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Scoping Review Of Tuberculosis And Centella Asiatica: Current Evidence And Future Directions

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Abstract
The emergence of drug-resistant strains and prolonged treatment duration associated with standard tuberculosis (TB) regimens have necessitated the development of novel therapeutic strategies. Traditional medicinal plants have attracted increasing attention as potential complementary treatments for TB because of their diverse bioactive compounds and extensive history of use in various cultures. Recent scientific investigations have begun to explore the potential of Centella asiatica in the context of TB management to leverage its multifaceted pharmacological properties to address the complexities of TB infection and treatment. This scoping review examined the current evidence and future directions for utilizing Centella asiatica as a complementary treatment for TB. A systematic search of scientific databases identified six relevant studies published between 2015 and 2025. Key findings indicate that Centella asiatica demonstrates potential benefits in TB management through multiple mechanisms, including antimycobacterial activity against drug-resistant strains of Mycobacterium tuberculosis, enhancement of the immune response, hepatoprotective effects against isoniazid-induced liver toxicity, and reduction of oxidative stress associated with TB infection and treatment. While preclinical studies show promise, further clinical research is required to fully elucidate the efficacy, optimal dosing, and potential interactions of Centella asiatica with standard TB medications.
Keywords: *centella asiatica, tuberculosis, TB, antimicrobial, gotu kola.*

1. INTRODUCTION

Tuberculosis (TB) continues to pose a substantial global health challenge, affecting millions of individuals annually (Villar-Hernández et al., 2023). The etiological agent, Mycobacterium tuberculosis, predominantly affects the pulmonary system but is also capable of infecting other body regions (Pang et al., 2019). Although traditional antibiotic regimens have proven effective in numerous instances, the advent of drug-resistant strains and the protracted nature of treatment have complicated TB management of TB (Schön et al., 2017). These issues contribute to patient non-compliance, therapeutic failure, and sustained prevalence of TB in communities worldwide.

The imperative for novel TB treatment strategies has prompted researchers to investigate complementary therapies that could augment the effectiveness of standard antibiotics while potentially diminishing the treatment duration and adverse effects. Such adjunctive therapies may encompass immunomodulators, natural compounds with antimicrobial properties, or interventions targeting host-pathogen interactions (Trøstrup et al., 2020). Furthermore, there is increasing interest in the development of innovative drug delivery systems and personalized treatment protocols to enhance patient outcomes. The integration of these supportive therapies with conventional treatments could potentially mitigate the challenges of drug resistance and adverse effects, thereby contributing to more effective TB control and prevention strategies.

The increasing interest in herbal plants as complementary treatments for tuberculosis (TB) has prompted extensive research on Centella asiatica, particularly in Asian countries where it is integral to traditional medicine (Sari, 2020). This herb, also known as pegagan, has attracted considerable attention because of its diverse therapeutic properties. Its potential as an anti-inflammatory, antioxidant, immunomodulatory, and antimicrobial agent makes it a promising candidate for adjunctive TB therapy (Rashid et al., 2023); (Harun et al., 2019).

These findings have significant implications for TB treatment, particularly in regions in which traditional medicine is deeply embedded in cultural practices. The potential of Centella asiatica to enhance the efficacy of conventional TB treatments could lead to improved patient outcomes and reduced treatment durations. Furthermore, its natural origin and long history of use in traditional medicine suggest a favorable safety profile, making it an attractive option for patients seeking complementary therapies

(Prakash et al., 2017); (Hoque et al., 2023); (Roy & Bharadvaja, 2017). However, while preclinical studies show promise, further clinical research is necessary to fully elucidate the herb's efficacy, optimal dosing, and potential interactions with standard TB medications before it can be widely recommended as adjunctive therapy.

A scoping review of Centella asiatica and tuberculosis treatment addresses a significant gap in the current literature. By systematically identifying, synthesizing, and mapping existing research, this review aimed to provide a comprehensive overview of the potential applications of Centella asiatica in tuberculosis management. This approach is particularly valuable given the increasing interest in natural remedies and ongoing challenges in treating tuberculosis, especially drug-resistant strains.

The findings of this research are expected to contribute to the development of alternative and more effective treatment strategies for TB, particularly in managing MDR-TB. This study could lead to the formulation of new treatment guidelines that integrate Centella asiatica with conventional therapies, improving patient outcomes and accelerating recovery times. Furthermore, the research will provide a foundation for further studies on the use of traditional medicinal plants in managing global infectious diseases.

2. METHOD

This scoping review was conducted in accordance with the methodological framework established by Arksey and O'Malley (2005), which comprises five principal stages: (1) identification of research questions, (2) identification of relevant studies, (3) selection of studies, (4) data mapping, and (5) analysis and reporting of results (Arksey & O'malley, 2005).

2.1Identification of Research Questions

The initial step involved formulating the primary research question for this scoping review: "What is the available scientific evidence regarding the use of Centella asiatica in the context of prevention, treatment, or management of tuberculosis?" Additional inquiries included: "What is the potential synergy between Centella asiatica and conventional anti-tuberculosis drugs?"

2.2Relevant Study Identification

A comprehensive literature search was conducted in scientific databases such as PubMed and Scopus, using the keywords "Centella asiatica" or "Gotu Kola" and "Tuberculosis." The inclusion criteria were original research articles and experimental studies published between 2015 and 2025. Articles not in English or review articles were excluded.

2.3Study Selection

The selection process was executed in two stages: screening of titles and abstracts by researchers, followed by a full-text review to assess relevance to the study being conducted.

2.4Data Mapping

Data were extracted from the selected studies using a table that included the author's name and year, research methods, main results

2.5Data Analysis and Reporting

The collected data were descriptively analyzed to identify general trends, knowledge gaps, and potential future research directions. The results were presented in narrative form and mapped based on the study type and main findings.

3. RESULT AND DISCUSSION

Based on the results, 43 articles were identified from the Scopus database and 7 articles from the PubMed

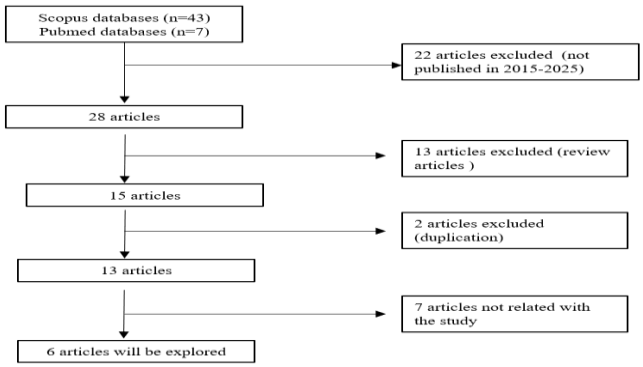

Figure 1. Articles screening related to Centella asiatica and Tuberculosis

A total of 22 articles were excluded because they were not published within the last ten years, 13 articles were excluded because they were review articles, 2 articles were excluded due to duplication, and 7 articles were excluded because they were not relevant to this study (Figure 1). Ultimately, six articles were identified and examined (Table 1).

Table 1. Articles related to Centella asiatica and Tuberculosis

Title	Author	Year	Method	Main Results Related to Centella asiatica
Comparative antimycobacterial activity of some Indonesian medicinal plants against multidrug-resistant Mycobacterium tuberculosis	Radji, Maksum, et al	2015	The leaves of Centella asiatica were subjected to maceration to obtain aqueous extracts, which were then analyzed for their phytochemical components. The antimycobacterial properties of these extracts were evaluated using proportion methods on Lowenstein Jensen (L-J) medium..	The water-based extract of Centella asiatica demonstrated a 78.5% inhibition rate against the Mycobacterium tuberculosis H37Rv strain and a 50.0% inhibition rate against the MDR strain.
Screening antimycobacterial activity of Baccharis dracunculifolia, Centella asiatica, Lantana camara and Pterodon emarginatus	Machado et al	2015	Extracts, essential oils, and certain fractions derived from four species of medicinal plants, which have been traditionally employed as general remedies for various ailments and specifically for treating tuberculosis, were assessed using the microplate resazurin assay. This evaluation was conducted against two species of the Mycobacterium tuberculosis Complex and three nontuberculous mycobacteria.	The hexane fraction of methanol extract from leaves of Centella asiatica also presented significant mycobacterial growth inhibition, but against M. chelonae only.
The ameliorating effect of Centella asiatica ethanolic extract on albino rats treated with isoniazid	Ghosh, Kavisa, et al	2017	In vivo study to assess the impact of C. asiatica ethanolic leaf extract (CA) on albino rats treated with INH	Histological analysis of both the liver and kidneys confirmed the efficacy of CA at a dosage of 100 mg/kg bw. Overall, the findings indicate that CA at this concentration can significantly mitigate the toxic effects of INH.
Mechanism of Centella asiatica extract in Increasing Alveolar Macrophages Apoptosis	Mustika, Arifa, et al	2021	In vivo study to determine effect and mechanism of the extract of Centella	Ethanol extract of Centella asiatica has active ingredients to enhance apoptosis of

Title	Author	Year	Method	Main Results Related to Centella asiatica
in Rat Tuberculosis Models			asiatica in enhancing macrophage apoptosis in rat tuberculosis models	alveolar macrophages from rat lung tissue that were infected by Mycobacterium tuberculosis through the increase of Caspase 8's expression, Bax'expression and decrease of Bcl-2's expression
Antimicrobial activity of Centella asiatica and Gigantochloa apus	Mudaliana, Siti	2021	The ethanol extracts of C. asiatica were created using a speed extractor, along with techniques involving pressure and temperature. Each extract was subjected to phytochemical analysis. The antimycobacterial activity of the ethanol extract was tested on Lowenstein Jensen (LJ) medium, while its antibacterial activity was determined using the Kirby-Bauer method on Mueller Hinton agar (MHA).	The extract from C. asiatica is composed of flavonoids, alkaloids, saponins, and tannins. It has demonstrated antimicrobial properties against the Mycobacterium tuberculosis H37Rv strain, Escherichia coli, Staphylococcus aureus, and Salmonella typhi, but not against B. subtilis. This medicinal plant's extract can inhibit the growth of five tested pathogenic bacteria, suggesting its potential as an alternative or complementary treatment for bacterial infections.
MIC and MKC analysis of herbal medicine in Indonesia against Mycobacterium tuberculosis	Pakadang, SesiliaR ante, et al	2021	Plant extracts are evaluated based on the in vitro sensitivity of M.tuberculosis to the test material, with an incubation duration of 7 weeks.	The concentration of Gotu kola leaves (Centella asiatica) that is effectively utilized as a treatment for tuberculosis is 275 ppm.

Table 1 summarizes six key studies exploring the role of Centella asiatica in tuberculosis (TB) management. The findings indicate its diverse pharmacological effects, including antimycobacterial activity against drug-resistant strains, enhancement of immune response via macrophage apoptosis, and hepatoprotective properties against isoniazid-induced liver toxicity. Several studies also highlight its broad-spectrum antimicrobial effects and identify effective inhibitory concentrations. These preclinical studies, conducted through in vitro and in vivo models, support the therapeutic potential of C. asiatica as a complementary agent in TB treatment. However, further clinical research is essential to confirm its efficacy, safety, dosage, and interaction with standard TB drugs.

3.1Antimycobacterial Activity

Centella asiatica exhibits antimicrobial properties against Mycobacterium tuberculosis that extend beyond its efficacy against the H37Rv strain. The aqueous extract of this plant has demonstrated promising results

in inhibiting the growth of various multidrug-resistant (MDR) strains, which are notoriously challenging to treat with conventional antibiotics (Radji et al., 2015). This broad-spectrum activity suggests that Centella asiatica contains multiple bioactive compounds targeting different aspects of mycobacterial growth and survival (Radji et al., 2015); (Machado et al., 2015). Additionally, investigating the potential synergistic effects of Centella asiatica extracts and existing anti-TB drugs could lead to more effective combination therapies for managing both drug-susceptible and drug-resistant forms of the disease.

The antimicrobial properties of plants are attributed to a diverse array of phytochemicals, including flavonoids, alkaloids, saponins, and tannins (Radji et al., 2015); (Mudaliana, 2021). These compounds synergistically inhibit the growth and proliferation of various microorganisms. Flavonoids, which are known for their antioxidant properties, can disrupt bacterial cell membranes and interfere with enzyme systems. Alkaloids, which are nitrogen-containing organic compounds, often exhibit potent antimicrobial effects by interfering with DNA replication or protein synthesis in microbes. Saponins, which are characterized by their soap-like foaming ability, can destabilize microbial cell membranes, leading to cell lysis. Tannins, which are polyphenolic compounds, can precipitate proteins and inhibit microbial enzymes, thereby preventing their growth. The combination of these bioactive compounds creates a multifaceted defense mechanism against a wide spectrum of pathogens, including bacteria, fungi, and certain viruses. This natural antimicrobial arsenal contributes to the ability of the plant to protect itself from infections and has potential applications in the development of novel antimicrobial agents for human use (Radji et al., 2015); (Mudaliana, 2021). The concentration of Gotu kola leaves (Centella asiatica), which is effectively utilized as a treatment for tuberculosis, is 275 ppm (Pakadang et al., 2021).

3.2Enhancement of Immune Response

Centella asiatica's capacity to enhance apoptosis in Mycobacterium tuberculosis-infected alveolar macrophages constitutes a pivotal mechanism in combating tuberculosis. This process entails a complex interaction between pro-apoptotic and anti-apoptotic proteins. Elevated expression of Bax, a pro-apoptotic protein, facilitates the formation of pores in the mitochondrial membrane, resulting in the release of cytochrome c and other apoptogenic factors. Concurrently, upregulation of Caspase 8, an initiator caspase, activates the extrinsic apoptotic pathway. The reduced expression of Bcl-2, an anti-apoptotic protein, further shifts the balance towards cell death by diminishing its inhibitory effect on Bax and other pro-apoptotic factors (Mustika et al., 2021).

Augmented apoptosis of infected macrophages serves several functions in controlling M. tuberculosis infection. First, it eradicates the intracellular environment on which bacteria depend for survival and replication. Apoptotic cell death, as opposed to necrosis, preserves the integrity of the cell membrane, thereby preventing the release of viable bacteria into the extracellular space. This containment strategy restricts bacterial dissemination and facilitates the uptake of apoptotic bodies containing bacterial antigens by other immune cells, potentially enhancing antigen presentation and adaptive immune response. Moreover, the modulation of these apoptotic markers by Centella asiatica indicates its potential as a complementary therapeutic agent in tuberculosis treatment, possibly augmenting the efficacy of conventional antibiotics by promoting the elimination of infected host cells (Mustika et al., 2021).

3.3Protective Effects Against Drug Toxicity

Centella asiatica, a medicinal herb extensively utilized in traditional medical systems, has exhibited promising hepatoprotective properties against isoniazid-induced liver toxicity. Isoniazid (INH), a primary anti-tuberculosis medication, causes hepatotoxicity as a severe adverse effect in certain patients. The ethanolic leaf extract of Centella asiatica, when administered at a dose of 100 mg/kg body weight, demonstrated significant efficacy in reducing liver damage markers and oxidative stress in INH-treated rats (Ghosh et al., 2017). This protective effect is likely attributed to the rich phytochemical composition of the herb, including triterpenoids, flavonoids, and phenolic compounds, which possess potent antioxidant and anti-inflammatory properties (Ghosh et al., 2017).

The hepatoprotective action of Centella asiatica extract is multifaceted and involves the modulation of various biochemical pathways. It may enhance the activity of antioxidant enzymes such as superoxide dismutase and catalase, while simultaneously reducing lipid peroxidation and free radical formation in liver tissues. Additionally, the extract may help to maintain the integrity of hepatocyte membranes and promote the regeneration of liver cells damaged by INH toxicity. These findings suggest that Centella asiatica could potentially be developed as a complementary therapy to mitigate the hepatotoxic effects of isoniazid and other drugs known to cause liver damage, thereby improving the safety profile of anti-tuberculosis treatment regimens (Ghosh et al., 2017).

3.4Oxidative Stress Reduction

Centella asiatica's antioxidant properties are attributed to its abundant polyphenols and flavonoids, which are recognized for their capacity to neutralize deleterious free radicals within the body. These compounds function as electron donors and stabilize reactive oxygen species (ROS), thereby preventing cellular damage. In the context of tuberculosis (TB) and its treatment, this antioxidant activity is particularly noteworthy because both the disease and its therapeutic interventions can exacerbate oxidative stress. Oxidative damage associated with TB arises through multiple mechanisms. Infection itself provokes an inflammatory response, resulting in the production of reactive oxygen species by immune cells (Ghosh et al., 2017); (Anand et al., 2010).

Furthermore, certain anti-TB medications, notably isoniazid and rifampicin, have been documented to induce oxidative stress as side effects. Centella asiatica may contribute to reducing the overall physiological burden during TB infection and treatment by potentially mitigating this oxidative damage. This could potentially lead to enhanced treatment outcomes, diminished side effects, and improved overall patient well-being. However, it is crucial to acknowledge that, while these properties are promising, further research is necessary to fully elucidate the benefits of Centella asiatica in TB management and to ascertain appropriate dosages and potential interactions with standard TB treatments. This can be beneficial in managing oxidative damage associated with TB and its treatment (Ghosh et al., 2017); (Anand et al., 2010).

Table 2. Effect of Centella asiatica for tuberculosis's treatment

Effect	Details
Antimycobacterial Activity	Inhibits the growth of Mycobacterium tuberculosis, including MDR strains
Immune Response Enhancement	Promotes apoptosis of infected macrophages
Liver Protection	Reduces the hepatotoxicity of isoniazid (INH)
Antioxidant Properties	Reduces oxidative stress and DNA damage

Table 2 outlines the key therapeutic effects of Centella asiatica in the treatment of tuberculosis (TB), as identified in reviewed studies. The plant exhibits strong antimycobacterial activity, including against multidrug-resistant strains, suggesting its potential as a complementary antimicrobial agent. It also enhances the immune response by promoting apoptosis in infected macrophages, aiding in pathogen clearance. Additionally, C. asiatica offers hepatoprotective effects by mitigating liver toxicity caused by isoniazid and reduces oxidative stress through its antioxidant compounds. These combined effects highlight the herb's multifaceted role in TB management, though clinical validation is needed to confirm its application in human treatments.

3.5Potential for Further Research

The existing body of evidence regarding the potential application of Centella asiatica in tuberculosis (TB) treatment is primarily based on preclinical studies, including animal models and in vitro experiments. These studies have yielded promising results, indicating that Centella asiatica may exhibit antimycobacterial properties and potentially augment the efficacy of conventional TB treatments. Nevertheless, extrapolation of these findings to human patients necessitates rigorous clinical evaluation (Sun et al., 2020); (Liang et al., 2025).

To ascertain the true therapeutic potential of Centella asiatica for TB treatment, it is imperative to conduct well-designed clinical trials. These trials should evaluate various parameters, including optimal dosage, route of administration, potential drug interactions, and long-term safety profiles in human subjects. Furthermore, clinical studies are instrumental in determining whether the antimycobacterial effects observed in preclinical settings are replicated in patients with active TB infections. Such trials would also provide valuable insights into the capacity of plants to modulate the immune response, reduce inflammation, and potentially shorten the duration of TB treatment when used in conjunction with standard anti-TB drugs (Sun et al., 2020), (Liang et al., 2025).

4. CONCLUSION

Centella asiatica, a medicinal herb with a longstanding history of traditional application, exhibits significant potential in addressing the challenges associated with tuberculosis (TB) treatment. Its

antimycobacterial properties specifically target the causative agent, Mycobacterium tuberculosis, thereby potentially enhancing the efficacy of conventional antibiotic therapies. Moreover, the immunomodulatory effects of herbs may strengthen the body's natural defense mechanisms against TB infection, potentially leading to improved treatment outcomes and reduced disease progression. Additionally, the protective effects of C. asiatica against drug toxicity are particularly noteworthy in the context of TB treatment. Standard TB regimens often necessitate prolonged use of potent antibiotics, which can result in significant side effects, particularly hepatotoxicity. By mitigating these adverse effects, Centella asiatica could potentially improve patient adherence to treatment protocols and reduce the risk of treatment discontinuation. However, while these preliminary findings are promising, it is imperative to emphasize the necessity of rigorous clinical trials to establish optimal dosing, potential drug interactions, and long-term safety profiles before Centella asiatica can be confidently integrated into TB management strategies. Future research should also explore standardized formulations and delivery mechanisms to maximize therapeutic outcomes.

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