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CARDIOSPERMUM HALICACABUM L. (BALLOON VINE): A COMPREHENSIVE REVIEW OF PHYTOCONSTITUENTS, TRADITIONAL USES, AND PHARMACOLOGICAL ACTIVITIES

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ABSTRACT

Cardiospermum halicacabum Linn. (Sapindaceae), commonly known as balloon vine, is a versatile climbing herb with a prominent history in traditional medical systems, particularly Ayurveda and Siddha, for the management of chronic inflammatory, arthritic, and neuropsychiatric conditions. This review systematically consolidates the botanical characteristics, ethnomedicinal utility, comprehensive phytochemical profile, and modern pharmacological validation of the species. Extensive phytochemical evaluations reveal a rich matrix of bioactive secondary metabolites—predominantly flavonoids, triterpenoids, phytosterols, and saponins—distributed across the leaves, stems, roots, and seeds. Contemporary in vitro and in vivo investigations robustly corroborate traditional claims, demonstrating profound anti-inflammatory, anti-arthritic, antimicrobial, antidiarrheal, anti-ulcerogenic, anticonvulsant, and anxiolytic properties. Mechanistically, these therapeutic effects are driven by the targeted modulation of pro-inflammatory cytokines (including dual inhibition of TNF-α and NO pathways) and central neurotransmitters (such as GABAergic enhancement). While preclinical evidence provides strong empirical justification for its diverse ethnomedicinal applications, clinical translation remains a significant gap. Future research must prioritize the precise isolation of active pharmacological principles, thorough pharmacokinetic profiling, and the integration of advanced computational methodologies—such as network

pharmacology and molecular docking—to map complex compound-target interactions, ultimately paving the way for standardized, clinically validated phytopharmaceuticals.

KEYWORDS: *Cardiospermum halicacabum*, Ethnopharmacology, Anti-inflammatory, Flavonoids, Rheumatoid arthritis, Anticonvulsant.

INTRODUCTION

Cardiospermum halicacabum Linn. Commonly referred to as balloon vine, is a perennial climbing herb belonging to the family Sapindaceae. Widely distributed across tropical and subtropical regions of Asia, Africa, and the Americas, it has maintained a prominent position in traditional medical systems, particularly Ayurveda and Siddha, for centuries.[1] Botanically characterized by its distinct inflated, membranous fruit capsules, the plant is frequently utilized as both a medicinal herb and a dietary supplement in indigenous populations, where it is highly regarded for its therapeutic efficacy in managing chronic inflammatory and neuropathic conditions.[2]

The ethnomedicinal utility of *C. halicacabum* spans a broad spectrum of indications. The leaves, roots, and aerial parts are classically documented for the treatment of rheumatism, lumbago, arthritis, earaches, and fever.[3] This diverse ethnopharmacological profile has catalysed extensive phytochemical investigations, which have revealed a complex matrix of bioactive secondary metabolites. The plant's pharmacological potency is primarily attributed to its rich concentration of flavonoids, saponins, triterpenoids, and phytosterols. Specific molecular characterizations have isolated key active constituents, including apigenin, luteolin, rutin, chrysoeriol, and stigmasterol, which serve as the primary drivers of its documented biological activities.[4]

Modern in vitro and in vivo studies have increasingly corroborated the traditional claims surrounding *C. halicacabum*, providing empirical evidence for its potent anti-inflammatory, antioxidant, anti-arthritic, antipyretic, and anti-ulcerogenic properties.[5] Recent mechanistic studies demonstrate the plant's capacity to significantly modulate pro-inflammatory cytokines and inhibit crucial inflammatory pathways, including the cyclooxygenase (COX) and lipoxygenase (LOX) cascades. As the global pharmaceutical focus shifts toward standardized phytopharmaceuticals with rigorous quality assurance and clinical validation, understanding the mechanistic pathways and bioavailability of *C. halicacabum* extracts becomes essential. This review aims to systematically consolidate the current botanical, phytochemical, and

pharmacological literature concerning *C. halicacabum*, identifying prevailing research gaps and evaluating its translational potential for contemporary therapeutic applications.

TAXANOMICAL CLASSIFICATION[6]

Kingdom : Plantae

Division : Magnoliophyta

Class : Magnoliopsida

Order : Sapindales

Family : Sapindaceae

Sub-family : Sapindoideae

Genus : *Cardiospermum*

Species : *Cardiospermum halicacabum* Linn.

VERNACULAR NAMES[7]

English : Balloon vine, Love in a puff, Heart pea, Heart seed

Sanskrit : Indravalli, Sakralata, Jyotishmati

Hindi : Kapalphoti, Kanphuti

Kannada : Agniballi, Erumballi

Tamil : Mudukattan

Telugu : Ekkudutige, Budda kakara

Marathi : Kakumardanika, Shibjal

Bengali : Lataphatkari

Malayalam : Katabhi

SYNONYM

Cardiospermum corumdum L.

Cardiospermum glabrum

Cardiospermum inflatum

GEOGRAPHICAL DISTRIBUTION

Cardiospermum halicacabum L. (family Sapindaceae) is a widely distributed herbaceous climbing vine exhibiting broad ecological tolerance across tropical, subtropical, and warm temperate regions globally.[8,9] While its precise biogeographical origin is debated, the consensus classifies the species as native to the Neotropics—spanning Mexico, Central

America, and South America (including Brazil, Argentina, and Paraguay)—from where it has naturalized worldwide.[8,10]

Regional Occurrence and Status

The Americas: Beyond its native range in Neotropical regions, *C. halicacabum* has spread northward into the southern and eastern United States. In agricultural contexts, it is often regarded as a troublesome weed due to its rapid growth and the difficulty of separating its seeds from commercial crop harvests like soybeans.[10,11]

Asia: The species is widely distributed across South and East Asia, notably in India, Sri Lanka, Bangladesh, Myanmar, China, and the Philippines.[8,9] Although its native or alien status in parts of Asia remains a subject of ongoing botanical classification, it is widely naturalized in grasslands, disturbed riverbanks, and cultivated fields.[8,10] In India, it is treated as a naturalized non-native plant heavily integrated into traditional systems of medicine (e.g., Ayurveda).[8,12]

Africa and Oceania: *C. halicacabum* is extensively distributed across tropical and subtropical Africa (including East and South Africa) as well as the Pacific Islands and Australia.[10] In regions such as South Africa, Kenya, and parts of Australia, its ability to form dense mats smothering native understory vegetation has led to its classification as an invasive species.[10]

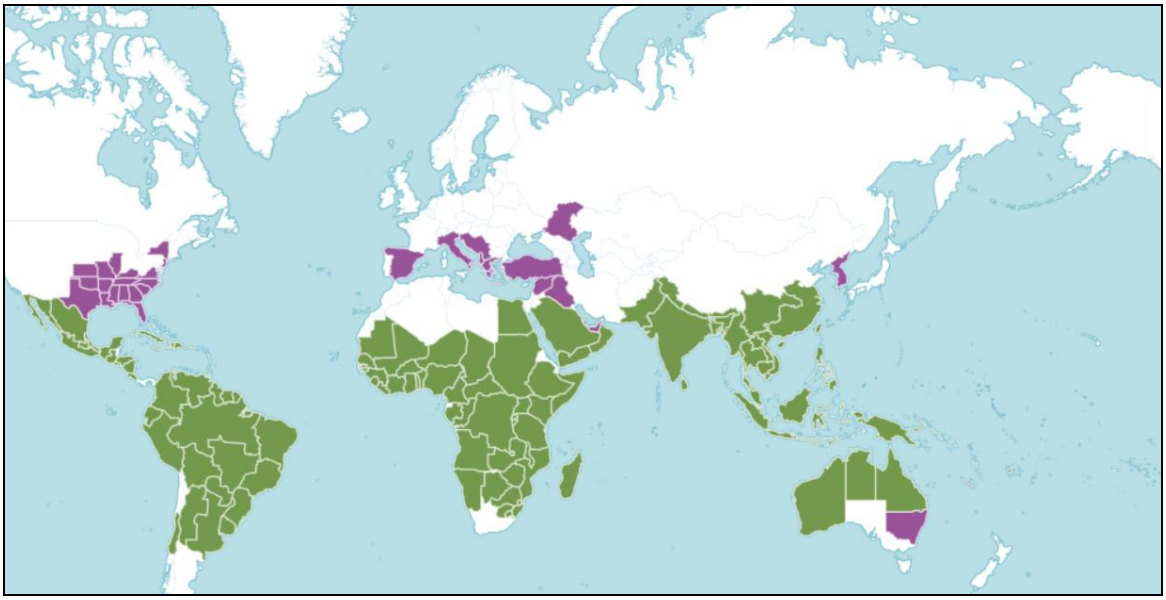

Figure 01: Global distribution of *Cardiospermum halicacabum*. Green: Native range.

Purple: Introduced and neutralized range. **Source**: POWO /KEW SCIENCE

MORPHOLOGICAL CHARACTERISTICS[13,14,15]

Cardiospermum halicacabum L., commonly known as the balloon vine or heartseed, is a branched, slender, herbaceous climber belonging to the family Sapindaceae. Depending on climate conditions, it grows as an annual or short-lived perennial liana, capable of reaching heights of 3 to 10 meters via tendril-assisted climbing.

Stem and Tendrils

The stems are slender, flexible, green, highly branched, and distinctly 5- or 6-grooved (striate). They vary from sub-glabrous to sparsely puberulent. Climbing is facilitated by axillary, peduncular, circinate tendrils (often arranged in pairs at the base of the inflorescence) that coil around adjacent support structures.

Leaves

The leaves are alternate, exstipulate, and biternate (triangular, twice-ternate compound leaves) measuring approximately 5–7 cm in length.

Inflorescence and Flowers

The inflorescence is an axillary, long-peduncled, umbellate cyme (peduncle 5–9 cm long) carrying 3 to 7 small, functionally unisexual (zygomorphic) flowers.

Seeds

Each of the 3 locules contains a single, globose-to-reniform seed (~5–6 mm in diameter). Seeds are smooth and turn from green to jet-black upon maturity, distinctly marked by a prominent, white, heart-shaped (cordate) aril/hilum around the micropyle—giving rise to both the generic name Cardiospermum ("heart-seed") and its primary common names.

[A]: Leaves

[B]: Ballon

[C]: Flowers

[D]: Seeds

Figure 02: Morphological features of *c. halicacabum*. source: POWO/KEW SCIENCE.

ETHNOMEDICAL USES

Cardiospermum halicacabum Linn. Possesses a rich history of utilization across diverse traditional medical systems, including Ayurveda, Unani, Homeopathy, and regional folk practices (16, 17). Across tropical and subtropical regions of Asia and Africa, the species is widely recognized for its versatile therapeutic applications, with nearly every anatomical part—including leaves, stems, roots, and seeds—utilized in ethnomedicinal remedies.[16,18]

Musculoskeletal and Inflammatory Disorders

The primary traditional indication for *C. halicacabum* is the management of inflammatory and musculoskeletal conditions. Decoctions, poultices, and oil preparations formulated from the leaves and aerial parts are extensively applied topically or administered orally to relieve joint pain, stiffness, rheumatoid arthritis, lumbago, and gouty arthritis.[16,18,19] In traditional Indian systems, leaves infused with warm castor oil are frequently applied to affected joints to alleviate swelling and localized pain.[18,19]

Gastrointestinal and Metabolic Ailments

The plant is traditionally recognized as a digestive tonic, laxative, stomachic, and emetic.[16,17] Oral decoctions prepared from the whole herb or roots are utilized to manage gastrointestinal disturbances such as dysentery, chronic diarrhea, and abdominal colic.[16,18] Furthermore, folk traditions employ root extracts as a demulcent to treat dropsy, jaundice, and metabolic disorders.[18,19]

Dermatological and Topical Applications

Topically, crude extracts and leaf pastes of *C. halicacabum* are prescribed for dermatological afflictions, including eczema, psoriasis, scabies, pruritus, and localized skin eruptions.[16,17] The crushed leaf juice is traditionally instilled into the ear canal to treat acute otalgia and otitis media.[16,18,19] Additionally, leaf pastes are applied as poultices to accelerate wound healing and reduce cutaneous swellings.[17,18]

Neurological and Systemic Conditions

In ethnomedicinal practice, *C. halicacabum* serves as a nervine tonic for neurological and psychiatric disturbances, such as anxiety, hyperthermia, and headaches.[16,17] Roots and seeds are employed for their antipyretic, diuretic, and emmenagogue properties, aiding in the management of malarial fevers, amenorrhea, and urinary tract infections.[16,17]

PHYTOCHEMICALS OF *CARDIOSPERMUM HALICACABUM*

SL.no	Parts of the plant	Phytoconstituents	References
01	LEAVES	Flavonoids (quercetin, kaempferol, luteolin, apigenin, rutin, vitexin, quercetin-3-O-α-L-rhamnoside, kaempferol-3-O-α-L-rhamnoside), Flavonoid glycosides (apigenin-7-O-β-D-glucuronide, luteolin-7-O-β-D glucuronide, chrysoeriol-7-O-glucuronide), Phenolic acids (gallic acid, caffeic acid, ferulic acid, p-coumaric acid,	[20,21,22,23,24]

		protocatechuic acid, benzene acetic acid), Sterols (β-sitosterol, stigmasterol, Campesterol), Triterpenoids (lupeol, phytol, squalene, friedelin), Sesquiterpenes (caryophyllene), Tannins (catechin, epicatechin), Diterpenes (neophytadiene, cyclohexane derivatives), Aliphatic hydrocarbons (hexadecane, heptadecane, nonadecane, 1-hydrotetradecane, 11-trimethyl-8-methylene, 14-methyl-8 hexadecyne), Nitrogenous compounds (N-methyl tomatidine, 3 methylbutanamide), phenylethyl alcohol, aliphatic esters, pinitol, cardiac glycosides, oxalic acid, amino acids.	
02	ROOTS	Alkaloids (indole alkaloids, piperidine derivatives), Flavonoids (quercetin, kaempferol, luteolin), Phenolic acids (gallic acid, caffeic acid, syringic acid, vanillic acid), Sterols (β-sitosterol, stigmasterol), Triterpenoids (lupeol, α-amyrin, β-amyrin), and cardiospermin (cyanogenic glucoside).	[20,25]
03	SEED	Flavonoids (quercetin, kaempferol, and rutin; Phenolic acids: gallic acid, caffeic acid, ferulic acid, chlorogenic acid), Sterols (β-sitosterol, stigmasterol, campesterol), and terpenoids/triterpenes (lupeol, phytol, squalene, and friedelin).	[20,23,24,25]
04	STEM	Flavonoids (quercetin, kaempferol, luteolin, apigenin), Phenolic acids (gallic acid, caffeic acid, ferulic acid), Sterols (β-sitosterol, stigmasterol, Campesterol), Triterpenoids (lupeol, α-amyrin, β-amyrin, friedelin), and terpenoids (phytol, neophytadiene)	[21,23,25]

PHARMACOLOGICAL ACTIVITY

Anti-inflammatory activity

The anti-inflammatory properties of the ethanolic fraction of *Cardiospermum halicacabum* leaf extract (EFC) have been analyzed by assessing its regulatory effects on key pro-inflammatory mediators associated with rheumatoid arthritis (RA). Evaluations demonstrate that EFC exerts a concentration-dependent suppression on tumor necrosis factor-alpha (TNF-α) production, achieving an IC50 of 17µg/mL in lipopolysaccharide (LPS)-stimulated human peripheral blood mononuclear cells (HPBMC) and LPS-activated L929 murine cell models. Furthermore, EFC significantly suppresses the production of nitric oxide (NO)—a free radical responsible for tissue damage and inflammatory amplification. In LPS-activated RAW 264.7 murine macrophage models, EFC yielded an IC50 value of 90 µg/mL and achieved 54% inhibition at a concentration of 100 µg/mL. Notably, MTS viability assays confirmed that these suppressive effects occurred without inducing cytotoxicity in the host cells. By demonstrating effective dual inhibition of both the TNF-α and NO pathways, these findings provide strong pharmacological justification for the traditional application of C.

halicacabum in the management of chronic inflammatory conditions and rheumatoid arthritis.[26]

Antibacterial activity

The pharmacognostic, phytochemical, and antimicrobial properties of *Cardiospermum halicacabum* L. have been systematically evaluated using its shade-dried leaves and stems. Crude extracts—prepared using acetone, alcohol, benzene, chloroform, and water—were analyzed to establish physiological baselines through pharmacognostic and fluorescence studies. Quantitative assessments of total, acid-insoluble, and water-soluble ash values, along with extractive yields, were conducted to provide standard parameters for detecting potential drug adulteration. Qualitative phytochemical screening confirmed the presence of diverse secondary metabolites, identifying phenols, tannins, and saponins in the leaves, alongside phenols, tannins, and amino acids in the stems. Furthermore, the antimicrobial efficacy of these extracts was assessed against seven clinically relevant Gram-positive and Gram-negative bacterial strains using the disc diffusion method. Ethanolic leaf and stem extracts exhibited notable activity against Streptococcus aureus and Bacillus subtilis (3 mm zone of inhibition). Additionally, acetone extracts of both parts demonstrated strong inhibitory effects against Salmonella typhi (3.5 mm zone of inhibition). Moderate antimicrobial activity was observed in benzene stem extracts against Escherichia coli and Pseudomonas aeruginosa, while acetone stem extracts effectively inhibited Klebsiella pneumoniae. Collectively, these findings underscore the therapeutic potential of *C. halicacabum*, positioning its leaves and stems as valuable bioactive sources for pharmaceutical development.[27]

Anti diarrheal activity

The antidiarrheal activity of *Cardiospermum halicacabum* (Linn.) has been evaluated to substantiate its application for enteric disorders from a traditional medicinal perspective. The therapeutic potential of the plant was investigated across various diarrhea-related rat models using petroleum ether (PeCH), alcoholic (AICH), and aqueous (AqCH) extracts. Qualitative phytochemical screening of these extracts revealed the presence of active secondary metabolites, including sterols, tannins, saponins, flavonoids, and triterpenes. Acute oral toxicity testing demonstrated no mortality in mice at doses up to 2000 mg/kg. Consequently, a dose of 400 mg/kg p.o. was selected to evaluate the extracts using castor oil-induced diarrhea, prostaglandin E2 (PGE2)-induced enteropooling, and charcoal meal gastrointestinal motility models. All evaluated extracts exhibited a statistically significant ($P < 0.01$)

antidiarrheal effect, with relative efficacy following the order of standard Loperamide > AqCH > AICH > PeCH. Among the plant fractions, the AqCH extract demonstrated the most potent activity against castor oil-induced diarrhea, inhibiting stool weight by 85.30%, reducing PGE2-induced intestinal fluid accumulation by 67.11%, and decreasing the gastrointestinal transit of the charcoal meal by 44.77%. It is proposed that the tannins and flavonoids act synergistically to precipitate intestinal proteins, reduce intestinal fluid secretion, and inhibit both hyperperistalsis and the metabolism of arachidonic acid.[27]

Anti-malarial activity

The mosquito larvicidal and ovicidal activities of crude leaf extracts of *Cardiospermum halicacabum* Linn. (Sapindaceae) have been investigated against the early third instar larvae and eggs of Culex quinquefasciatus and Aedes aegypti. Toxicity against both the mosquito larvae and eggs was assessed using five distinct extraction solvents: benzene, hexane, ethyl acetate, methanol, and chloroform. Findings indicate that both larvae and eggs exhibited sensitivity to all tested liquid extracts, with C. quinquefasciatus demonstrating a higher susceptibility. For C. quinquefasciatus, the median lethal concentration (LC50) values for larvicidal activity ranged from 150.44 ppm (methanol extract) to 193.31 ppm (hexane extract). Corresponding LC50 values for A. aegypti ranged from 156.80 ppm (methanol) to 200.02 ppm (hexane). In ovicidal bioassays conducted over a concentration gradient of 100 to 600 ppm, both methanol and benzene extracts demonstrated profound egg mortality. Complete inhibition of hatchability was achieved at 300 ppm for C. quinquefasciatus and at 400 ppm for A. aegypti. Notably, the methanol extract of *C. halicacabum* leaves exhibited the most potent ovicidal properties overall. These results suggest that the biodegradable and ecologically safe leaf extracts of C. halicacabum hold significant potential as alternative biocontrol agents against early-stage mosquito vectors.[28]

Anti-ulcer activity

The phytochemical composition, alongside the analgesic and antiulcerogenic activities, of various aerial part extracts of *Cardiospermum halicacabum* Linn. have been comprehensively evaluated. Extracts were prepared through successive fractionation using petroleum ether, chloroform, ethyl acetate, and ethanol. Preliminary phytochemical screening of these solvent fractions revealed the presence of several bioactive secondary metabolites, including carbohydrates, alkaloids, sterols, flavonoids, and saponins. In assessments of analgesic efficacy, the petroleum ether extract demonstrated dose-dependent activity, achieving 58%

and 82% analgesia relative to morphine and paracetamol, respectively, at a concentration of 0.3 mg/mL. Furthermore, antiulcerogenic activity was evaluated in albino rat models utilizing the standard pylorus ligation technique. Among the tested fractions, the ethanolic extract exhibited the most significant antiulcerogenic effect, showing a 48.2% reduction in ulceration at a concentration of 18.75 mg/mL, compared to a 67.2% reduction achieved by the standard reference drug ranitidine. These findings indicate that the diverse phytochemical constituents present in the extracts are responsible for the observed therapeutic effects against pain and gastric ulcers, thereby providing pharmacological corroboration for the traditional medicinal use of *C. halicacabum*.[29]

Anti-convulsant

The anticonvulsant activity of the alcoholic extract of *Cardiospermum halicacabum* roots (ARECH) has been extensively investigated, providing scientific rationale for the plant's traditional use in Ayurvedic and Indian folklore medicine for the management of neuropsychiatric disorders such as anxiety and epilepsy. In vivo evaluations of ARECH's anticonvulsant potential utilized various experimental epilepsy models in male Swiss albino mice following the oral administration of graded doses (30, 100, and 300 mg/kg). Findings indicate that ARECH at 100 and 300 mg/kg significantly prolongs the latency period to the onset of clonic and tonic seizures in pentylenetetrazol-, isoniazid-, and picrotoxin-induced seizure models. Furthermore, the extract significantly reduces the duration of hind limb tonic extension in maximal electroshock (MES) models. Notably, ARECH exhibits no protective effect against strychnine-induced convulsions, suggesting its mechanism of action does not involve glycine receptor antagonism. Instead, quantification of brain monoamine levels via High-Performance Liquid Chromatography (HPLC) reveals that ARECH treatment significantly elevates central levels of gamma-aminobutyric acid (GABA). These neurochemical findings strongly indicate that the observed anticonvulsant activity is mediated by GABAergic enhancement. Safety profiling, including acute neurotoxicity and rotarod tests, demonstrates that ARECH possesses a wide safety margin with an LD50 value of 1098 mg/kg. Even at elevated doses of up to 900 mg/kg, the extract does not significantly impair motor coordination or induce psychomotor dysfunction. Collectively, these behavioral and neurochemical evaluations provide robust pharmacological validation for the traditional medicinal use of C. halicacabum roots in treating convulsive disorders.[30]

Anxiolytic activity

The anxiolytic properties of *Cardiospermum halicacabum* root extracts, traditionally utilized for the management of anxiety and epilepsy, have been systematically evaluated in Swiss albino mice. Anxiolytic efficacy was assessed at dosages of 100 mg/kg and 300 mg/kg across three established behavioural paradigms: the elevated plus-maze (EPM), the light-dark model (LDM), and the open field test (OFT), utilizing diazepam (1 mg/kg) as a positive control. In the EPM paradigm, extract administration significantly increased both the frequency of entries and the duration of time spent in the open arms, alongside a concurrent decrease in neutral zone time, indicating a reduced aversion to open spaces. Similarly, results from the LDM demonstrated a marked reduction in time spent in the dark compartment, coupled with an increase in both light zone occupancy and overall locomotor activity. Furthermore, in the OFT, the anxiety-induced suppression of exploratory behavior was notably reversed; treated mice exhibited a reduced latency to leave the central starting area, increased central zone duration, and a higher frequency of line crossings. Collectively, both the aqueous and alcoholic extracts exhibited comparable anxiolytic profiles, providing robust empirical evidence validating the traditional application of *C. halicacabum* roots in the treatment of anxiety disorders.[31]

Anti-viral activity

Antiviral research by demonstrating how Sanskrit therapeutic applications documented in the Ayurvedic Pharmacopoeia of India directly correspond with modern clinical manifestations of major viral infections. The authors systematically map historical botanical uses to modern antiviral data, highlighting how traditional remedies for conditions such as Vrana (ulcers), Jwara (fever), Sula (pain), and Daha (burning sensation) correlate with treatment protocols for Herpes Simplex Virus (HSV) through plant extracts like Dracaena cinnabari, Cicer arietinum, and Achyranthes aspera. Furthermore, the paper correlates Melia azedarach with influenza management, links Piper longum to Hepatitis B Virus (HBV) symptom reduction, and evaluates reverse-transcriptase-inhibiting species such as Acacia nilotica, Ocimum sanctum, Euphorbia hirta, Alpinia galanga, and *Cardiospermum halicacabum* against Human Immunodeficiency Virus (HIV). Additionally, the review notes the efficacy of Carica papaya leaf extracts in mitigating Dengue-induced thrombocytopenia and leukopenia, supporting the plant's traditional use for blood-related disorders (Raktavikara). Ultimately, the study asserts that ancient Ayurvedic medical systems successfully recognized and treated viral disease symptomatology long before modern virological frameworks were established, advocating

for the translation of Sanskrit texts as a pathway to discovering modern bio-active antiviral candidates.[32]

Anti arthritic activity

The present study evaluated the anti-arthritic efficacy of the ethanolic leaf extract of Cardiospermum halicacabum Linn (CEE) using Freund's complete adjuvant (FCA) induced arthritis model in albino rats. The oral administration of CEE (125 and 250 mg/kg) showed significant ($p<0.001$) dose dependent suppression of FCA induced paw edema with maximum inhibition (94.17%) at a dose of 250 mg/kg which was comparable to the standard drug indomethacin (10 mg/kg). In addition, the extract effectively controlled the secondary paw edema and nodules formation occurred due to FCA induced hypersensitivity response. Besides, the extract exhibited prominent anti-arthritic activity by restoring the FCA induced anemic condition as evident from the increased red blood cell count and hemoglobin percentage along with the decreased total leucocyte count, packed cell volume and erythrocyte sedimentation rate towards the normal value. Thus, the study established the ethanolic leaf extract of Cardiospermum halicacabum as potential anti-arthritic agent that not only inhibit the local joint tissue destruction but also modulate the systemic biological alterations occurred during chronic arthritis. This provides scientific validation to the traditional claim of the plant for the treatment of rheumatic disorders.[33]

CONCLUSION

Cardiospermum halicacabum Linn. emerges as a highly valuable therapeutic resource, effectively bridging the gap between traditional ethnomedicine and modern pharmacology. Extensive literature robustly corroborates its historical application in traditional systems, particularly for the management of chronic inflammatory, arthritic, and neuropsychiatric conditions. The plant's profound pharmacological profile—encompassing potent anti-inflammatory, anti-arthritic, anticonvulsant, anxiolytic, anti-ulcerogenic, and antimicrobial activities—is fundamentally driven by a rich matrix of bioactive secondary metabolites, notably flavonoids, triterpenoids, and phytosterols.

Crucially, contemporary in vitro and in vivo models have successfully begun to elucidate the specific physiological mechanisms underlying these therapeutic effects. The demonstrated ability of the extracts to execute dual inhibition of pro-inflammatory mediators (such as TNF-α and NO), modulate central neurotransmitters (evidenced by GABA elevation), and exhibit

notable antiviral and antidiarrheal properties provides strong empirical validation for its diverse ethnomedicinal claims.

However, while current preclinical data is compelling, the clinical translation of these findings remains an ongoing challenge. To advance the development of standardized phytopharmaceuticals, future research must prioritize the precise isolation of individual bioactive principles and the comprehensive evaluation of their pharmacokinetic and toxicological profiles. Integrating advanced computational methodologies, such as network pharmacology and molecular docking, alongside rigorous experimental validation will be essential in thoroughly mapping the complex compound-target-pathway interactions of the plant's constituents. Ultimately, well-designed clinical trials are required to fully realize the translational potential of *C. halicacabum* as a safe, efficacious, and targeted therapeutic intervention in modern clinical practice.

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CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest regarding the publication of this review article.

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