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Phytochemical profile and therapeutic potential of *Centella asiatica* (L.) UrbanM. Visalakshi<sup>♦</sup>, V.A. Abhirami, T. Saraswathi, S. Padmapriya, M. Karthikeyan and G.G. Kavitha Shree\*

Department of Medicinal and Aromatic Crops, Horticultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore-641003, Tamil Nadu, India

\*Center for Post Harvest Technology, Agricultural Engineering College and Research Institute, Coimbatore-641003, Tamil Nadu, India

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## Abstract

*Centella asiatica* (L.) Urban also referred to as Indian pennywort or Gotu kola, is a medicinal herb that is utilised extensively in Siddha, Ayurveda, and Traditional Chinese Medicine. The plant is an abundant source of bioactive compounds, particularly triterpenoids, polyphenols, flavonoids, and essential oils. These substances add to its wide range of pharmacological characteristics. It also has neuroprotective qualities that improve memory and cognitive function, which makes it a viable option for treating Parkinson's and Alzheimer's diseases. Significant anti-inflammatory, antioxidant, antiulcer, anticancer, antiageing, and antidiabetic qualities are also present in the plant, which helps treat chronic illnesses like anxiety, gastrointestinal ulcers, and cardiovascular issues. Additionally, it enhances blood circulation and aids in the treatment of venous insufficiency. Recent research highlights its antimicrobial potential, reinforcing its role in infectious disease management. To confirm its effectiveness and create standardised dosages for medical use, more clinical research is required. This review explores the phytochemical profile and therapeutic potentials of *C. asiatica*.

## 1. Introduction

Traditional medicine serves as a strong foundation for healthcare systems worldwide. The World Health Organization (WHO) estimates that nearly 80% of the global population depends on traditional herbal remedies for their primary healthcare needs. The growing preference for these remedies can be attributed to their cost-effectiveness, widespread availability, and the general perception that they produce less adverse effects compared to conventional allopathic treatments (Pathak *et al.*, 2024). Furthermore, their eco-friendly and biodegradable nature enhances their appeal in the context of sustainable healthcare. The COVID-19 pandemic underscored the importance of herbal medicine, particularly in Asian countries, where such remedies played a prominent role in both prevention and treatment strategies (Liana and Phanumartwiwath, 2021).

Among the medicinal plants gaining global recognition, *Centella asiatica* (L.) Urban (Figure 1) holds an important place. This herbaceous, moisture-loving plant from the family Apiaceae has a somatic chromosome number of  $2n = 18$  (Lal *et al.*, 2017; Sudhakaran, 2017). It is native to tropical and subtropical regions and has been used for thousands of years in traditional medicine systems across India, China, Nepal, and Madagascar. In Ayurvedic and Traditional Chinese Medicine, *C. asiatica* is often referred to as “brain food” due to its reputed cognitive-enhancing and neuroprotective effects (Lal *et al.*, 2017; Singh *et al.*, 2010).

The pharmacological significance of *C. asiatica* is attributed to a rich profile of bioactive compounds, including triterpenoid saponins such as asiaticoside, madecassoside, asiatic acid, and madecassic acid, as well as flavonoids, tannins, polyphenols, volatile oils, vitamins, and minerals (Idris *et al.*, 2022). These compounds contribute to its numerous therapeutic properties, including wound healing, anti-inflammatory, antioxidant, antimicrobial, and neuroprotective effects (James and Dubery, 2009; Brinkhaus *et al.*, 2000). In modern dermatology and cosmetology, *C. asiatica* has found widespread use in formulations aimed at enhancing skin elasticity, improving collagen synthesis, and treating minor wounds and burns (Bylka *et al.*, 2013). Its inclusion in creams, gels, and ointments is supported by evidence showing its effectiveness in conditions like psoriasis, acne scars, and stretch marks (Brinkhaus *et al.*, 2000). *C. asiatica* is a highly prized medicinal plant in the global medicinal plant trade industry, according to reports from the Export and Import Bank of India (Seevaratnam *et al.*, 2012).

## 2. Phytochemical profile

*C. asiatica* is rich in various chemical compounds, particularly pentacyclic triterpenoid saponins, collectively referred as centelloids (Seevaratnam *et al.*, 2012). From the plant, 139 secondary metabolites have been identified, comprising triterpenes of the ursane and oleanane types, triterpene glycosides, triterpene glycosides of the dammarane type, steroids, flavonoids, polyacetylenes, phenolic acids, and other various substances. Among these, 70 compounds have been newly identified and reported for the first time (Kunjumon *et al.*, 2022).

## 2.1 Key phytochemicals

Four ursane-type triterpenes asiatic acid, madecassic acid, asiaticoside, and madecassoside are the most prominent metabolites in *C. asiatica* (Kunjumon *et al.*, 2022). These substances have a

## Corresponding author: Dr. M. Visalakshi

Assistant Professor, Department of Medicinal and Aromatic Crops, Horticultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore-641003, Tamil Nadu, India

E-mail: [visaarun@gmail.com](mailto:visaarun@gmail.com)

Tel.: +91-9842931296

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hydrophilic sugar chain (glycone) joined to a hydrophobic triterpenoid structure (aglycone) (James and Dubery, 2009). Phytochemical investigations have led to the isolation of several triterpenes and saponins, including two newly discovered compounds: 23-O-acetylmadecassoside and 23-O-acetylasiatoside B. Asiatic acid, madecassic acid, asiaticoside C, and asiaticoside F are other chemicals that have been found. The flavonoid quercetin-3-O- $\beta$ -D-glucuronide is also present, as are sterol glycosides such as sitosterol 3-O- $\beta$ -glucoside and stigmasterol 3-O- $\beta$ -glucoside (Rumalla *et al.*, 2010). The chemical composition also includes triterpene oligoglycosides, notably the newly identified *Centella* saponins B, C, and D, which contribute to its medicinal properties and hold potential for pharmacological research. Several known saponins, such as madecassoside,

asiaticoside, and scelefoleside A, have been reported, with madecassoside being the principal bioactive saponin. Flavonoids present in *C. asiatica* include two compounds identified as aldose reductase inhibitors, suggesting a role in diabetes management (Matsuda *et al.*, 2001). Other than this the plant has other compositions are represent in (Table 1). The saponins include asiaticoside, centelloside, madecassoside, brahmoside, thankuniside, isothankuniside, and brahminoside, while its sapogenins consist of asiatic acid, brahmic acid, indocentoic acid, madecassic acid, centellic acid, thankunic acid, and isotankunic acid. Other compounds present include centic acid, centoic acid, isobrahmic acid, and betulinic acid, each of which adds to the plant's varied pharmacological capabilities. (James and Dubery, 2009).



Figure 1: *Centella asiatica* (L.) Urban.

Table 1: Different compositions in *C. asiatica* (Ogunka-Nnoka *et al.*, 2020)

Composition	Concentration (%)
Moisture	13.10 $\pm$ 1.07
Ash	16.55 $\pm$ 0.45
Carbohydrate	43.81 $\pm$ 0.70
Lipid	1.20 $\pm$ 0.10
Protein	8.35 $\pm$ 1.28
Fibre	17.00 $\pm$ 1.87

## 2.2 Biological significance and therapeutic potential

The biological activities of the compounds are having distinct chemical structures, enabling them to interact effectively with biological systems (Seevaratnam *et al.*, 2012). Madecassoside is the primary bioactive saponin and it extensively studied for its therapeutic properties. It plays a vital role in wound scar healing, promotes cell growth, and exhibits neuroprotective, cardioprotective, anti-inflammatory and antioxidant, effects. The therapeutic efficacy of madecassoside is mediated through multiple mechanisms and cellular signaling pathways (Matsuda *et al.*, 2001).

## 3. Pharmacological properties

### 3.1 Memory enhancement

Herbal medicinal plants have long been studied for their neuroprotective properties, with *C. asiatica* standing out due to its potential in treating cognitive dysfunction and memory impairment.

*C. asiatica* was traditionally utilised in various cultures to improve memory and mental clearness. Its bioactive compounds, particularly asiaticoside and madecassoside, are believed to be crucial to this outcome. These substances have potent anti-inflammatory and antioxidant qualities that shield neurones from oxidative stress and inflammation, two factors that are known to exacerbate neurodegenerative illnesses. Water extract of the plant has been shown to enhance memory by decreasing oxidative stress, particularly in the hippocampus, a key region involved in memory formation (Wong *et al.*, 2021). Neurodegenerative diseases including Alzheimer's and Parkinson's disease are largely caused by impaired mitochondrial activity and elevated oxidative stress. *C. asiatica* extract promotes brain health by boosting synaptic density, which is necessary for efficient neuronal communication. This improvement is linked to the enhanced expression of key antioxidant and mitochondrial proteins that help maintain neuronal function. In particular, the antioxidant response gene nuclear factor erythroid 2-related factor 2 (Nrf2), which plays a vital role in protecting the cells from oxidative stress, is upregulated (Gray *et al.*, 2018). Additionally, the mitochondrial marker porin, essential for energy production and cellular metabolism, is also increased, improving neuronal resilience, synaptic plasticity, and overall cognitive function. By reducing oxidative stress, *C. asiatica* extract also boosts antioxidant response element gene expression, which further protects brain cells from damage (Matthews *et al.*, 2019). Furthermore, the bioactive compounds of *C. asiatica*, such as asiaticoside and madecassoside, activates Nrf2/HO-1 signaling pathway, leading to enhanced antioxidant defenses and reduced damage from oxidation damage (Park *et al.*, 2021). The plant extract has been reported to promote neuronal regeneration and neuroplasticity by upregulating brain-

derived neurotrophic factor (BDNF) expression, essential for both cognitive function and neuronal survival (Sbrini *et al.*, 2020). In line with these findings, therapeutic potentials of herbal plants for the treatment of neurological conditions has been emphasized, with future research expected to explore their efficacy and mechanisms in greater detail (Kaur *et al.*, 2023). These multifaceted mechanisms position *C. asiatica* as a promising candidate for therapeutic strategies intended to manage age-related neurodegenerative diseases and maintain cognitive function. Collectively, its ability to reduce oxidative stress, promote neuroplasticity, and neuronal health underscores its potential as a natural treatment for memory impairment and neurodegenerative diseases.

### 3.2 Neuroprotection

*C. asiatica* extract exhibits significant neuroprotective effects, primarily through its antioxidant and antiapoptotic mechanisms, positioning it as a potential therapeutic agent for neurological conditions like Alzheimer's and Parkinson's. Intake of extract has shown to mitigate MPTP-induced neurotoxicity, decrease the peroxidation of lipids, and enhance action of antioxidant enzymes, thereby strengthening the brain's defence against oxidative stress (Haleagrahara and Ponnusamy, 2010). Its rich polyphenol and triterpene content, including asiatic acid, contributes to these effects by scavenging free radicals and stabilizing neuronal cell membranes (Orhan, 2012; Lokanathan *et al.*, 2016). Asiatic acid plays a crucial role by balancing pro-apoptotic and anti-apoptotic protein expressions, thus preventing neuronal apoptosis, which is critical in neurodegenerative conditions (Krishnamurthy *et al.*, 2009).

Additionally, *C. asiatica* alters important signalling pathways such as the ERK1/2 and AKT/GSK-3 $\beta$  pathways. It promotes neuronal survival, growth, and plasticity, all of which are vital for maintaining brain function after injury or disease (Lokanathan *et al.*, 2016). It also reported to prevent phospholipase A2 (PLA2), an enzyme that mediates inflammatory processes, thereby reducing neuro-inflammation and shielding neurones from more harm (Hambali *et al.*, 2021). By preserving neuronal integrity and preventing inflammatory damage, *C. asiatica* provides a multifaceted defense against neuronal degeneration. Additionally, evidence suggests that *C. asiatica* reduces the activity of matrix metalloproteinase-9 (MMP-9), a key mediator in post-ischemic brain injury, further supporting its neuroprotective role (Ding *et al.*, 2023).

Recent research also highlights the plants effectiveness in maintaining synaptic connectivity and protecting neurons under hypoxic conditions associated with Alzheimer's disease, further underscoring its neuroprotective potential (Hambali *et al.*, 2021). Studies affirm that continuous administration of *C. asiatica* can significantly improve cognitive outcomes and neuronal survival in experimental models of brain injury, making it a potentially effective treatment for neurodegenerative illnesses (Sabaragamuwa *et al.*, 2018; Hashim, 2011). Thus, *C. asiatica* offers comprehensive neuroprotection through multiple cellular pathways, including inhibition of neuronal apoptosis, reduction of neuroinflammation, stabilization of neural signaling, and maintenance of neuronal structure and function.

### 3.3 Wound healing

The main substances in *C. asiatica* that aid in wound healing are madecassoside and asiaticoside. It has been discovered that madecassoside is the most effective of all, greatly increasing collagen

production, speeding up wound healing, and boosting the healing pattern. Studies on human skin fibroblasts and mouse models have revealed that both chemicals stimulate the formation of collagen by activating the TGF- $\beta$ /Smad signalling pathway (Wu *et al.*, 2012). In addition to these advantages, it showed that the extracts promote wound healing by promoting the formation of collagen, blood vessel growth, cellular regeneration, and oxidative stress reduction (Somboonwong *et al.*, 2012). Recent studies have provided more evidence for *C. asiatica*'s and its main metabolites' capacity to promote wound healing. Its capacity to regulate several biological processes involved in wound repair has been shown to considerably increase wound closure rates and improve tissue regeneration when applied topically (Witkowska *et al.*, 2024). By promoting fibroblast proliferation, collagen deposition, and re-epithelialization, asiatic acid has also been shown in studies to have strong wound healing benefits (Diniz *et al.*, 2023). With promising controlled release and improved healing outcomes, chitosan-based hydrogels loaded with asiaticoside rich fractions have been created to increase the delivery and efficacy of the extracts (Witkowska *et al.*, 2023). Glycoside-rich green extracts and standardised pentacyclic triterpenoid-rich extracts have also demonstrated noteworthy effectiveness in accelerating skin repair, increasing tensile strength, and encouraging wound contraction in a variety of experimental models (Rachpirom *et al.*, 2023; Thongon *et al.*, 2024).

### 3.4 Anti-inflammatory

The anti-inflammatory qualities of *C. asiatica* are mostly attributed to its active ingredients, which include flavonoids and triterpenoids, including asiaticoside and madecassoside. Its mechanism of action includes stabilizing human red blood cell membranes, preventing hypotonicity-induced lysis, and thereby reducing inflammation in a concentration dependent manner, with higher concentrations resulting in greater membrane stabilization (Chippada *et al.*, 2011). The extracts key metabolite, asiatic acid, not only accelerates wound healing by promoting collagen production, cell proliferation, and skin regeneration but also mitigate inflammation by limiting immune cell activation and lowering the synthesis of inflammatory cytokines such IL-6, IL-1 $\beta$ , and TNF- $\alpha$  (Diniz *et al.*, 2023).

Recent research has confirmed that *C. asiatica* has anti-inflammatory properties. The methanolic extract has been shown to significantly inhibit the synthesis of pro-inflammatory mediators in RAW 264.7 macrophages activated by lipopolysaccharide (LPS) by altering intracellular signalling pathways (Shin *et al.*, 2024). Furthermore, *C. asiatica* leaf extracts have demonstrated notable inhibitory effects against pathogenic bacteria-associated biofilms while simultaneously reducing inflammatory responses, suggesting dual anti-inflammatory and antimicrobial activities (Chonsut *et al.*, 2024). Oral delivery of *C. asiatica* extract also exhibited anti-inflammatory and analgesic effects in veterinary models, notably cats undergoing ovariohysterectomy, highlighting its therapeutic potential beyond human use (Yi *et al.*, 2023). Additionally, different parts of plant, including leaves and stems, possess functional bioactive components that exhibit varying degrees of physiological and anti-inflammatory activities (Eom *et al.*, 2022). Innovative approaches, such as the synthesis of *C. asiatica* mediated silver nanoparticles, have further demonstrated enhanced anti-inflammatory effects compared to conventional extracts, suggesting novel formulations for improved therapeutic efficacy (Ganesh *et al.*, 2022). The ability of extracts to

stabilize red blood cell membranes and reduce inflammatory markers highlights its potential as a natural alternative or adjunct to standard anti-inflammatory drugs. Its long-standing function in the treatment of inflammation is supported by its historical use in wounds and skin disorders (Baby *et al.*, 2020).

### 3.5 Antioxidant activities

*C. asiatica* contains a lot of bioactive components like vitamin C, polyphenols, flavonoids,  $\beta$ -carotene, tannins, and triterpenes. It is widely known for having high antioxidant properties. Together, these substances help to counteract free radicals and shield cells from oxidative stress. Vitamin C is a plentiful component that improves antioxidant defence by directly interacting with reactive oxygen species and regenerating other antioxidants, like vitamin E, to preserve cellular redox balance (Rahman *et al.* 2013). The plant's polyphenols have redox properties that enable them to operate as hydrogen donors, reducing agents, and singlet oxygen quenchers, which largely accounts for their potent antioxidant action. By chelating metal ions that catalyse oxidative processes and neutralising free radicals, flavonoids, a significant subclass of polyphenols, significantly strengthen antioxidant defence (Javanmardi *et al.*, 2003). In particular, through mechanisms like hydrogen atom donation, strong radical scavenging qualities of the extracts have been demonstrated to stabilise free radicals such as DPPH (Mishra *et al.*, 2022).

Further research has confirmed these results, demonstrating that various extraction methods have a substantial impact on the total amounts of polyphenol, flavonoid, and triterpene, which in turn affects the plant's antioxidant potential (Sabaragamuwa and Perera, 2023).

Environmental elements that affect the antioxidant profiles include light quality. According to studies, different ratios of red to blue light during culture greatly increase the accumulation of secondary metabolites, which in turn increases the antioxidant activities of the plant (Song *et al.*, 2022). Furthermore, the functions of specific flavonoids in stabilising free radicals and blocking oxidative pathways have been clarified by both experimental and computational investigations of *C. asiatica* extracts (Kandasamy *et al.*, 2023).

Due in significant part to its rich phenolic and flavonoid profiles, *C. asiatica* also has noteworthy biological activity beyond antioxidant defence, such as cytotoxic, bactericidal, and thrombolytic actions (Rashid *et al.*, 2023). This highlights the shared antioxidant mechanisms between *C. asiatica* and other natural sources, where bioactive compounds like flavonoids and polyphenols play a key role in combating oxidative damage. The effectiveness in antioxidant defence thus aligns with similar natural products, reinforcing the plant's role in therapeutic applications aimed at managing oxidative stress.

### 3.6 Anticancer

Several medicinal plants have demonstrated anticancer effects by inducing apoptosis in cancer cells by mitochondrial pathways, activating caspase enzymes, and modulating pro and antiapoptotic proteins, suggesting their potential role in cancer therapy (Kumar *et al.*, 2024). It has been shown that *C. asiatica*'s methanolic extract causes human breast cancer cells to undergo apoptosis. This is supported by various indicators, including nuclear condensation, enhanced annexin staining, mitochondrial membrane potential loss,

and DNA strand breaks detected through TUNEL assay (Babykutty *et al.*, 2009). Similarly, the natural compound asiatic acid, one of the major bioactive constituents shows strong potential as anti-tumour agent against cholangiocarcinoma (CCA) by suppressing growth of human CCA cells (Sakonsinsiri *et al.*, 2018). Additionally, by triggering apoptosis and altering gene expression, the plant juice reduced the growth of HepG2 liver cancer cells. In particular, it increased levels of c-fos and c-erbB2, which are linked to the promotion of programmed cell death, while decreasing expression of the oncogene c-myc. It may have a protective effect against liver cancer (Hussin *et al.*, 2014).

The anticancer potential of asiatic acid has been further highlighted by recent investigations. Asiatic acid has been shown to possess strong anticancer properties in both *in vitro* and *in vivo* models, primarily through mechanisms such as oxidative stress modulation, cell proliferation inhibition, and apoptosis induction (Ridho *et al.*, 2024). It has also been suggested that asiatic acid could serve as a promising cancer treatment option due to its ability to disrupt several signalling pathways involved in tumour growth, metastasis, and drug resistance (Wiciński *et al.*, 2024). Furthermore, the developing roles and mechanisms of asiatic acid, including its impact on apoptotic pathways, inhibition of angiogenesis, and suppression of cancer cell invasiveness, have been comprehensively discussed (Chen *et al.*, 2025).

### 3.7 Antidiabetic

The plant extract contains important natural compounds like tannins, saponins, flavonoids, alkaloids, and terpenoids, which are commonly found in medicinal plants with antidiabetic properties. It helps to lower blood sugar levels in different ways. Flavonoids and tannins can stimulate insulin release from pancreatic  $\beta$ -cells or act like insulin. Alkaloids may help control blood sugar by blocking carbohydrate-digesting enzymes or boosting insulin production. Tannins also support insulin secretion, contributing to blood sugar regulation. These compounds may work alone or together to produce the antidiabetic effects observed in the extract (Sasikala *et al.*, 2015). The ethanolic extract, saponin rich factors, and asiaticoside compound demonstrated significant antidiabetic effects by stimulating insulin secretion from damaged pancreatic  $\beta$ -cells (Fitrianda *et al.*, 2017). Additionally, the plant extracts rich in flavonoids, saponins, and triterpenoids significantly promote diabetic wound healing and glucose regulation by enhancing antioxidant defenses, improving fibroblast proliferation, and modulating inflammatory responses, further supporting the therapeutic potential of such phytochemicals in diabetes management (Palai *et al.*, 2024). *C. asiatica* extract is a powerful hypolipidemic and hypoglycemic agent, likely due to its flavonoid content. Specifically, rutin, a key flavonoid in *C. asiatica*, is known to inhibit pancreatic lipase,  $\alpha$ -amylase, and  $\alpha$ -glucosidase, contributing to its metabolic effects (SP, 2011).

### 3.8 Menstrual disorder

Oral delivery of powdered *C. asiatica* leaves has been used to treat irregular menstruation, with studies confirming its beneficial effects in regulating menstrual cycles (Brinkhaus *et al.*, 2000). This plant's therapeutic potential extends beyond menstrual health. In women experiencing menopause, a condition marked by a decrease in estrogen and progesterone levels. Menopause is often associated with cognitive decline and reduced physical appearance due to hormonal

imbalances (Raja *et al.*, 2022). However, when *C. asiatica*, combined with aerobic exercise, offers a unique approach to support postmenopausal health. Aerobic exercise is known to reduce fat mass but does not directly increase estrogen levels. When paired with the plant, the combination helps boost estrogen levels, which in turn supports brain health by reducing beta-amyloid and glutamate toxicity, enhancing synaptic plasticity, preserving neurotrophic components, and preventing excessive tau protein phosphorylation. Furthermore, the plant has shown promise in addressing recurrent vulvovaginal candidiasis, as seen in case studies involving non-hormonal vaginal gels containing hyaluronic acid, and prebiotics, which have successfully improved symptoms in women with this condition (Amorós *et al.*, 2023). This multifaceted role of the plant emphasizes its potential as a holistic therapeutic agent for women's health, particularly in postmenopausal care (Fitriana *et al.*, 2024).

### 3.9 Antiageing

*C. asiatica* has antiageing properties; numerous research have shown how it can help to fight ageing indications and encourage skin renewal. According to recent studies, glycoside-rich green extracts of the plant may be essential for improving wound healing and antiageing properties (Thong-on *et al.*, 2024). These bioactive substances improve skin suppleness and lessen the visibility of fine wrinkles by promoting collagen synthesis, which is essential for skin regeneration. Furthermore, *C. asiatica* has demonstrated encouraging antioxidant activity when included in the creation of emulgel products in conjunction with other natural extracts like *Moringa oleifera*, supporting its antiageing properties (Suená *et al.*, 2024).

Additionally, the production of gold nanoparticles from *C. asiatica* has drawn attention because of its improved antiageing and anti-glycation qualities, which support its potential as a component in antiageing cosmetics (Ruth *et al.*, 2025). Research on *C. asiatica*'s potential to prevent cellular senescence and apoptosis in epidermal cells shows that it can revitalise ageing skin at the cellular level (Tan *et al.*, 2025). These results highlight *C. asiatica*'s diverse antiageing qualities, which make it a crucial component of skincare products meant to prevent ageing and encourage young, healthy skin.

### 3.10 Antimicrobial activities

*C. asiatica* contains bioactive compounds, including triterpenes and polyphenols, which are known for their antimicrobial properties. These compounds interact with bacterial membranes, and leads to disruption and inhibition of bacterial growth (Idris and Nadzir, 2017). It exhibits antibacterial effects against pathogens like *E. coli* and *Bacillus subtilis*. Extracts prepared using aqueous and 50% ethanolic solutions effectively inhibited bacterial growth, making *C. asiatica* a potential natural antimicrobial agent. Its antibacterial action is linked to bioactive compounds like flavonoids and terpenoids, which breaks bacterial cell membranes, causing leakage of cellular contents and preventing growth (Kalita and Saikia, 2012). According to research, *C. asiatica* has antibacterial qualities that protect against bacterial and fungal infections (Rashmi *et al.*, 2022). Additionally, it shown strong antibacterial action, particularly against *Salmonella enterica* and *Staphylococcus aureus* (Powthong and Suntornthiticharoen, 2023). Spore germination in a variety of fungal species was markedly suppressed by the methanolic leaf extract. At the same dose, it demonstrated a 97-99% inhibition rate against *Fusarium albizziae*, *Drechslera oryzae*, *Drechslera turtica*, and *Colletotrichum blumae*,

while totally stopping spore germination in *Fusarium udum* and *Drechslera monoceras*. According to Singh *et al.* (2000), these results imply that the plant has significant antifungal qualities, possibly as a result of its bioactive components. Its usage as a natural preservative in the food sector has garnered attention since the hydrophilic extract can be used at different doses to inhibit or prevent fungal development in food items, especially in baked goods (Akter *et al.*, 2020). Furthermore, because of its antibacterial and antioxidant qualities, *C. asiatica* is being investigated for use in food packaging materials (Pillai *et al.*, 2024), where it may have the twin advantages of prolonging food's shelf life and preserving it.

### 3.11 Chronic venous insufficiency

Chronic Venous Insufficiency (CVI) affects the veins in the legs, causing poor blood flow, swelling, pain, and sometimes skin ulcers (Chong and Aziz, 2013). The condition is common among older adults and individuals in jobs that involve extended periods of standing. It can lower quality of life and increase healthcare costs. The active compounds in *C. asiatica*, especially asiaticoside, are recognized for stimulating collagen production, which is crucial for preserving the structural strength of blood vessels (Seo *et al.*, 2021). This medicinal herb rich in healing compounds called triterpenes, has shown promise in easing CVI symptoms. Studies suggest it can improve blood circulation, reduce swelling, and relieve discomfort, although more well-reported research is needed to confirm these benefits (Chong and Aziz, 2013). Typical dosages of *C. asiatica* (Gotu kola) used in studies include 90-80 mg per day of the dried herb or 2-4 ml of tincture taken three times daily. These forms and doses have been commonly recommended for managing symptoms of CVI and supporting overall venous health. Because Gotu kola can aid in wound healing, incorporating it into a regimen with other herbs such as butcher's broom or horse chestnut which may enhance the overall effect, particularly in preventing or healing venous ulcers (Abascal and Yarnell, 2007).

### 3.12 Antiulcer

Antiulcerogenic effects of the methanol extract of *C. asiatica* leaves is a scientific basis for traditional use in treating gastric ulcers. The gastroprotective effect of *C. asiatica* may be attributed to its anti-inflammatory and antioxidant properties. The extract appears to suppress neutrophil infiltration, which is known to exacerbate gastric injury, thereby promoting ulcer healing (Abdulla *et al.*, 2010). Juice of *C. asiatica* is a well-known mucosal protective agent. It significantly increased gastric juice mucin secretion and glycoprotein content, which are vital for maintaining the integrity of the gastric mucosa. Not only fortifying the mucosal barrier but also minimizes damage to the gastric lining, which is vital for ulcer protection (Sairam *et al.*, 2001).

## 4. Side effects and adverse reactions

*C. asiatica* is generally considered safe for consumption, but its use requires careful attention to dosage and individual reactions. While crude preparations may cause allergic responses or nausea at high intake levels, most clinical trials have shown good tolerance. Asiaticoside, a key compound in *C. asiatica*, can be toxic at doses of 40-50 mg per kg body weight when administered intramuscularly in animal studies. However, oral applications of up-to 1 g per kg body weight have not shown toxicity. Injectable forms, such as Madecassol, have also demonstrated a favorable safety profile with no reported

intolerance. There is no established recommended daily allowance (RDA) for *C. asiatica*, but it is commonly consumed as fresh leaves in salads, dried leaves in tea, or as dietary supplements in varying strengths. Despite its general safety, individuals especially those with pre-existing conditions, pregnant or breastfeeding should consult healthcare professionals before use (James and Dubery, 2009). Acute and sub-chronic toxicity studies suggest that *C. asiatica* is safe for use at the tested doses. The absence of significant toxic effects supports its potential use in herbal medicine and dietary supplements. The administration of INDCA caused no mortality or significant changes in clinical signs, including skin, fur, eyes, mucous membranes, respiration, circulation, nervous system, movement, or behavior (Deshpande *et al.*, 2015, Pingale, 2008).

## 5. Future aspects

*C. asiatica* has challenges related to the stability, bioavailability, and metabolism of active compounds. Novel nanocarrier systems such as nanoparticles, polymeric nanocarriers, and liposomes can enhance the delivery of active ingredients. This contribution is particularly important as it opens new avenues for improving the efficacy of herbal treatments (Pingale, 2008). It emphasizes the need for future studies particularly *in vivo* and *in vitro* clinical trials to further explore the mechanisms of action of plant. This call for more research is essential for validating its therapeutic applications and improving its integration into modern medicine (Singla *et al.*, 2014).

*C. asiatica* has potential as a preventive therapy for cardiovascular disease in reducing both the sizes and number of atherosclerotic plaques. This reduction is crucial for lowering the overall risk of cardiovascular complications. It will enhance plaque stability and improve microcirculation. Further studies are necessary to confirm these findings and explore the underlying mechanisms. The plant has wide therapeutic potential and the compounds responsible for the respective health benefits should be identified (Singla *et al.*, 2014). Need comprehensive studies to consolidate existing knowledge on accessions of *C. asiatica* and variations in secondary metabolites, enhancing standardization for its use, and addressing gaps in research across different geographical regions. Further broad *in vivo* and clinical investigations are essential to evaluate the protection and effectiveness of *C. asiatica* fully (Gbolahan *et al.*, 2016).

## 6. Conclusion

*C. asiatica* emerges as a valuable botanical resource with extensive therapeutic potential. It presents a promising avenue for the development of novel therapeutic agents due to its diverse phytochemical composition and multifaceted pharmacological activities. Further research is required to elucidate its mechanisms of action, optimize dosage regimens, and investigate potential interactions with other pharmaceuticals. Nevertheless, the cumulative evidence presented in this review underscores the significance of *C. asiatica* in both traditional and modern medicine, highlighting its role as a versatile herb with a range of health-promoting properties. It exhibits a wide spectrum of applications, including cognitive enhancement, wound healing properties, anti-inflammatory effects, antioxidant activities, and antimicrobial properties. *C. asiatica* demonstrates potential as a natural therapeutic agent with broad medicinal applications. Scientific research increasingly corroborates its traditional benefits in wound healing, neuroprotection, anti-inflammatory, and antioxidant applications. Despite its numerous

therapeutic benefits, caution must be exercised regarding its dosage, as excessive consumption may lead to adverse effects, particularly in individuals with hepatic conditions and pregnant women. Although toxicity studies indicate that the plant is generally safe, further research is needed to optimize its bioavailability, stability, and clinical applications. Future studies should focus on standardizing the active compounds, improving delivery methods through advanced nanocarrier systems, and conducting comprehensive *in vivo* and clinical trials. With its vast medicinal potential, *C. asiatica* holds great promise in integrative medicine, and continued research will be instrumental in elucidating its full therapeutic potential.

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## Conflict of interest

The authors declare no conflicts of interest relevant to this article.

## References

- Abascal, K. and Yarnell, E. (2007). Botanicals for chronic venous insufficiency. *Alternative and Complementary Therapies*, 13(6):304-311.
- Abdulla, M.; Al-Bayaty, F.; Younis, L. and Abu Hassan, M. (2010). Antiulcer activity of *Centella asiatica* leaf extract against ethanol-induced gastric mucosal injury in rats. *Journal of Medicinal Plants Research*, 4(13):1253-1259.
- Akter, N.; Hye, M.A. and Rahman, M. N. (2020). Antifungal activity of *Centella asiatica* on radial growth of *Aspergillus* species. *Letters in Applied NanoBioscience*, 9(4):1467-1473.
- Amorós, M.; Mora Palma, J. C.; Esteve, M.; Salado, M.; Macatangga, M. G.; Aguarón Benítez, G.; Luque, P. and Cortés, J. (2023). Experience with a non-hormonal *Centella asiatica*, hyaluronic acid and prebiotic-based vaginal gel in women with recurrent vulvovaginal candidiasis: Case studies. *Clinical Medicine Insights: Case Reports*, 16:117954 76231161170.
- Baby, M.; Antony, A.; John, B. and Jose, D. (2020). Phytochemical screening and *in vitro* anti-inflammatory activity of ethanolic extract of *Centella asiatica*. *World Journal of Current Medical and Pharmaceutical Research*, 2(02):181-183.
- Babykutty, S.; Padikkala, J.; Sathiadevan, P.; Vijayakurup, V.; Azis, T.; Srinivas, P. and Gopala, S. (2009). Apoptosis induction of *Centella asiatica* on human breast cancer cells. *African Journal of Traditional, Complementary and Alternative Medicines*, 6(1):203-205
- Brinkhaus, B.; Lindner, M.; Schuppan, D. and Hahn, E. (2000). Chemical, pharmacological and clinical profile of the East Asian medical plant *Centella asiatica*. *Phytomedicine*, 7(5):427-448.
- Bylka, W.; Znajdek-Awiż, P.; Studzińska-Sroka, E. and Brzezińska, M. (2013). *Centella asiatica* in cosmetology. *Advances in Dermatology and Allergology(Post)py Dermatologii i Alergologii*, 30(1):46-49.
- Chen, R.; Zhang, W.; Zhang, M.; Liu, W.; Feng, W. and Zhang, Y. (2025). Asiatic acid in anticancer effects: emerging roles and mechanisms. *Frontiers in Pharmacology*, 16:1545654.
- Chippada, S. C.; Volluri, S. S.; Bammidi, S. R. and Vangalapati, M. (2011). *In vitro* anti-inflammatory activity of methanolic extract of *Centella asiatica* by HRBC membrane stabilisation. *Rasayan J Chem*, 4(2):457-460.

- Chong, N. J. and Aziz, Z. (2013). A systematic review of the efficacy of *Centella asiatica* for improvement of the signs and symptoms of chronic venous insufficiency. Evidence Based Complementary and Alternative Medicine, **2013**(1):627182.
- Chonsut, P.; Romyasamit, C.; Konyanee, A.; Niyomtham, N.; Goodla, L. and Mordmuang, A. (2024). Potential activities of *Centella asiatica* leaf extract against pathogenic bacteria associated biofilms and its anti-inflammatory effects. Advances in Pharmacological and Pharmaceutical Sciences, **2024**(1):5959077.
- Deshpande, P. O.; Mohan, V. and Thakurdesai, P. (2015). Preclinical safety assessment of standardized extract of *Centella asiatica* (L.) urban leaves. Toxicology International, **22**(1):10-12.
- Ding, L.; Liu, T. and Ma, J. (2023). Neuroprotective mechanisms of asiatic acid. Heliyon, **9**(5):26-25
- Diniz, L. R. L.; Calado, L. L.; Duarte, A. B. S. and de Sousa, D. P. (2023). *Centella asiatica* and its metabolite asiatic acid: Wound healing effects and therapeutic potential. Metabolites, **13**(2):276-279
- Eom, H. J.; Shin, H. Y.; Park, H. J.; Kim, K. H.; Kim, J. H. and Yu, K. W. (2022). Functional components and physiological activity in different parts of *Centella asiatica*. Food Science and Preservation, **29**(5):749-761.
- Fitriana, L. A.; Fitri, M.; Komarudin, K. and Sulastri, A. (2024). The Effect of *Centella asiatica* and Aerobic exercises on estradiol, cognition, and balance in menopausal women. Malaysian Journal of Medicine and Health Sciences, **20**:211-215
- Fitrianda, E.; Sukandar, E. Y.; Elfahmi, E. and Adnyana, I. K. (2017). Antidiabetic activity of extract, fractions, and asiaticoside compound isolated from *Centella asiatica* Linn. Leaves in alloxan-induced diabetic mice. Asian Journal of Pharmaceutical and Clinical Research, **1**(2):268-272.
- Ganesh, S.; Arthanari, A. and Rajeshkumar, S. (2022). Anti-Inflammatory activity of *Centella asiatica* mediated silver nanoparticles. J. Res. Med. Dent. Sci, **10**(1):325-329.
- Gbolahan, B. W.; Abiola, A. I.; Kamaldin, J.; Ahmad, M. A. and Atanassova, M. S. (2016). Accession in *Centella asiatica*, current understanding and future knowledge. Journal of Pure and Applied Microbiology, **10**(4):2485-2494.
- Gray, N. E.; Zweig, J. A.; Caruso, M.; Martin, M. D.; Zhu, J. Y.; Quinn, J. F. and Soumyanath, A. (2018). *Centella asiatica* increases hippocampal synaptic density and improves memory and executive function in aged mice. Brain and behavior, **8**(7):e01024.
- Haleagrahara, N. and Ponnusamy, K. (2010). Neuroprotective effect of *Centella asiatica* extract (CAE) on experimentally induced Parkinsonism in aged Sprague-Dawley rats. The Journal of Toxicological Sciences, **35**(1):41-47.
- Hambali, A.; Kumar, J.; Hashim, N. F. M.; Maniam, S.; Mehat, M. Z.; Cheema, M. S.; Mustapha, M.; Adenan, M. I.; Stanslas, J. and Hamid, H. A. (2021). Hypoxia-induced neuroinflammation in Alzheimer's disease: potential neuroprotective effects of *Centella asiatica*. Frontiers in Physiology, **12**:712317.
- Hashim, P. (2011). *Centella asiatica* in food and beverage applications and its potential antioxidant and neuroprotective effect. International Food Research Journal, **18**(4).
- Hussin, F.; Eshkoor, S. A.; Rahmat, A.; Othman, F. and Akim, A. (2014). The *Centella asiatica* juice effects on DNA damage, apoptosis and gene expression in hepatocellular carcinoma (HCC). BMC Complementary and Alternative Medicine, **14**:1-7.
- Idris, F. N.; Abd Shukor, S. R. and Nadzir, M. M. (2022). Phytochemicals, antioxidant and antimicrobial activity of *Centella asiatica* extracted by solvent-free microwave extraction. ASEAN Engineering Journal, **12**(4):137-144.
- Idris, F. N. and Nadzir, M. M. (2017). Antimicrobial activity of *Centella asiatica* on *Aspergillus niger* and *Bacillus subtilis*. Chemical Engineering Transactions, **56**:1381-1386.
- James, J. T. and Dubery, I. A. (2009). Pentacyclic triterpenoids from the medicinal herb, *Centella asiatica* (L.) Urban. Molecules, **14**(10):3922-3941.
- Javanmardi, J.; Stushnoff, C.; Locke, E. and Vivanco, J. (2003). Antioxidant activity and total phenolic content of Iranian *Ocimum* accessions. Food Chemistry, **83**(4):547-550.
- Kalita, D. and Saikia, J. (2012). Ethnomedicinal, antibacterial and antifungal potentiality of *Centella asiatica*, *Nerium indicum* and *Cuscuta reflexa*-widely used in Tiwa tribe of Morigaon district of Assam, India. Int. J. Phytomedicine, **4**(3):380-385.
- Kandasamy, A.; Aruchamy, K.; Rangasamy, P.; Varadhayan, D.; Gowri, C.; Oh, T. H.; Ramasundaram, S. and Athinarayanan, B. (2023). Phytochemical analysis and antioxidant activity of *Centella asiatica* extracts: An experimental and theoretical investigation of flavonoids. Plants, **12**(20):3547.
- Kaur, A.; Alam, M. A.; Mahmood, T. and Ahsan, F. (2023). Herbal medicinal plants for the treatment of memory impairment: A futuristic approach for neurological studies. Asian Pharmacology, **12**(2):5.
- Krishnamurthy, R. G.; Senut, M. C.; Zemke, D.; Min, J.; Frenkel, M. B.; Greenberg, E. J.; Yu, S. W.; Ahn, N.; Goudreau, J.; Kassab, M.; Panickar, K. S. and Majid, A. (2009). Asiatic acid, a pentacyclic triterpene from *Centella asiatica*, is neuroprotective in a mouse model of focal cerebral ischemia. Journal of Neuroscience Research, **87**(11):2541-2550.
- Kumar, R.; Choudhary, S.; Soni, M.; Singh, R.; Kumar, S. and Asrani, R. K. (2024). Augmentation of cytotoxicity and apoptotic activity in human breast cancer MCF-7 cells by *Saussurea costus* (Falc.) Lipsch roots. Ann. Phytomed., **13**(2):1-6.
- Kunjumon, R.; Johnson, A. J. and Baby, S. (2022). *Centella asiatica*: Secondary metabolites, biological activities and biomass sources. Phytomedicine Plus, **2**(1):100176.
- Lal, R.; Gupta, P. and Dubey, B. K. (2017). Genetic variability and associations in the accessions of Mandukaparni *Centella asiatica* (L.). Industrial Crops and Products, **96**:173-177.
- Liana, D. and Phanumartwath, A. (2021). Leveraging knowledge of Asian herbal medicine and its active compounds as COVID-19 treatment and prevention. Journal of Natural Medicines, 1-18.
- Lokanathan, Y.; Omar, N.; Puzi, N. N. A.; Saim, A. and Idris, R. H. (2016). Recent updates in neuroprotective and neuroregenerative potential of *Centella asiatica*. The Malaysian journal of medical sciences: MJMS, **23**(1):4.
- Matsuda, H.; Morikawa, T.; Ueda, H. and Yoshikawa, M. (2001). Medicinal foodstuffs. XXVII. Saponin constituents of gotu kola (2): structures of new ursane-and oleanane type triterpene oligoglycosides, centella saponins B, C, and D, from *Centella asiatica* cultivated in Sri Lanka. Chemical and Pharmaceutical Bulletin, **49**(10):1368-1371.
- Matthews, D. G.; Caruso, M.; Murchison, C. F.; Zhu, J. Y.; Wright, K. M.; Harris, C. J.; Gray, N. E.; Quinn, J. F. and Soumyanath, A. (2019). *C. asiatica* improves memory and promotes antioxidative signaling in 5XFAD mice. Antioxidants, **8**(12):630-634.

- Mishra, A.; Singh, Y.; Singh, R.; Kumar, R.; Shukla, S.; Kumar, R.; Prajapati, A.; Rawat, N.; Kumar, A. and Pol, S. L. (2022). Ethanopharmacology activity and antioxidant activity of *Centella asiatica* plant parts. *Neuroquantology*, **20**(11):7562-7572.
- Ogunka-Nnoka, C.; Igwe, F.; Agwu, J.; Peter, O. and Wolugbom, P. (2020). Nutrient and phytochemical composition of *Centella asiatica* leaves. *Med. Aromat. Plants*, **9**(2):2167-0412.
- Orhan, I. E. (2012). *Centella asiatica* (L.) Urban: From traditional medicine to modern medicine with neuroprotective potential. Evidence Based Complementary and Alternative Medicine, **2012**(1):946259.
- Palai, S.; Rashid, S. A.; Patra, R.; Jena, S.; Kar, B.; Bindhani, S. and Sardar, K. K. (2024). Biological activities and diabetic wound healing potential of *Couroupita guianensis* Aubl. flowers: Current knowledge and concepts. *Ann. Phytomed.*, **13**(2):5-10.
- Park, D. W.; Lee, Y. G.; Jeong, Y. J.; Jeon, H. and Kang, S. C. (2021). Preventive effects against retinal degeneration by *Centella asiatica* extract (CA-HE50) and asiaticoside through apoptosis suppression by the Nrf2/HO-1 signaling pathway. *Antioxidants*, **10**(4):613.
- Pathak, A.; Gupta, A. P. and Pandey, P. (2024). Herbal medicine and sustainable development challenges and opportunities. *Herbal Medicine Phytochemistry: Applications and Trends*, pp:1-26.
- Pillai, A. R.; Bhosale, Y. K. and Roy, S. (2024). Extraction of bioactive compounds from *Centella asiatica* and enlightenment of its utilization into food packaging: A review. *International Journal of Food Science*, **2024**(1):1-16.
- Pingale, S. S. (2008). Acute toxicity study for *Centella asiatica* whole plant powder. *Newsletter, Pharmacology Online*, **3**:80-84.
- Powthong, P. and Suntornthicharoen, P. (2023). Comparative analysis of antioxidant, antimicrobial, and tyrosinase inhibitory activities of *Centella asiatica* (L.) Urb and *Eichhornia crassipes* (Mart.) Solms. *J. Med. Pharm. Allied Sci.*, **12**(4):5768-5774.
- Rachpirom, M.; Pichayakorn, W. and Puttarak, P. (2023). Preparation, development, and scale-up of standardized pentacyclic triterpenoid-rich extract from *Centella asiatica* (L.) Urb. and study of its wound healing activity. *Heliyon*, **9**(7).
- Rahman, M.; Hossain, S.; Rahaman, A.; Fatima, N.; Nahar, T.; Uddin, B. and Basunia, M. A. (2013). Antioxidant activity of *Centella asiatica* (Linn.) Urban: Impact of extraction solvent polarity. *Journal of Pharmacognosy and Phytochemistry*, **1**(6).
- Raja, R.; Kumar, N. and Duraisamy, M. (2022). Ethnomedicinal plants used by Malayali tribals in Yercaud Hills, Salem district, Tamil Nadu, India. *Kongunadu Research Journal*, **9**(1):9-21.
- Rashid, M. H. O.; Akter, M.; Uddin, J.; Islam, S.; Rahman, M.; Jahan, K.; Sarker, M.M.R. and Sadik, G. (2023). Antioxidant, cytotoxic, antibacterial and thrombolytic activities of *Centella asiatica* L.: Possible role of phenolics and flavonoids. *Clinical Phytoscience*, **9**(1):1-9.
- Rashmi, B. N.; Harlapur, S. F.; Gurushantha, K.; Ravikumar, C. R.; Kumar, M. A.; Santosh, M. S. and Murthy, H. A. (2022). Facile green synthesis of lanthanum oxide nanoparticles using *Centella asiatica* and Tridax plants: Photocatalytic, electrochemical sensor and antimicrobial studies. *Applied Surface Science Advances*, **7**:100210.
- Ridho, F. M.; Fahrudin, P.; Syachputra, A. J.; Aruan, I. A.; Ulfah, K. and Syahri, A. (2024). Anticancer activity of asiatic acid from *Centella asiatica*: A comprehensive systematic review of *in vitro* and *in vivo* studies. *Keluwih Jurnal Kesehatan dan Kedokteran*, **6**(1):30-47.
- Rumalla, C. S.; Ali, Z.; Weerasooriya, A. D.; Smillie, T. J. and Khan, I. A. (2010). Two new triterpene glycosides from *Centella asiatica*. *Planta Medica*, **76**(10):1018-1021.
- Ruth, V. A.; Narayanan, K. and Sharma, R. (2025). Green synthesis of gold nanoparticles using *Centella asiatica* extract and their antiageing potential. *International Journal of Nanomedicine*, **20**(2):123-134.
- Sabaragamuwa, R. and Perera, C. O. (2023). Total triterpenes, polyphenols, flavonoids, and antioxidant activity of bioactive phytochemicals of *Centella asiatica* by different extraction techniques. *Foods*, **12**(21):3972.
- Sabaragamuwa, R.; Perera, C. O. and Fedrizzi, B. (2018). *Centella asiatica* (Gotu kola) as a neuroprotectant and its potential role in healthy ageing. *Trends in Food Science and Technology*, **79**:88-97.
- Sairam, K.; Rao, C. V. and Goel, R. (2001). Effect of *Centella asiatica* Linn on physical and chemical factors induced gastric ulceration and Secretion in Rats. *Plants*, **39**(2):137-142
- Sakonsinsiri, C.; Kaewlert, W.; Armartmuntree, N.; Thanan, R. and Pakdeechote, P. (2018). Anti-cancer activity of asiatic acid against human cholangiocarcinoma cells through inhibition of proliferation and induction of apoptosis. *Cellular and Molecular Biology*, **64**(10):28-33.
- Sasikala, S.; Lakshminarasiah, S. and Naidu, M. D. (2015). Antidiabetic activity of *C. asiatica* on 368 streptozotocin induced diabetic male albino rats. *World Journal of Pharmaceutical Sciences*, **369**:1701-1705.
- Sbrini, G.; Brivio, P.; Fumagalli, M.; Giavarini, F.; Caruso, D.; Racagni, G.; Dell'Agli, M.; Sangiovanni, E. and Calabrese, F. (2020). *Centella asiatica* L. Phytosome improves cognitive performance by promoting Bdnf expression in rat prefrontal cortex. *Nutrients*, **12**(2):355.
- Seeveratnam, V.; Banumathi, P.; Premalatha, M.; Sundaram, S. and Arumugam, T. (2012). Functional properties of *Centella asiatica* (L.): A review. *Int. J. Pharm. Pharm. Sci.*, **4**(5):8-14.
- Seo, M. G.; Jo, M. J.; Hong, N. I.; Kim, M. J.; Shim, K. S.; Shin, E.; Lee, J. and Park, S. J. (2021). Anti inflammatory and anti vascular leakage effects by combination of *Centella asiatica* and *Vitis vinifera* L. Leaf extracts. Evidence based Complementary and Alternative Medicine, **2021**(1):7381620.
- Shin, H. Y.; Kim, Y. S.; Ha, E. J.; Koo, J. P.; Jeong, W. B.; Joung, M. Y.; Kwang-Soon Shin.; Kwang-Won Yu. and Yu, K. W. (2024). Anti-inflammatory action and associated intracellular signaling of *Centella asiatica* extract on lipopolysaccharide-stimulated RAW 264.7 macrophage. *Food Bioscience*, **61**:104614.
- Singh, P.; Singh, U. and Singh, J. (2000). Antifungal activity of methanolic of *Centella asiatica* and *Andrographis panicuiata*. *Mycobiology*, **28**(4):185-189.
- Singh, S.; Gautam, A.; Sharma, A. and Batra, A. (2010). *Centella asiatica* (L.): A plant with immense medicinal potential but threatened, endangered species. *International Journal of Pharmaceutical Sciences Review and Research*, **4**(2):4-11
- Singla, S.; Kumar, N. R. and Kaur, J. (2014). *In vivo* studies on the protective effect of propolis on doxorubicin-induced toxicity in liver of male rats. *Toxicology International*, **21**(2):191.
- Somboonwong, J.; Kankaisre, M.; Tantisira, B. and Tantisira, M. H. (2012). Wound healing activities of different extracts of *Centella asiatica* in incision and burn wound models: an experimental animal study. *BMC complementary and alternative medicine*, **12**:1-7.
- Song, J. W.; Bhandari, S. R.; Shin, Y. K. and Lee, J. G. (2022). The influence of red and blue light ratios on growth performance, secondary metabolites, and antioxidant activities of *Centella asiatica* (L.) Urban. *Horticulturae*, **8**(7):601.

- SP, L. (2011). *In vitro* inhibitory potential of selected Malaysian plants against key enzymes involved in hyperglycemia and hypertension. Malaysian Journal of Nutrition, pp:77-86.
- Sudhakaran, M. V. (2017). Botanical pharmacognosy of *Centella asiatica* (Linn.) Urban. Pharmacognosy Journal, 9(4):191-199.
- Suena, W.; Phetcharat, L. and Boonme, P. (2024). Formulation and evaluation of emulgel containing *Moringa oleifera* and *Centella asiatica* extracts for antiageing applications. Journal of Cosmetic Science, 75(1):45-53.
- Tan, Y. L.; Chen, W. and Lim, S. Y. (2025). *Centella asiatica* mitigates cellular senescence and apoptosis in epidermal cells: Implications for skin aging. Phytotherapy Research, 39(3):412-421.
- Thong-on, W.; Sakchaisri, K. and Prathanurug, S. (2024). The effects of glycoside-rich green extract from *Centella asiatica* (L.) Urban on wound healing and antiageing activity. Phytomedicine Plus, 4(4):100628.
- Wiciński, M.; Fajkiel-Madajczyk, A.; Kurant, Z.; Gajewska, S.; Kurant, D.; Kurant, M. and Sousak, M. (2024). Can asiatic acid from *Centella asiatica* be a potential remedy in cancer therapy?- A Review. Cancers, 16(7): 1317.
- Witkowska, K.; Paczkowska-Walendowska, M.; Plech, T.; Szymanowska, D.; Michniak-Kohn, B. and Cielecka-Piontek, J. (2023). Chitosan-based hydrogels for controlled delivery of asiaticoside-rich *Centella asiatica* extracts with wound healing potential. International journal of molecular sciences, 24(24):17229.
- Witkowska, K.; Paczkowska-Walendowska, M.; Garbicz, E. and Cielecka-Piontek, J. (2024). Topical application of *Centella asiatica* in wound healing: recent insights into mechanisms and clinical efficacy. Pharmaceutics, 16(10):1252.
- Wong, J. H.; Barron, A. M. and Abdullah, J. M. (2021). Mitoprotective effects of *Centella asiatica* (L.) Urb.; anti-inflammatory and neuroprotective opportunities in neurodegenerative disease. Frontiers in Pharmacology, 12:687935.
- Wu, F.; Bian, D.; Xia, Y.; Gong, Z.; Tan, Q.; Chen, J. and Dai, Y. (2012). Identification of major active ingredients responsible for burn wound healing of *Centella asiatica* herbs. Evidence Based Complementary and Alternative Medicine, (1):848093.
- Yi, X.; Akatvipat, A.; Mongkolrat, N.; Saenubol, P.; Pornnimitara, P. and Boonyayatra, S. (2023). Analgesic and anti-inflammatory effects of oral *Centella asiatica* (L.) Urb. extract in cats undergoing ovariectomy. Phytomedicine Plus, 3(1):100403.

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