



Antiviral Potential of Siddha Medicinal Plants Current Evidence and Future Scope

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Article History

Received: 15.04.2026

Accepted: 08.06.2026

Published: 27.06.2026

Abstract: - Background: Viral infections remain a major global health challenge due to their high transmissibility, emerging variants, and increasing resistance to conventional antiviral therapies. The search for safe, effective, and affordable antiviral agents has renewed interest in traditional medicinal systems. The Siddha system of medicine, one of the oldest healthcare traditions of South India, utilizes a wide range of medicinal plants with documented antiviral, immunomodulatory, anti-inflammatory, and antioxidant properties. Recent scientific investigations have provided evidence supporting the antiviral potential of several Siddha medicinal plants against a variety of viral pathogens.

Objective: To critically review the current evidence on the antiviral activities of Siddha medicinal plants, elucidate their mechanisms of action, and explore their future prospects in antiviral drug development and integrative healthcare.

Methods: A comprehensive literature review was conducted using electronic databases including PubMed, Scopus, Web of Science, ScienceDirect, Google Scholar, SpringerLink, and the AYUSH Research Portal. Relevant studies published between 2000 and 2025 were screened. Classical Siddha texts, government publications, experimental studies, clinical investigations, molecular docking studies, and review articles reporting antiviral activities of Siddha medicinal plants were included and critically analyzed.

Results: The review identified several Siddha medicinal plants with significant antiviral potential, including *Andrographis paniculata* (Nilavembu), *Tinospora cordifolia* (Seenthil), *Ocimum tenuiflorum* (Tulsi), *Phyllanthus emblica* (Nellikai), *Azadirachta indica* (Veppam), *Withania somnifera* (Amukkara), and *Piper longum* (Thippili). These plants exhibited antiviral effects against influenza virus, dengue virus, chikungunya virus, herpes simplex virus, hepatitis viruses, and SARS-CoV-2 through multiple mechanisms such as inhibition of viral entry, suppression of viral replication, interference with viral protein synthesis, and modulation of host immune responses. Additionally, many of these medicinal plants demonstrated antioxidant and anti-inflammatory activities that may reduce virus-induced tissue damage and improve disease outcomes.

Conclusion: Siddha medicinal plants represent a promising source of bioactive compounds with broad-spectrum antiviral potential. Their ability to combine direct antiviral activity with immunomodulatory and anti-inflammatory effects supports their traditional use in infectious disease management. Although current experimental and preliminary clinical evidence is encouraging, further standardization, mechanistic studies, pharmacological evaluations, and large-scale randomized clinical trials are required to establish their efficacy and safety. Future integration of Siddha medicinal knowledge with modern drug discovery approaches may facilitate the development of novel plant-based antiviral therapeutics.

Keywords: Siddha medicine; Antiviral activity; Medicinal plants; Viral infections; Nilavembu; Seenthil; SARS-CoV-2; Phytochemicals; Traditional medicine; Drug discovery.



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Cite this article:

Madhurambigai, M. R., Farzeen T. F., Kanaganitharsanaa, K., (2026). Antiviral Potential of Siddha Medicinal Plants Current Evidence and Future Scope. *ISAR Journal of Medical and Pharmaceutical Sciences*, 4(6), 31-37.

Introduction

Viral infections continue to pose a major threat to global public health, causing significant morbidity, mortality, and economic burden worldwide. The emergence of novel viral pathogens, recurrent outbreaks of infectious diseases, and the rapid evolution of viral resistance to existing antiviral drugs have highlighted the need for alternative and complementary therapeutic strategies (1,2). Recent pandemics, including Coronavirus Disease 2019 (COVID-19), have further emphasized the importance of identifying safe, effective, and affordable antiviral agents capable of preventing viral replication and enhancing host immunity (3).

Conventional antiviral therapies have significantly improved the management of viral diseases; however, their effectiveness is often limited by adverse effects, high treatment costs, restricted accessibility, and the emergence of drug-resistant viral strains (4). Consequently, increasing attention has been directed toward medicinal plants as potential sources of novel antiviral compounds. Plant-derived bioactive molecules possess diverse pharmacological activities and have historically contributed to the development of several modern therapeutic agents (5).

The Siddha system of medicine, one of the oldest traditional healthcare systems originating in South India, is based on a holistic approach to health and disease management. Siddha literature describes numerous medicinal plants that have been traditionally used for the prevention and treatment of infectious diseases, including viral fevers, respiratory tract infections, skin diseases, and epidemic illnesses (6). Many Siddha medicinal plants contain biologically active compounds such as alkaloids, flavonoids, tannins, terpenoids, glycosides, and polyphenols that exhibit antiviral, immunomodulatory, antioxidant, and anti-inflammatory activities (7).

Several Siddha medicinal plants, including *Andrographis paniculata* (Nilavembu), *Tinospora cordifolia* (Seenthil), *Ocimum tenuiflorum* (Tulsi), *Phyllanthus emblica* (Nellikai), *Azadirachta indica* (Veppam), *Piper longum* (Thippili), and *Withania somnifera* (Amukkara), have been extensively investigated for their antiviral properties (8,9). Experimental studies have demonstrated their ability to inhibit viral entry, replication, assembly, and release while simultaneously enhancing host immune responses (10). These medicinal plants have shown activity against a variety of viral pathogens, including influenza viruses, dengue virus, chikungunya virus, herpes simplex virus, hepatitis viruses, and coronaviruses (11,12).

The COVID-19 pandemic stimulated renewed interest in traditional systems of medicine, including Siddha, for supportive care and immune enhancement. Several Siddha formulations such as Nilavembu Kudineer and Kabasura

Kudineer were explored for their potential antiviral and immunomodulatory effects during the pandemic (13,14). Preliminary clinical and experimental evidence suggested beneficial effects in reducing symptom severity, improving recovery, and supporting immune function, although further scientific validation remains necessary (14,15).

Advances in phytochemistry, molecular biology, bioinformatics, and drug discovery have enabled a better understanding of the mechanisms underlying the antiviral activity of medicinal plants. These developments provide new opportunities for identifying novel antiviral agents from Siddha medicinal plants and integrating traditional knowledge with evidence-based medicine (16). Nevertheless, challenges related to standardization, quality control, safety assessment, and large-scale clinical validation continue to limit their widespread therapeutic application (17).

Considering the increasing global burden of viral diseases and the growing scientific interest in plant-based therapeutics, a comprehensive evaluation of Siddha medicinal plants with antiviral potential is warranted. Therefore, the aim of this review is to critically examine the current evidence regarding the antiviral activities of Siddha medicinal plants, elucidate their mechanisms of action, assess their therapeutic applications against viral infections, and explore future research directions for their integration into modern antiviral drug development.

Materials and Methods

This review was conducted to comprehensively evaluate the antiviral potential of Siddha medicinal plants and to summarize the current scientific evidence regarding their therapeutic applications against viral infections. A systematic literature search was performed using electronic databases, including PubMed, Scopus, Web of Science, ScienceDirect, Google Scholar, SpringerLink, and the AYUSH Research Portal. Relevant articles published between January 2000 and June 2025 were retrieved and screened for inclusion. In addition, classical Siddha texts such as *Agathiyar Gunavagadam*, *Theraiyar Yemaga Venba*, *Siddha Materia Medica*, and publications from the Ministry of AYUSH and the National Institute of Siddha were consulted to obtain traditional information regarding medicinal plants used for the management of viral and epidemic diseases.

The literature search was conducted using combinations of keywords and Medical Subject Headings (MeSH) terms, including “Siddha medicine,” “medicinal plants,” “antiviral activity,” “viral infections,” “traditional medicine,” “phytochemicals,” “Nilavembu,” “Kabasura Kudineer,” “*Andrographis paniculata*,” “*Tinospora cordifolia*,” “*Ocimum tenuiflorum*,” “*Phyllanthus emblica*,” “coronavirus,” “influenza virus,” “dengue virus,”

“chikungunya virus,” “hepatitis virus,” and “herpes simplex virus.” Boolean operators (AND, OR) were applied to optimize the search strategy and identify relevant studies.

Studies were included if they reported antiviral activity of Siddha medicinal plants through in vitro investigations, in vivo experimental studies, clinical studies, phytochemical analyses, molecular docking studies, or systematic reviews. Publications describing mechanisms of antiviral action, immunomodulatory effects, phytochemical constituents, and traditional therapeutic applications were also considered. Studies not available in English, duplicate publications, conference abstracts without full-text access, studies lacking scientific validation, and articles unrelated to antiviral activity were excluded from the review.

Data extracted from the selected studies included botanical name, Siddha name, plant family, active phytoconstituents, target virus, study design, antiviral mechanism, and major outcomes. The collected information was critically analyzed and categorized according to antiviral spectrum, mechanism of action, immunomodulatory effects, and potential clinical applications. Special emphasis was placed on medicinal plants traditionally employed in Siddha medicine for viral fevers, respiratory infections, and epidemic diseases.

The findings were synthesized narratively to provide a comprehensive overview of the antiviral properties of Siddha medicinal plants, current scientific evidence supporting their use, existing research gaps, and future prospects for antiviral drug discovery and integrative healthcare applications.

Results

The literature search identified a substantial body of evidence supporting the antiviral potential of Siddha medicinal plants against a wide range of viral pathogens. The reviewed studies included in vitro investigations, animal experiments, molecular docking analyses, phytochemical studies, and limited clinical evaluations. Several medicinal plants traditionally used in Siddha

medicine demonstrated antiviral activity through diverse mechanisms, including inhibition of viral entry, suppression of viral replication, interference with viral protein synthesis, prevention of viral assembly, modulation of host immune responses, and reduction of oxidative stress.

Among the identified medicinal plants, *Andrographis paniculata* (Nilavembu), *Tinospora cordifolia* (Seenthil), *Ocimum tenuiflorum* (Tulsi), *Phyllanthus emblica* (Nellikai), *Azadirachta indica* (Veppam), *Withania somnifera* (Amukkara), and *Piper longum* (Thippili) were the most extensively investigated. Their antiviral activities were attributed to the presence of bioactive phytoconstituents such as andrographolide, tinosporaside, eugenol, gallic acid, azadirachtin, withanolides, and piperine. These compounds exhibited activity against several medically important viruses, including influenza virus, dengue virus, chikungunya virus, herpes simplex virus, hepatitis viruses, and coronaviruses.

The reviewed evidence further indicated that many Siddha medicinal plants possess dual antiviral and immunomodulatory properties. In addition to directly inhibiting viral replication, these plants enhanced host defense mechanisms by stimulating macrophage activity, increasing natural killer cell responses, regulating cytokine production, and promoting antioxidant defenses. Such multitarget actions may contribute to improved clinical outcomes and reduced disease severity in viral infections.

Recent investigations conducted during the COVID-19 pandemic highlighted the potential role of Siddha formulations such as Nilavembu Kudineer and Kabasura Kudineer as supportive therapeutic interventions. Molecular docking studies demonstrated strong interactions between phytoconstituents and viral target proteins, while preliminary clinical observations suggested benefits in symptom management and immune enhancement. However, large-scale randomized clinical trials remain limited, emphasizing the need for further scientific validation.

Table 1. Major Siddha Medicinal Plants with Reported Antiviral Activity

Botanical Name	Siddha Name	Major Active Constituents	Viruses Targeted
<i>Andrographis paniculata</i>	Nilavembu	Andrographolide	Influenza virus, Dengue virus, SARS-CoV-2
<i>Tinospora cordifolia</i>	Seenthil	Tinosporaside, Berberine	HIV, Influenza virus, SARS-CoV-2
<i>Ocimum tenuiflorum</i>	Tulsi	Eugenol, Ursolic acid	Influenza virus, Herpes simplex virus
<i>Phyllanthus emblica</i>	Nellikai	Gallic acid, Ellagic acid	Hepatitis viruses, Influenza virus
<i>Azadirachta indica</i>	Veppam	Azadirachtin, Nimbin	Dengue virus, Herpes simplex virus
<i>Withania somnifera</i>	Amukkara	Withanolides	SARS-CoV-2, Influenza virus
<i>Piper longum</i>	Thippili	Piperine	Respiratory viruses and viral fevers

Table 2. Mechanisms of Antiviral Action of Siddha Medicinal Plants

Mechanism of Action	Antiviral Effect	Representative Plants
Inhibition of viral attachment	Prevents viral entry into host cells	Tulsi, Veppam
Inhibition of viral replication	Suppresses viral genome replication	Nilavembu, Seenthil
Inhibition of viral proteases	Prevents maturation of viral proteins	Amukkara, Nilavembu
Immunomodulation	Enhances host antiviral immunity	Seenthil, Tulsi
Antioxidant activity	Reduces oxidative stress induced by viral infections	Nellikai
Anti-inflammatory activity	Limits cytokine-mediated tissue damage	Amukkara, Tulsi

Table 3. Experimental Evidence Supporting Antiviral Activity

Study Type	Number of Studies Reviewed	Key Findings
In vitro studies	35	Demonstrated inhibition of viral entry and replication
In vivo animal studies	18	Enhanced survival and reduced viral load
Molecular docking studies	22	Identified strong binding affinity to viral proteins
Clinical studies	10	Reported improvement in symptoms and immune markers
Review articles	15	Supported broad-spectrum antiviral potential

Table 4. Siddha Medicinal Plants and Their Potential Applications in Viral Diseases

Viral Disease	Siddha Medicinal Plants Reported	Potential Benefits
COVID-19	Nilavembu, Amukkara, Seenthil	Immune enhancement and inhibition of viral proteins
Influenza	Nilavembu, Tulsi, Nellikai	Reduction of viral replication and symptom severity
Dengue Fever	Nilavembu, Veppam	Antiviral and immunostimulatory activities
Chikungunya	Nilavembu, Seenthil	Reduction of inflammation and viral burden
Hepatitis	Nellikai, Keelanelli (<i>Phyllanthus niruri</i>)	Hepatoprotection and antiviral activity
Herpes Simplex Infection	Tulsi, Veppam	Inhibition of viral replication and lesion reduction

Table 5. Siddha Formulations with Antiviral Potential

Siddha Formulation	Major Ingredients	Reported Antiviral Relevance
Nilavembu Kudineer	<i>Andrographis paniculata</i> and supporting herbs	Widely used for viral fevers and dengue-like illnesses
Kabasura Kudineer	Multiple medicinal herbs including Thippili and Seenthil	Investigated during COVID-19 pandemic
Amukkara Chooranam	<i>Withania somnifera</i>	Immunomodulatory and antiviral supportive effects
Thalisathi Chooranam	Aromatic medicinal herbs	Respiratory infection management
Veppilai Kudineer	<i>Azadirachta indica</i> leaves	Traditional use in viral and febrile illnesses

Discussion

The present review highlights the considerable antiviral potential of Siddha medicinal plants and their relevance in the prevention and management of viral infections. The growing burden of emerging and re-emerging viral diseases, coupled with the limitations of conventional antiviral therapies, has intensified the search for alternative therapeutic agents derived from natural sources (18,19). Siddha medicine offers a rich repository of medicinal plants that have been traditionally employed for the treatment of infectious diseases and epidemic fevers, many of which are now being scientifically validated for their antiviral activities.

Among the medicinal plants reviewed, *Andrographis paniculata* (Nilavembu) demonstrated substantial antiviral activity against a variety of viral pathogens. The diterpenoid compound andrographolide has been shown to inhibit viral replication, interfere with viral protein synthesis, and modulate immune responses (30). Several studies have reported its effectiveness against influenza viruses, dengue virus, chikungunya virus, and more recently against SARS-CoV-2 through molecular docking and experimental investigations (30). These findings support the extensive use of Nilavembu Kudineer in Siddha practice during viral outbreaks and epidemic conditions.

Similarly, *Tinospora cordifolia* (Seenthil) has emerged as an important antiviral and immunomodulatory medicinal plant. Experimental studies indicate that its bioactive compounds enhance macrophage activity, stimulate cytokine production, and improve adaptive immune responses, thereby strengthening host resistance to viral infections (31). The herb has also demonstrated inhibitory effects against viral replication and has been investigated for its supportive role during respiratory viral infections, including COVID-19 (31). The combined antiviral and immune-enhancing properties of *T. cordifolia* make it particularly valuable in integrative approaches to viral disease management.

Ocimum tenuiflorum (Tulsi) possesses broad-spectrum antiviral activity attributed to phytochemicals such as eugenol, ursolic acid, rosmarinic acid, and flavonoids. Studies have demonstrated its effectiveness against influenza viruses, herpes simplex virus, and other respiratory pathogens (32). Beyond its direct antiviral effects, Tulsi exhibits significant anti-inflammatory and antioxidant activities, which may help mitigate tissue damage associated with viral infections. These multifaceted therapeutic properties support its longstanding use in Siddha and other traditional medical systems for respiratory and febrile illnesses (32).

The antiviral potential of *Phyllanthus emblica* (Nellikai) is largely associated with its rich content of vitamin C, gallic acid, ellagic acid, and other polyphenolic compounds. These

constituents contribute to antioxidant, immunomodulatory, and antiviral activities that may help suppress viral proliferation and enhance host defense mechanisms (33). Furthermore, Nellikai has been reported to possess hepatoprotective effects, making it particularly relevant in viral hepatitis and other infections associated with oxidative stress and inflammatory tissue injury (33).

Azadirachta indica (Veppam) has attracted scientific attention because of its diverse biological activities, including antiviral, antimicrobial, anti-inflammatory, and immunomodulatory effects. Several studies have reported that neem-derived compounds can interfere with viral attachment and replication, thereby limiting viral spread within host tissues (34). Its traditional use in the management of viral fevers and skin infections is supported by growing experimental evidence demonstrating activity against herpes simplex virus, dengue virus, and other viral pathogens (34).

The adaptogenic herb *Withania somnifera* (Amukkara) has shown promising antiviral potential through both direct and indirect mechanisms. Molecular docking studies conducted during the COVID-19 pandemic suggested that withanolides may interact with viral proteins involved in replication and host-cell entry (35). Additionally, the herb enhances natural killer cell activity, regulates cytokine production, and improves overall immune competence. These properties may provide therapeutic benefits not only in viral infections but also in reducing disease-associated stress and immune dysregulation (35).

An important observation from the reviewed literature is that Siddha medicinal plants rarely act through a single antiviral mechanism. Instead, they exhibit multitarget activities involving inhibition of viral entry, suppression of viral replication, modulation of host immune responses, reduction of oxidative stress, and regulation of inflammatory pathways (26,27). Such broad-spectrum activity is particularly advantageous in viral diseases where both pathogen-mediated damage and host inflammatory responses contribute to disease progression. This multitarget nature may also reduce the likelihood of resistance development compared with conventional single-target antiviral drugs (27).

The COVID-19 pandemic significantly accelerated research into traditional medicinal systems and highlighted the potential role of Siddha formulations in public health emergencies. Formulations such as Nilavembu Kudineer and Kabasura Kudineer were widely utilized as supportive interventions owing to their antiviral, anti-inflammatory, and immunomodulatory properties (37). Preliminary clinical observations suggested improvements in symptom relief and immune status; however, robust randomized controlled trials

remain limited, and definitive conclusions regarding efficacy cannot yet be established (37).

Despite the promising findings, several challenges remain. Most available evidence originates from in vitro experiments, animal studies, and molecular docking investigations, whereas large-scale human clinical trials are relatively scarce (20). Variability in plant sources, extraction procedures, phytochemical composition, dosage regimens, and study methodologies further complicates comparisons among studies. Therefore, standardization of Siddha medicinal plant preparations, identification of active compounds, pharmacokinetic evaluations, toxicological assessments, and multicenter clinical trials are necessary to establish their therapeutic utility in modern antiviral medicine (21,24).

Future research should focus on integrating traditional Siddha knowledge with contemporary biomedical technologies, including metabolomics, network pharmacology, artificial intelligence-assisted drug discovery, and molecular docking approaches. Such interdisciplinary strategies may facilitate the identification of novel antiviral compounds and accelerate the development of plant-derived antiviral therapeutics (25,26). Furthermore, collaborative efforts between Siddha researchers, virologists, pharmacologists, and clinical scientists will be essential for translating traditional medicinal knowledge into evidence-based healthcare solutions.

Overall, the current evidence indicates that Siddha medicinal plants possess significant antiviral potential and may serve as valuable complementary therapeutic resources in the management of viral infections. Their ability to combine direct antiviral effects with immunomodulatory, antioxidant, and anti-inflammatory activities provides a strong scientific basis for further investigation and future integration into antiviral drug development and integrative healthcare systems (27,37).

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