnobasuki H (2021) Growth, secondary metabolite production, and *in vitro* antiplasmodial activity of *Sonchus arvensis* L. callus under dolomite [$CaMg(CO_3)_2$] treatment. PLoS One 16(8): e0254804. https://doi.org/10.1371/journal.pone.0254804

Wahyuni DK, Wacharasindhu S, Bankeeree W, Punnapayak H, Parikesit AA, Kharisma VD (2022) Molecular simulation of compounds from n-hexane fraction of *Sonchus arvensis* L. leaves as SARS-CoV-2 antiviral through inhibitor activity targeting strategic viral protein. J Pharm Pharmacogn Res 10(6): 1126–1138. https://doi.org/10.56499/jppres22.1489_10.6.1126

Wahyuni DK, Wacharasindhu S, Bankeeree W, Wahyuningsih SPA, Ekasari W, Purnobasuki H, Punnapayak H, Prasongsuk S (2023c) *In vitro* and *in vivo* antiplasmodial activities of leaf extracts from *Sonchus arvensis* L. BMC Complement Med Ther 23(1): 47. https://doi.org/10.1186/s12906-023-03871-7

Walker AW, Sanderson JD, Churcher C, Parkes GC, Hudspith BN, Rayment N, Brostoff J, Parkhill J, Dougan G, Petrovska L (2011) High-throughput clone library analysis of the mucosa-associated microbiota reveals dysbiosis and differences between inflamed and non-inflamed regions of the intestine in inflammatory bowel disease. BMC Microbiology 11: 7. https://doi.org/10.1186/1471-2180-11-7

Xia DZ, Yu XF, Zhu ZY, Zou ZD (2011) Antioxidant and antibacterial activity of six edible wild plants (*Sonchus* spp.) in China. Nat Prod Res 25(20): 1893-1901. https://doi.org/10.1080/14786419.2010.534093

Xia Z, Lu L, Li L (2020) Cytotoxic steroids from *Sonchus arvensis*. Chem Nat Compd 56: 1094–1099. https://doi.org/10.1007/s10600-020-03234-5

Xia Z, Qu W, Lu H, Fu J, Ren Y, Liang J (2010) Sesquiterpene lactones from *Sonchus arvensis* L. and their antibacterial activity against *Streptococcus mutans* ATCC 25175. Fitoterapia 81(5): 424–428. https://doi.org/10.1016/j.fitote.2009.12.001

Xia Z, Yao J, Liang J (2012) Two new sesquiterpene lactones from *Sonchus arvensis*. Chem Nat Compd 48: 47–50. https://doi.org/10.1007/s10600-012-0155-y

Xu YJ, Sun SB, Sun LM, Qiu DF, Liu XJ, Jiang ZB, Yuan CS (2008) Quinic acid esters and sesquiterpenes from *Sonchus arvensis*. Food Chem 111(1): 92–97. https://doi.org/10.1016/j.foodchem.2008.03.028

Yanuarisa R, Agustina D, Santosa A (2016) Antibacterial activity of ethanolic extract from tempuyung leaf (*Sonchus arvensis* L.) againts *Salmonella typhi* by *in vitro* study. J Agromed Med Sci 2(2): 1–6.

Yuan T, Wu D, Sun K, Tan X, Wang J, Zhao T, Ren B, Zhao B, Liu Z, Liu X (2019) Anti-fatigue activity of aqueous extracts of *Sonchus arvensis* L. in exercise trained mice. Molecules 24(6): 1168. https://doi.org/10.3390/molecules24061168

Zulkefle NN, Zainal N, Wahyuni DK, Mahmood S, Ramarao KDR, & Chin KL (2025) Antimicrobial properties of *Sonchus* species: A review. Asian Pac J Trop Biomed 15(5): 177–188. https://doi.org/10.4103/apjtb.apjtb_42_25

AUTHOR CONTRIBUTION:

Contribution	Wahyuni DK	Silas E	Pratama ASP	Asyahidah RK	Syukriya AJ	Rahmawati CT	Ikram NKK	Saiman MZ	Subramaniam S
Concepts or ideas	x	x							
Design	x	x							
Definition of intellectual content	x	x					x	x	x
Literature search	x	x	x	x	x	x			
Experimental studies									
Data acquisition	x	x	x	x	x	x	x	x	x
Data analysis		x	x	x					
Statistical analysis									
Manuscript preparation	x	x	x	x	x	x			
Manuscript editing	x	x	x	x	x	x	x	x	x
Manuscript review	x	x	x	x	x	x	x	x	x

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Supplementary Data

Table S1. Preferred reporting items for systematic reviews and meta-analyses extension for scoping reviews (PRISMA-ScR) checklist.

SECTION	ITEM	PRISMA-SCR CHECKLIST ITEM	REPORTED ON PAGE
TITLE	1	Identify the report as a scoping review.	1
ABSTRACT			
Structure summary	2	Provide a structured summary that includes (as applicable): background, objectives, eligibility criteria, sources of evidence, charting methods, results, and conclusions that relate to the review questions and objectives.	3
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known. Explain why the review questions/objectives lend themselves to a scoping review approach.	3-4
Objectives	4	Provide an explicit statement of the questions and objectives being addressed with reference to their key elements (e.g., population or participants, concepts, and context) or other relevant key elements used to conceptualize the review questions and/or objectives.	4-5
METHODS			
Protocol and registration	5	Indicate whether a review protocol exists; state if and where it can be accessed (e.g., a Web address); and if available, provide registration information, including the registration number.	5
Eligibility criteria	6	Specify characteristics of the sources of evidence used as eligibility criteria (e.g., years considered, language, and publication status), and provide a rationale.	6
Information sources*	7	Describe all information sources in the search (e.g., databases with dates of coverage and contact with authors to identify additional sources), as well as the date the most recent search was executed.	5
Search	8	Present the full electronic search strategy for at least 1 database, including any limits used, such that it could be repeated.	5, S2
Selection of sources of evidence	9	State the process for selecting sources of evidence (i.e., screening and eligibility) included in the scoping review.	5-6
Data charting process	10	Describe the methods of charting data from the included sources of evidence (e.g., calibrated forms or forms that have been tested by the team before their use, and whether data charting was done independently or in duplicate) and any processes for obtaining and confirming data from investigators.	6, S5
Data items	11	List and define all variables for which data were sought and any assumptions and simplifications made.	6
Critical appraisal of individual sources of evidence§	12	If done, provide a rationale for conducting a critical appraisal of included sources of evidence; describe the methods used and how this information was used in any data synthesis (if appropriate).	6, S4
Synthesis of results	13	Describe the methods of handling and summarizing the data that were charted.	6

Selection of sources of evidence	14	Give numbers of sources of evidence screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally using a flow diagram.	6-7, Fig. 1
Characteristics of sources of evidence	15	For each source of evidence, present characteristics for which data were charted and provide the citations.	8-27, Table 1
Critical appraisal within sources of evidence	16	If done, present data on critical appraisal of included sources of evidence (see item 12).	S4
Results of individual sources of evidence	17	For each included source of evidence, present the relevant data that were charted that relate to the review questions and objectives.	8-27, Table 1, Fig. 2, Fig. 3, Fig. 4, Fig. 5
Synthesis of results	18	Summarize and/or present the charting results as they relate to the review questions and objectives.	28-29
DISCUSSION			
Summary of evidence	19	Summarize the main results (including an overview of concepts, themes, and types of evidence available), link to the review questions and objectives, and consider the relevance to key groups.	29
Limitations	20	Discuss the limitations of the scoping review process.	41-42
Conclusions	21	Provide a general interpretation of the results with respect to the review questions and objectives, as well as potential implications and/or next steps.	34
FUNDING			
Funding	22	Describe sources of funding for the included sources of evidence, as well as sources of funding for the scoping review. Describe the role of the funders of the scoping review.	34

Table S2. Keywords used for each database.

Database	Keyword Used	Search result
Scopus	ALL("Sonchus arvensis" OR "S. arvensis" OR "tempuyung" OR "field sow thistle" OR "perennial sow thistle") AND ALL("phytochemical*" OR "metabolite*" OR "secondary metabolite*" OR "bioactive compound*" OR "plant extract*" OR "extract*") AND ALL("antioxidant*" OR "antimicrob*" OR "anti-inflammat*" OR "antidiabetic" OR "antiplasmodi*" OR "antimalari*" OR "anticancer*" OR "anti cancer*")	783 (Data obtained on 23 September 2025)
PubMed	("Sonchus arvensis" OR "S. arvensis" OR "tempuyung" OR "field sow thistle" OR "perennial sow thistle" OR "Sonchus"[MeSH Terms]) AND ("phytochemical*" OR "metabolite*" OR "secondary metabolite*" OR "bioactive compound*" OR "plant extract*" OR "extract*" OR "Phytochemicals"[MeSH Terms] OR "Plant Extracts"[MeSH Terms]) AND ("antioxidant*" OR "antimicrob*" OR "anti-inflammat*" OR "antidiabetic*" OR "antiplasmodi*" OR "antimalari*" OR "Antioxidants"[MeSH Terms] OR "Anti-Infective Agents"[MeSH Terms] OR "Anti-Inflammatory Agents"[MeSH Terms] OR "Hypoglycemic Agents"[MeSH Terms] OR "Antimalarials"[MeSH Terms] OR "Antineoplastic agents"[MeSH Terms])	56 (Data obtained on 23 September 2025)
Google Scholar	("Sonchus arvensis" OR "S. arvensis" OR "tempuyung" OR "field sow thistle" OR "perennial sow thistle") AND (phytochemical* OR metabolite* OR Secondary metabolite* OR bioactive compound* OR plant extract* OR extract*) AND (antioxidant* OR antimicrob* OR anti-inflammat* OR antidiabetic* OR antiplasmodi* OR antimalari* OR anticancer*)	898 (Data obtained on 23 September 2025)
EBSCOhost	("Sonchus arvensis" OR "S. arvensis" OR "tempuyung" OR "field sow thistle" OR "perennial sow thistle") AND (phytochemical* OR metabolite* OR Secondary metabolite* OR bioactive compound* OR plant extract* OR extract*) AND (antioxidant* OR antimicrob* OR anti-inflammat* OR antidiabetic* OR antiplasmodi* OR antimalari* OR anticancer*)	0 (Data obtained on 23 September 2025)

Table S3. Data extraction table.

No	Title	(1) A clear definition of the study objective and aim	(2) Research objective(s) relevant to the review	(3) Study design appropriate for the stated aims	(4) Type of study clearly defined	(5) Extraction solvent and method reported	(6) Methodology clearly described	(7) Quantity of plant extract used clearly stated	(8) Study results described	(9) Discussions and conclusions justified	(10) Study limitations discussed

Table S4. Critical appraisal score average using MMAT

No	Title	Average article quality score	Quality index score	Citation
1	Analytical, bioactivity and stability studies on *Strobilanthes crispus* L. Bremek and *Sonchus arvensis* L. extracts	9.3	High	Afrizal, 2008
2	Angiotensin converting enzyme inhibitor activity of ethanol extract of *Sonchus arvensis* (Linn.) leaves	8.7	High	Suryani et al., 2017
3	An HPLC-DAD method to quantify flavonoids in *Sonchus arvensis* and able to classify the plant parts and their geographical area through principal component analysis	8.7	High	Khuluk et al., 2021
4	*Anredera cordifolia* (Ten.) Steenis and *Sonchus arvensis* L. inhibit gentamicin-induced nephrotoxicity: The role of urinary N-acetyl beta-D-glucosaminidase	9.7	High	Suliska et al., 2021c
5	Anti-dysentery activity of tetracycline in combination with *Curcuma xanthorrhiza* Roxb. or *Sonchus arvensis* L.	9.0	High	Sukandar et al., 2016
6	Anti-fatigue activity of aqueous extracts of *Sonchus arvensis* L. in exercise trained mice	9.7	High	Yuan et al., 2019
7	Antihypertensive activity of ethanol extract combination of *Anredera cordifolia* (Ten.) v. steenis and *Sonchus arvensis* L. leaves on angiotensin II-induced male Wistar rat	9.3	High	Suliska et al., 2021b
8	Antioxidant activity screening of seven Indonesian herbal extract	8.7	High	Sukweenadhi et al., 2020
9	Antioxidant and antibacterial activity of six edible wild plants (*Sonchus* spp.) in China	9.3	High	Xia et al., 2011
10	Antioxidant, antimicrobial, and antiplasmodial activities of *Sonchus arvensis* L. leaf ethyl acetate fractions	9.0	High	Wahyuni et al., 2023a
11	Callus induction of *Sonchus arvensis* L. and its antiplasmodial activity	8.0	High	Wahyuni et al., 2020a
12	Cardioprotective potential of ethanol extract of *Sonchus arvensis* L. leaves on isoproterenol-induced myocardial infarction in rat	9.0	High	Kurniati et al., 2018
13	Chemical composition of essential oils and *in vitro* antibacterial activity of methanolic extract of *Sonchus arvensis* and *Eremurus spectabilis* against food-borne pathogenic bacteria	9.3	High	Kanaani & Mohamadi, 2015
14	Cytotoxic steroids from *Sonchus arvensis*	8.7	High	Xia et al., 2020
15	Efek infusa akar tempuyung (*Sonchus arvensis*) terhadap penurunan kadar asam urat pada tikus putih (*Rattus norvegicus*)	8.3	High	Retnowati et al., 2014
16	Effect of tempuyung (*Sonchus arvensis* L.) leaf extract on kidney histology of mice exposed to *Plasmodium berghei*	9.0	High	Wahyuni et al., 2023b
17	Ekstrak etanol 96% daun tempuyung (*Sonchus arvensis* L.) terhadap *Staphylococcus epidermidis* dan *Pseudomonas aeruginosa* secara *in vitro* (Korelasi Metabolite …)	8.0	High	Taris et al., 2021
18	Evaluation effect of polarity of the compound from *Sonchus arvensis* (Linn.) leaves as hypertension inhibitor	8.0	High	Suryani et al., 2020
19	Evaluation of flavonoids and diverse antioxidant activities of *Sonchus arvensis*	8.7	High	Khan, 2012

20	Evaluation of the anti-gout effect of *Sonchus arvensis* on monosodium urate crystal-induced gout arthritis via anti-inflammatory action - An *in vivo* study	9.7	High	Parisa et al., 2021
21	Extract ethanol of tempuyung (*Sonchus arvensis*) Leaves as anti-hyperuricemia: *In vitro* studies	9.3	High	Parisa et al., 2024
22	Fatty acid derived compounds - The dominant volatile class of the essential oil poor *Sonchus arvensis* subsp. uliginosus (Bieb.) Nymana	8.0	High	Radulović et al., 2009
23	FTIR- and UHPLC-Q-Orbitrap HRMS-based metabolomics of *Sonchus arvensis* extracts and evaluation of their free radical scavenging activity	8.0	High	Rafi et al., 2022a
24	FTIR-based fingerprinting combined with chemometrics for discrimination of *Sonchus arvensis* leaf extracts and correlation with their antioxidant activity	8.3	High	Rafi et al., 2021
25	Growth, secondary metabolite production, and *in vitro* antiplasmodial activity of *Sonchus arvensis* L. callus under dolomite [$CaMg(CO_3)_2$] treatment	9.0	High	Wahyuni et al., 2021
26	Harvest methods determine the yield and quality of *Sonchus arvensis* accessions cultivated in organic way	7.3	Moderate	Raisawati et al., 2023
27	*In vitro* and *in silico* evaluation of xanthine oxidase inhibitory activity of quercetin contained in *Sonchus arvensis* leaf extract	8.3	High	Hendriani et al., 2017
28	*In vitro* and *in vivo* antiplasmodial activities of leaf extracts from *Sonchus arvensis* L.	9.0	High	Wahyuni et al., 2023c
29	*In vitro* evaluation of xanthine oxidase inhibitory activity of selected medicinal plants	8.0	High	Hendriani et al., 2016
30	*In vitro* evaluation of xanthine oxidase inhibitory activity of *Sonchus arvensis* leaves	8.3	High	Hendriani et al., 2014
31	Isolasi senyawa antioksidan dari fraksi etil asetat daun tempuyung (*Sonchus arvensis* L.)	8.7	High	Putra et al., 2013
32	Molecular simulation of compounds from n-hexane fraction of *Sonchus arvensis* L. leaves as SARS-CoV-2 antiviral through inhibitor activity targeting strategic viral protein	8.3	High	Wahyuni et al., 2022
33	Nephroprotective effect of ethanol extract of *Sonchus arvensis* L. leaves in gentamicin-piroxicam induced rat renal failure	8.7	High	Suliska et al., 2021a
34	Partial coding sequence identification, gene expression analysis, and content of anticancer phenolic compounds in *Sonchus arvensis* L. under drought stress conditions	7.3	Moderate	Azizyan & Mandoulakani, 2024
35	Pharmacological studies of methanolic extracts of *Sonchus arvensis* from Kathmandu	9.0	High	Poudel et al., 2015
36	Phenolic compounds from *Sonchus arvensis* Linn. and *Hemerocallis citrina* Baroni. inhibit sucrose and stearic acid induced damage in *Caenorhabditis elegans*.	8.0	High	An et al., 2023
37	Antioxidant potential of tempuyung (*Shoncus arvensis* L.) leaf extract in two drying methods	9.0	High	Harun & Khairunissa, 2022
38	Potential test of nephropathy *Sonchus arvensis* L. leaves on male rats (*Rattus norvegicus*) diabetes mellitus	9.0	High	Tandi et al., 2020
39	Quantitative HPLC analysis of phenolic acids, flavonoids and ascorbic acid in four different solvent extracts of two wild edible leaves, *Sonchus arvensis* and *Oenanthe linearis* of North-Eastern region in India	9.0	High	Seal, 2016
40	Selection of potential Indonesian plant species for antioxidant	9.0	High	Kartini et al., 2020
41	Sesquiterpene lactones from *Sonchus arvensis* L. and their antibacterial activity against *Streptococcus mutans* ATCC 25175	9.0	High	Xia et al., 2010
42	*Sonchus arvensis*: Antioxidant activity, phenolic profile, and phytochemical screening	9.0	High	Ghosal et al., 2023

43	*Sonchus arvensis* L. water extract attenuates dextran sulfate sodium-induced colitis by adjusting gut microbiota	9.0	High	Ren et al., 2023
44	Tempuyung leaves (*Sonchus arvensis*) ameliorates monosodium urate crystal-induced gouty arthritis in rats through anti-inflammatory effects	8.7	High	Hidayat et al., 2020
45	The effect of perennial sow-thistle (*Sonchus arvensis*) leaf extract on blood glucose and plasma insulin levels of diabetic mice	8.7	High	Haryta et al., 2021
46	The effect of shade and vermicompost application on yield and flavonoid levels of tempuyung (*Sonchus arvensis*)	8.3	High	Putri et al., 2018
47	The immunomodulatory activity of ethanol extract of tempuyung leaves (*Sonchus arvensis* Linn.)	8.3	High	Sukmayadi et al., 2014
48	The influence of *Sonchus arvensis* extract against *Escherichia coli* and *Candida utilis*	9.0	High	Pasaribu et al., 2024
49	Potency of secondary metabolites from *Salacca zalacca*, *Sonchus arvensis*, and *Carica papaya* against *Aedes aegypti* L.	8.3	High	Astuti et al., 2023
50	Total flavonoid content and antioxidant activity in leaves of ten cultivated *Sonchus arvensis* L. accessions	8.7	High	Raisawati et al., 2020
51	Two new sesquiterpene lactones from *Sonchus arvensis*	9.0	High	Xia et al., 2012
52	Exploring irritant activity of some of the phytochemical components from wild *Sonchus arvensis* (Ll.) ssp arvensis (D.C.) kirp herb	9.7	High	Asif & Saeed, 2020
53	Analysis of component composition of volatile compounds of field sow thistle (*Sonchus arvensis* L.) leaves using the method of gas chromatography with mass-detection	8.7	High	Delyan, 2016
54	CCl_4 induced genotoxicity and DNA oxidative damages in rats: hepatoprotective effect of *Sonchus arvensis*	9.0	High	Alkreathy et al., 2014
55	Effect of ethanol extract *Sonchus arvensis* Linn leaf on BUN, SCr, ALT, AST in healthy male albino mice (*Rattus norvegicus*)	9.0	High	Harun et al., 2019
56	Thin layer chromatography fingerprint analysis of tempuyung (*Sonchus arvensis* L.)	8.0	High	Fauziah et al., 2023
57	Protective effect of ethanolic extract *Sonchus arvensis* L. in gentamicin-induced acute tubular necrosis on Wistar rats	8.0	High	Imelda et al., 2018
58	Cardioprotective potential of ethanol extract of *Sonchus arvensis* L. leaves on isoproterenol-induced myocardial infarction in rat	8.3	High	Kurniati et al., 2018
59	Uji efektivitas infusa daun tempuyung (*Sonchus arvensis* L.) sebagai antipiretik pada tikus putih jantan (*Rattus norvegicus*)	8.3	High	Mbaubedari et al., 2020
60	Pengujian kandungan total fenol ekstrak etanol tempuyung (*Sonchus arvensis* L.)	8.3	High	Hapsari et al., 2018
61	Pengaruh frekuensi penggunaan teh daun tempuyung kering (*Sonchus arvensis*) terhadap daya larut kalsium oksalat (CaC_2O_4)	7.7	Moderate	Mukaromah & Anggraini, 2009
62	Kestabilan ekstrak metanol daun *Sonchus arvensis* pada penyimpanan	7.7	Moderate	Itam et al., 2013
63	Efikasi fraksi etanolik akar tempuyung (*Sonchus arvensis* L.) sebagai kemoterapi kanker kolon berdasarkan ekspresi caspase-9	8.3	High	Rohima et al., 2011
64	Uji aktivitas antiagregasi platelet ekstrak etanol daun tempuyung (*Sonchus arvensis* L.) pada mencit Swiss Webster jantan	6.0	Moderate	Ningsih et al., 2017
65	Isolasi, identifikasi dan uji antioksidan senyawa flavonoid dari ekstrak etil asetat daun tempuyung (*Sonchus arvensis* L.)	6.0	Moderate	Ramadhani et al., 2013
66	Ekstraksi senyawa antioksidan daun tempuyung (*Sonchus arvensis* L.) dengan menggunakan metode ultrasound-assisted extraction	8.0	High	Laksono, 2020
67	Uji aktivitas antihiperurisemia ekstrak etanol beberapa tumbuhan famili Asteraceae	8.0	High	Amal et al., 2021

68	Potensi antioksidan dan uji organoleptik loloh daun tempuyung (*Sonchus arvensis* L.)	4.0	Low	Sudewi et al., 2015
69	Perbadingan efek diuretika serta kadar natrium dan kalium darah antaa pemberian ekstrak etanol daun tempuyung (*Sonchus arvensis* Linn) dengan furosemida	8.0	High	Rustam et al., 2006
70	Uji toksisitas akut ekstrak etanol daun tempuyung (*Sonchus arvensis* L.) pada mencit betina dengan metode fixed dose	8.0	High	Amal et al., 2022
71	Protective effect of ethanol extract tempuyung leaf (*Sonchus arvensis* L.) against gentamicin induced renal injury viewed from blood ureum level	9.0	High	Imelda et al., 2017
72	Penetapan parameter dan penetapan kadar flavonoid total pada ekstrak daun tempuyung (*Sonchus arvensis* L.)	7.0	Moderate	Sari, 2020
73	Skrining dan karakterisasi simplisia daun tempuyung (*Sonchus arvensis* L.) Imelda Pekerja Indonesia	8.0	High	Harahap, 2020
74	Kadar flavonoid total simplisia tempuyung (*Sonchus arvensis* L.) dengan metode pengeringan kombinasi di dataran tinggi	9.0	High	Safrina et al., 2020
75	Analisis kualitatif kandungan kimia kalus *Sonchus arvensis* L. hasil pertumbuhan secara kultur jaringan	8.0	High	Katno & Widiyastuti, 2004
76	Uji aktivitas antioksidan ekstrak daun tempuyung (*Sonchus arvensis* L.)	9.0	High	Ediningsih et al., 2016
77	Pengaruh ekstrak daun tempuyung (*Sonchus arvensis* L.) terhadap jumlah osteoblas pada penyembuhan soket pasca pencabutan gigi tikus putih (*Rattus norvegicus*)	8.0	High	Rahmaniar, 2018
78	Aktivitas antibakteri ekstrak etanol daun tempuyung (*Sonchus arvensis* L.) terhadap *Salmonella typhi* secara *in vitro*	8.0	High	Yanuarisa et al., 2016
79	Potensi daun tempuyung (*Sonchus arvensis* L.) sebagai antihiperurisemia pada mencit putih jantan	8.0	High	Laili & Savitri, 2021
80	Analisis kadar flavonoid total ekstrak etanol tempuyung (*Sonchus arvensis*) dengan menggunakan metode spektrofotometri UV-Vis	8.0	High	Syarifuddin et al., 2022
81	Aktivitas antioksidan ekstrak etanol daun *Sonchus arvensis* L.	8.0	High	Istikharah, 2015
82	Identifikasi senyawa sitotoksik dalam ekstrak kloroform daun tempuyung (*Sonchus arvensis* L.) menggunakan GC-MS	8.0	High	Azifa et al., 2014
83	Uji efektifitas ekstrak daun tempuyung (*Sonchus arvensis* L.) untuk menurunkan kadar asam urat pada tikus putih Wistar jantan yang dibuat hiperurisemia	9.0	High	Brajawikalpa et al., 2018
84	Pengaruh kehalusan bahan dan lama ekstraksi terhadap mutu ekstrak tempuyung (*Sonchus arvensis* L.)	8.0	High	Manoi, 2017
85	Pengaruh variasi jenis pelarut terhadap kualitas ekstrak daun tempuyung (*Sonchus arvensis* L.) dengan metode maserasi	9.0	High	Rosandi & Oktavia, 2018
86	Isolasi dan identifikasi senyawa flavonoid ekstrak n-butanol daun tempuyung (*Sonchus arvensis* L.) secara spektrofotometri infra merah	8.0	High	Syarifuddin & Yuysriyani, 2021
87	Senyawa antibakteri bis (2-etilheksil) ester dan triterpenoid dalam estrak n-heksana daun tempuyung (*Sonchus arvensis* L.)	8.0	High	Sukadana & Santi, 2011