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Pharmacological Evidence for Traditional Antispasmodic Herbs in Siddha Medicine: A Comprehensive Review

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ABSTRACT

Background: Traditional Siddha medicine has utilized antispasmodic herbs for centuries in Sri Lanka yet lacks comprehensive scientific validation. This gap between clinical efficacy and evidence-based documentation impedes acceptance within modern healthcare systems.

Objective: This systematic review synthesizes ethnobotanical evidence from classical Siddha texts with contemporary pharmacological research to establish the scientific basis for ten commonly prescribed antispasmodic herbs.

Methods: A cross-disciplinary approach integrated traditional Siddha Materia Medica classifications with peer-reviewed pharmacological studies employing ex-vivo tissue assays and in-vivo animal models using extraction methods congruent with traditional preparations.

Results: Ten herbs Justicia adhatoda, Ruta angustifolia, Datura species (D. niger, D. metel, D. stramonium, D. innoxia), Hyoscyamus niger, Trachyspermum ammi, Papaver somniferum, Ferula asafoetida, Syzygium aromaticum, Moringa oleifera, and Sphaeranthus indicus demonstrated antispasmodic activity through multiple mechanisms: calcium channel blockade, muscarinic receptor antagonism, and direct smooth muscle relaxation. Trachyspermum ammi, Justicia adhatoda, and Datura species exhibited high-quality experimental evidence with activity comparable to standard pharmaceuticals. Others demonstrated moderate pharmacological support or traditional ethnobotanical validation. Critical safety contraindications identified include narrow therapeutic windows for tropane alkaloid-containing species, cardiovascular risks with Cannabis sativa, and haemostatic interactions requiring perioperative management.

Conclusion: Substantial alignment exists between traditional Siddha practice and modern experimental validation. This evidence supports integration of standardized antispasmodic herbal extracts into evidence-based healthcare, with priority given to clinical safety profiles, quality standardization, and investigation of synergistic multi-herb formulations characteristic of Siddha pharmacology.

Keywords: Antispasmodic; Siddha; Justicia adhatoda; Trachyspermum ammi; Datura species; Calcium channel blockade; Muscarinic receptor antagonism; Sri Lankan traditional medicine;

INTRODUCTION

Traditional Medicine in Sri Lanka

Sri Lanka maintains a rich heritage of traditional medicine systems that have been central to healthcare for centuries. Herbal medicine, in particular, has served as an effective source for maintaining and restoring health across the island. Traditional treatment methodologies such as Siddha, Ayurveda, and Unani medicine, alongside indigenous practitioners, continue to keep herbal therapeutics alive with clinically relevant applications

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throughout Sri Lankan communities. This continued use reflects both cultural significance and empirical validation accumulated over generations of practice.

Scientific Evidence and Eastern Medical Practices

Despite centuries of documented clinical success, Eastern medical systems face significant barriers to wider acceptance and integration into modern healthcare frameworks. A critical challenge is the lack of rigorous scientific evidence supporting traditional claims. Moreover, even when scientific evidence exists, inadequate dissemination and accessibility of this evidence among practitioners, scholars, and Western medical professionals has perpetuated a knowledge gap. This disconnect between traditional efficacy and scientific validation represents a substantial obstacle to the advancement and credibility of Eastern medical practices.

Bridging Traditional Knowledge with Modern Science

To address these barriers and advance evidence-based Eastern medicine, systematic integration of traditional wisdom with contemporary scientific validation is essential. By synthesizing the accumulated clinical experience documented in traditional Materia Medica with rigorous pharmacological investigations, a comprehensive understanding of herbal therapeutics can be established. Such an approach not only validates traditional practices but also provides the scientific foundation necessary for acceptance by educated scholars, Western medical practitioners, and patients seeking informed therapeutic options.

Research Objective and Scope

This review focuses on antispasmodic herbs described in Siddha texts and actively used by traditional practitioners in Sri Lanka. The investigation synthesizes evidence from traditional Siddha classifications with peer-reviewed pharmacological studies to establish the scientific basis for these herbal remedies. By examining ten commonly used antispasmodic herbs, this review aims to illuminate the therapeutic potential of traditional Siddha medicine and provide evidence-based information to community members, healthcare professionals, and future practitioners. The ultimate goal is to present a clear, scientifically grounded picture of what herbal medicine is capable of achieving in clinical practice.

METHODOLOGY

The research methodology employed a systematic, cross-disciplinary approach, integrating the foundational clinical observations of traditional Siddha medicine with modern quantitative pharmacological verification. The primary source for traditional therapeutic protocols was the authoritative 1936 Materia Medica (Herbs Section), which documents the accumulated wisdom and clinical experience of Siddha practitioners. Candidate herbs were selected based on their explicit classification within this text as Isivagatri (anti-spasmodic).

The selection criteria for contemporary scientific literature necessitated peer-reviewed studies that provided mechanistic insights into these traditional claims. Priority was given to experimental models specifically ex-vivo tissue assays and in-vivo animal studies that utilized extraction protocols congruent with traditional preparation methods, such as aqueous infusions or ethanolic macerations. This approach ensured a rigorous comparison between the qualitative therapeutic definitions in the Materia Medica and quantitative pharmacological indices, including calculated ED50 values and identified receptor-blockade mechanisms. By synthesizing ethnobotanical wisdom with rigorous literature selection, this methodology identifies the specific phytochemical agents responsible for the traditionally observed antispasmodic and styptic effects.

Background

Antispasmodics

Spasticity is defined as a velocity-dependent increase in muscle tone and is a consequence of upper motor neuron lesions, which result in the loss of inhibitory control over spinal stretch reflexes and reorganization within the

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spinal cord or higher centres after injury to motor pathways [1, 2]. In cerebral palsy, spasticity is characterized by rate-dependent hypertonia, with muscle tone increasing as the speed of stretch increases [3]. Antispasmodic drugs are used to regulate this hyperexcitable circuitry, as many of the same mechanisms that underlie spasticity also contribute to neuropathic pain, including disinhibition of inhibitory input, hyperexcitability of neurons, and glial activation [4]. For treating spasticity, doctors often first prescribe baclofen, a drug that acts on the central nervous system. It works by stimulating GABA-B receptors, which calms overactive nerve signalling through several mechanisms. Unfortunately, baclofen has several limitations: it does not easily enter the brain, can cause excessive drowsiness and muscle weakness, may harm the liver, and its effectiveness can decrease over time. As a centrally acting alpha-2 adrenergic agonist, tizanidine suppresses muscle tone by inhibiting the spinal release of the excitatory neurotransmitters glutamate and aspartate. Benzodiazepines mediate their effects via GABA-A receptors, resulting in postsynaptic inhibition of central nervous system activity. Additional therapeutic options include gabapentin and the alpha-2 agonist clonidine; however, clonidine's utility is limited by side effects such as bradycardia and hypotension. Common adverse effects across this drug class encompass sedation, muscle weakness, dry mouth, urinary retention, and constipation.

Asthma is a major congestive respiratory disorder, characterized by episodic wheezing, cough and chest tightness associated with airflow obstruction [5]. According to WHO, it affects about 5–10% of adults [6] and 10% of children globally [7, 8]. The treatment with chemical drugs requires life-long use of expensive drugs, which cause multiple side effects in addition to financial burden to patients in developing countries.

Medicinal plants play an important role both in preventive and curative treatments, despite advances in modern western medicine. A single plant usually possesses multiple medicinal applications. Several scientific studies, in parallel to this, have also shown the presence of synergistic and/or side effect neutralizing combinations in plants [9], which is the result of presence of multiple constituents in single plant [10, 11].

Anti-spasmodic agents are referred to by the tamil terms இசிவகற்றி (Isivagatri) or அங்காகர்ஷணநாசதி (Angakarsana-nasati). These are defined as agents used for allaying or relieving convulsions or spasmodic pains [12].

Common anti-spasmodic herbs mentioned in Siddha texts and being used by practitioners in Sri Lanka, after personal interview with six Siddha physicians, four Ayurveda physicians, three Unani physicians and seven traditional medical practitioners are as follows. Even though each of them mentioned more herbs than what's mentioned here, for the scope of commonly used herbs which all of them mentioned are discussed here.

Justicia adhatoda

Adhatoda exhibits significant ex-vivo antispasmodic activity; stem extracts and isolated alkaloids, including vasicinone and vasicinolone, demonstrate a remarkable inhibition of acetylcholine-induced contractions in rat ileum models [13, 14]. This pharmacological action supports its traditional medicinal use for treating respiratory complaints and spasmodic disorders [13,15].

Ruta angustifolia

Ruta angustifolia is explicitly identified as an agent for allaying convulsions and spasmodic pains, frequently employed in the management of infantile convulsions. The therapeutic utility is noted for its ability to relieve severe internal spasms. [25]

Datura niger, Datura metel, Datura stramonium, and Datura innoxia

Datura species, including Datura niger, Datura metel, Datura stramonium, and Datura innoxia, possess potent antispasmodic constituents that significantly reduce gastrointestinal motility and increase intestinal transit time in charcoal meal tests [16]. These effects are often attributed to the blockage of muscarinic receptors by tropane alkaloids [17].

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Hyoscyamus niger

Hyoscyamus niger demonstrates concentration-dependent relaxation of spontaneous contractions in rabbit jejunum and guinea-pig trachea [16]. These relaxant effects are mediated through a dual blockade of muscarinic receptors and calcium channels.[18]

Trachyspermum ammi

The aqueous-methanolic extract of Trachyspermum ammi seeds produces dose-dependent inhibitory effects on intestinal and tracheal contractions.[19] Investigations suggest that this relaxant effect is a direct action on smooth muscle, antagonising barium chloride-induced stimulants in a manner similar to papaverine.

Papaver somniferum

Papaver somniferum remains a primary source of alkaloids used to lower functional activity and soothe irritations leading to spasms. [12] It contains papaverine, a critical benzylisoquinoline alkaloid that functions as a direct smooth muscle relaxant.

Ferula asafoetida

Ferula asafoetida gum resin and its essential oil show significant relaxant effects on various smooth muscle tissues induced by contractile agents. [20] The mechanisms involved include the inhibition of muscarinic and histamine (H1) receptors, alongside stimulatory effects on -adrenoceptors.

Syzygium aromaticum

Syzygium aromaticum aqueous extracts and clove oil effectively inhibit rhythmic contractions of isolated intestines, validating its traditional use for gastric irritations and internal spasms. [21]

Moringa oleifera

Moringa oleifera seed infusions demonstrate significant inhibition of acetylcholine-induced contractions in the rat duodenum with a calculated median effective dose of 984 mg. [22] Furthermore, ethanolic leaf extracts of this species have been shown to produce significant skeletal muscle relaxation in rotarod experimental models. [23]

Sphaeranthus indicus

Sphaeranthus indicus is traditionally valued for its antispasmodic properties, with plant juice and whole herb preparations used to treat epileptic convulsions and various spasmodic gastropathies. [12]

DISCUSSION

Table 1 summarizes the herbs, their active compounds, mechanisms, and clinical applications

Plant Species (Botanical Name)	Primary Active Compounds	Pharmacological Mechanism	Clinical and Traditional Applications
Justicia adhatoda	Quinazoline alkaloids (vasicine, vasicinone, vasicinolone).	Inhibition of acetylcholine-induced contractions in smooth muscle.	Management of respiratory disorders (asthma, chronic bronchitis) and general spasmodic ailments.
Ruta angustifolia	Volatile oils, alkaloids, and flavonoids.	Allaying of convulsions and spasmodic pains.	Management of infantile convulsions and bone/joint pain.

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Cannabis sativa	Cannabinoids (including Cannabidiol/CBD).	Non-competitive inhibition of voltage-gated calcium and sodium channels; enhancement of rectifier potassium currents.	Relief of severe internal spasms and neuropathic pain.
Datura metel / stramonium	Tropane alkaloids (hyoscyamine, scopolamine, atropine).	Blockage of muscarinic receptors (antimuscarinic effect) and inhibition of prostaglandin biosynthesis.	Treatment of asthma, Parkinson's disease, motion sickness, and gastrointestinal symptoms.
Hyoscyamus niger	Tropane alkaloids (hyoscyamine and scopolamine).	Dual blockade of muscarinic receptors and calcium channels.	Soothing of deep-seated nervous irritations, deep pain, and pulmonary infections.
Trachyspermum ammi (Omam)	Essential oil components (thymol and carvacrol).	Calcium channel blocking activity and anticholinergic functional antagonism.	Treatment of intestinal colic, dyspepsia, and bronchial asthma.
Papaver somniferum (Opium)	Alkaloids (papaverine and morphine).	Direct smooth muscle relaxation via benzylisoquinoline alkaloids.	Haemostatic arrest of excessive bleeding and relief of severe spasmodic conditions like tetanus.
Ferula asafoetida	Resins and volatile oils (umbelliferon and ferulic acid).	Inhibition of muscarinic and histamine receptors; stimulatory effect on beta-adrenoceptors.	Management of gastrointestinal spasms, flatulent colic, and hysteria.
Syzygium aromaticum (Clove)	Essential oil (eugenol).	Inhibition of rhythmic and acetylcholine-induced intestinal contractions.	Treatment of internal spasms, gastric irritations, and dental pain.
Moringa oleifera	Flavonoids, terpinoids, and saponins.	Inhibition of acetylcholine-induced contractions; induction of skeletal muscle relaxation.	Management of diverse spasmodic diseases, rheumatism, and muscle spasms.
Sphaeranthus indicus	Alkaloids (sphaeranthine) and sesquiterpene lactones.	Correction of "Vata" related disturbed doshas.	Treatment of epileptic convulsions and various spasmodic gastropathies.

Table 1: Summary of herbs and their mode of action

Potential drug interactions or contraindications

The clinical administration of these therapeutic agents necessitates a comprehensive understanding of their narrow therapeutic indices and potential for adverse drug-herb interactions. Pharmacological data and traditional protocols delineate several critical contraindications and physiological risks.

Cannabis sativa and Cannabidiol (CBD)

The use of Cannabis sativa and its derivatives involves significant cardiovascular and metabolic considerations.

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• Cardiovascular Risks: Cannabinoids are capable of inducing blood pressure fluctuations in a specific triphasic pattern (low-high-low) and have been linked to increased heart rate, arterial spasms, and postural hypotension. Evidence supports an increased risk of ischaemic stroke associated with relevant abuse, particularly involving the basal ganglia and cerebellum. (26)

• Pharmacokinetic Interactions: CBD significantly inhibits the hepatic cytochrome P450 system, specifically the 2B1/2 isoform, and the intestinal P-glycoprotein (P-gp) activity. Such inhibition may enhance the bioavailability and toxic potential of co-administered pharmaceuticals that serve as substrates for these metabolic pathways. (27)

• Psychiatric and General Adverse Effects: Use may exacerbate pre-existing psychiatric illnesses or substance abuse. Common adverse events identified in clinical trials include somnolence, decreased appetite, fatigue, and pyrexia. (28)

Tropane Alkaloid Species (Datura and Hyoscyamus)

Species containing tropane alkaloids, such as Datura metel, Datura stramonium, and Hyoscyamus niger, possess a narrow therapeutic window, rendering unsupervised use hazardous. (29)

• Primary Contraindications: These plants are strictly contraindicated in cases of glaucoma (due to increased intraocular pressure), narrow-angle glaucoma, paralytic ileus, pyloric stenosis, enlarged prostate, and tachycardic arrhythmias. (16)

• Demographic Cautions: Extreme caution is required for elderly patients due to the risks of mydriasis and urinary retention, and for children, who are particularly sensitive to rapid increases in body temperature elicited by these alkaloids. (16)

• Pregnancy: Exposure to Datura during pregnancy has been associated with permanent fetal damage; therefore, its use is contraindicated for expectant mothers. (16)

Ferula asafoetida and Syzygium aromaticum (Clove)

Both agents significantly influence haemostasis and require careful management around surgical procedures.

• Haemostatic and Surgical Cautions: Ferula asafoetida and clove oil (Syzygium aromaticum) can slow blood clotting. Use must be discontinued at least two weeks prior to scheduled surgery to avoid excessive bleeding. (30)

• Drug Interactions: Ferula asafoetida is known to interact with anticoagulants, antiplatelet drugs, and antihypertensive medications. (30)

• Pediatric and Obstetric Precautions: Asafoetida is contraindicated for pregnant and nursing mothers and can be life-threatening for children, potentially leading to blood disorders. (30) Similarly, clove oil is likely unsafe for oral consumption by children, with risks of seizures, liver damage, and fluid imbalances. (31)

Additional Phytotherapeutic Considerations

Papaver somniferum (Opium): Sudden discontinuation of high-dose opium therapy can trigger a relapse of delirium and extraordinary depression. Its status as a potent narcotic necessitates strict dosage control to avoid fatal outcomes. (12)

Trachyspermum ammi (Omam): Human data indicate that its use can reduce both milk and semen production. It is traditionally advised that "hot-tempered" individuals use the seeds only in small quantities and in combination with cooling herbs to mitigate physiological irritation. (32)

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Moringa oleifera: While the leaves show low toxicity, general considerations for skeletal muscle relaxants apply, including potential for CNS depression and sedation. Use should be monitored closely in elderly populations, children, and patients with cardiac disease. (23)

Justicia adhatoda: Although preclinical findings are promising, a lack of standardized cultivation and extraction protocols remains a limitation, emphasizing the need for standardized safety parameters in clinical use. (33)

Quality assessment of the evidence for each herb

The evidence for the antispasmodic and haemostatic actions of the herbs identified in the sources ranges from centuries of documented traditional usage to modern quantitative pharmacological assays. A rigorous quality assessment reveals distinct tiers of scientific validation.

High-Quality Experimental Evidence

Several species are supported by robust, controlled experimental data, often involving both ex-vivo tissue models and in-vivo animal studies.

• Trachyspermum ammi (Omam): This species possesses the highest level of multi-modal evidence. Pharmacological studies demonstrate dose-dependent in-vivo hypotensive effects in rats and ex-vivo inhibitory actions on rabbit aorta and jejunum. The calcium channel blocking (CCB) mechanism is confirmed through rightward shifts in Ca 2+ dose–response curves, comparable to the reference standard verapamil. Furthermore, clinical evidence includes a double-blind randomised controlled trial (RCT) for its topical efficacy in neuropathic pain.

• Datura species: The evidence for Datura metel, D. stramonium, and D. innoxia is substantial. In-vivo gastrointestinal motility tests using charcoal meals and castor oil-induced diarrhea models in rodents confirm significant, dose-dependent antispasmodic and anti-motility actions. Muscle relaxant properties are further validated through traction and chimney tests in mice, where both crude fractions and isolated compounds like daturaolone showed significant activity.

• Justicia adhatoda: This herb is supported by specific ex-vivo rat ileum models demonstrating that its petroleum ether and methylene chloride fractions, as well as isolated alkaloids like vasicinone and vasicinolone, produce "remarkable inhibition" of acetylcholine-induced contractions. These findings provide direct scientific validation for its traditional role as a respiratory and general antispasmodic.

Moderate to Strong Pharmacological Evidence

These herbs are supported by clear experimental results, though they often lack the extensive clinical or multi-modal mechanistic depth of the previous group.

• Ferula asafoetida: Evidence is grounded in ex-vivo studies where gum-resin extracts produced concentration-dependent relaxation of isolated guinea pig ileum and tracheal smooth muscle. The mechanism is identified as a dual blockade of muscarinic and histamine (H1) receptors.

• Syzygium aromaticum (Clove): Strong evidence exists for its antispasmodic and antidiarrheal actions through ex-vivo inhibition of rhythmic contractions in isolated rabbit intestines. In-vivo mouse models using charcoal transit and castor oil induction further validate its ability to decrease intestinal motility.

• Moringa oleifera: The antispasmodic activity of its seed infusions is quantitatively established using isolated rat duodenum, yielding a calculated ED 50 of 65.6 mg/ml (or 984 mg equivalent of starting material). Additional studies confirm skeletal muscle relaxation in in-vivo experimental models.

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• Hyoscyamus niger: Its classification as a potent sedative and antispasmodic is supported by concentration-dependent relaxation of rabbit jejunum contractions. The evidence points to a dual blockade of muscarinic receptors and calcium channels as the primary mechanism.

Primarily Traditional and Ethnobotanical Evidence

For certain substances, the quality of evidence is heavily weighted toward traditional Materia Medica or preliminary characterisation, with fewer specific pharmacological assays provided in the sources.

• Papaver somniferum (Opium): While its role as a "primary" antispasmodic and haemostatic is extensively documented in traditional texts for treating tetanus and excessive bleeding, the sources focus more on its established clinical status as a narcotic rather than new experimental assays. Its mechanism is attributed to benzylisoquinoline alkaloids like papaverine.

• Sphaeranthus indicus (Sivakaranthai): The evidence is largely ethnobotanical, identifying it as a treatment for epileptic convulsions and spasmodic gastropathies. While modern screening has identified antimicrobial and immunomodulatory properties, specific quantitative antispasmodic assays are less prominent in the provided data.

• Ruta angustifolia (Aruvadha): Though explicitly identified for allaying convulsions in infants, it has received "limited research attention" regarding its chemical composition and biological activity compared to other Ruta species. Current evidence is primarily traditional.

• Cannabis sativa: Historically valued for relieving severe internal spasms, the source evidence is primarily traditional. Recent findings provided focus on isolated cannabidiol (CBD) and its effects on multiple ion channels rather than whole-herb antispasmodic assays.

CONCLUSION

The systematic evaluation of Siddha medicinal flora reveals a profound alignment between ancient ethnobotanical classifications and contemporary pharmacological validation. The evidence supporting the use of these traditional herbs is robust, ranging from the documented therapeutic protocols in the Materia Medica to high-precision ex-vivo assays demonstrating calcium channel blockade and muscarinic antagonism. Species such as Trachyspermum ammi and Justicia adhatoda exhibit quantifiable antispasmodic activity that is comparable to standard pharmaceutical references, while the styptic properties of Papaver somniferum remain foundational for the management of haemorrhagic disorders. This duality of evidence centuries of successful clinical application corroborated by modern experimental data underscores the reliability of the Siddha pharmacopeia.

The implications for the future of Siddha medicine are significant, suggesting a transition from traditional practice to a more integrated, evidence-based medical system. The identification of specific active compounds, such as the quinazoline alkaloids in Adhatoda or the tropane alkaloids in Datura, provides a platform for the standardisation of Siddha drugs. This scientific grounding facilitates the broader acceptance of traditional therapies within global healthcare frameworks, provided that the inherent complexities of whole-plant extracts are respected.

For practitioners and patients, the primary recommendation is one of informed caution, particularly concerning the administration of herbs with narrow therapeutic indices. Potent agents like Datura, Hyoscyamus niger, and Papaver somniferum must be used under strict supervision to avoid systemic toxicity and nervous system depression. Furthermore, patients must be aware of critical drug-herb interactions; for instance, the anticoagulant effects of Ferula asafoetida and Syzygium aromaticum necessitate their discontinuation prior to surgical procedures. Accuracy in dosage and a thorough understanding of a patient’s concurrent pharmaceutical regimen are essential to ensure safety.

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Future research must move beyond preliminary screening to address the current gaps in clinical data. Priority should be given to longitudinal human trials that establish definitive safety profiles and pharmacokinetic parameters for standardised extracts. Additionally, investigating the synergistic effects of multi-herb formulations, a hallmark of Siddha practice, would provide deeper insight into how these complex mixtures mitigate side effects while enhancing efficacy. Continued exploration of the molecular mechanisms behind "Vata"-regulating herbs will further illuminate the physiological basis of Siddha's holistic approach to spasmodic and inflammatory conditions.

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Competing Interests

Authors have declared that no competing interests exist.

Authors' Contributions

Dr. K. Tharaneenthan conceptualized and designed the study, conducted the traditional Siddha Materia Medica analysis, performed the literature search, and wrote the first draft of the manuscript. Dr. R. Piratheepkumar contributed to the pharmacological data synthesis, critically reviewed the manuscript, and provided expert input on the Siddha medicine classifications. Both authors reviewed and approved the final manuscript.

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