OPEN ACCESS
World Journal of Applied Medical Sciences
ISSN: 3049-0200 (Online) | Vol. 2, No. 6, 2025
Website: https://wasrpublication.com/index.php/wjams/

Revitalizing Siddha Antimicrobial Knowledge for Modern Medical Applications

Dakshinya K. P[1], Devaki V[1*]

[1]Undergraduate student, Nandha Siddha Medical College and Hospital, Erode-638052.

Received: 01/04/2025 | Accepted: 22/05/2025 | Published: 27/06/2025

Abstract:

Background:
Antimicrobial resistance (AMR) has emerged as a major global health threat, leading to reduced effectiveness of existing antibiotics and increased burden of infectious diseases worldwide. The rapid rise of multidrug-resistant (MDR) pathogens and the lack of new antimicrobial agents have intensified the need for alternative therapeutic strategies. Traditional Siddha medicine, one of the oldest indigenous systems of medicine from South India, contains a rich repository of herbal, mineral, and herbo-mineral formulations with historical use in infectious diseases. Classical preparations such as Linga Chendooram, Vishnu Chakara Mathirai, and Adathodai Manapagu are increasingly being explored for their antimicrobial potential.

Objective:
To systematically review the antimicrobial potential of selected Siddha formulations and evaluate available scientific evidence supporting their activity against pathogenic and multidrug-resistant microorganisms, with emphasis on their relevance to modern antimicrobial drug discovery and integrative medicine.

Methods:
A comprehensive literature review was conducted using databases including PubMed, Scopus, Web of Science, ScienceDirect, Google Scholar, SpringerLink, and AYUSH Research Portal covering studies published from 2000 to 2025. Classical Siddha texts, in vitro and in vivo studies, phytochemical analyses, molecular docking studies, and relevant review articles were included. Data related to antimicrobial activity, phytoconstituents, mechanisms of action, and clinical relevance were extracted and analyzed.

Results:
Available evidence indicates that Linga Chendooram, Vishnu Chakara Mathirai, and Adathodai Manapagu exhibit broad-spectrum antimicrobial activity against Gram-positive and Gram-negative bacteria, including multidrug-resistant strains such as MRSA and ESBL-producing organisms. Reported mechanisms include disruption of microbial cell membranes, inhibition of biofilm formation, suppression of quorum sensing, antioxidant effects, and immunomodulatory actions. The presence of bioactive compounds such as alkaloids, phenolics, and mineral-based constituents contributes to their therapeutic potential in infectious diseases.

Conclusion:
Siddha formulations demonstrate promising antimicrobial potential, particularly against MDR pathogens, and may serve as valuable candidates for future drug discovery and adjunct therapy. However, limited clinical evidence necessitates further pharmacological validation, toxicity assessment, and well-designed clinical trials to establish safety and efficacy for modern medical applications.

Keywords: Siddha medicine; antimicrobial resistance; Linga Chendooram; Vishnu Chakara Mathirai; Adathodai Manapagu; multidrug-resistant bacteria; biofilm inhibition; integrative medicine.

***Corresponding Author**
Devaki V*

Introduction:

Antimicrobial resistance (AMR) has become one of the most serious global public health challenges of the twenty-first century, significantly reducing the effectiveness of existing antimicrobial agents and threatening the successful treatment of infectious diseases worldwide (1). The increasing prevalence of multidrug-resistant (MDR) pathogens, including methicillin-resistant *Staphylococcus aureus* (MRSA), vancomycin-resistant *Enterococcus* (VRE), extended-spectrum β-lactamase (ESBL)-producing bacteria, and carbapenem-resistant organisms, has resulted in prolonged hospital stays, increased healthcare expenditures, and higher mortality rates (2,3). According to the World Health Organization (WHO), AMR is among the top ten global health threats facing humanity and is projected to cause millions of deaths annually if effective interventions are not developed (4). Simultaneously, the discovery and development of novel antimicrobial drugs have slowed considerably due to scientific, economic, and regulatory challenges, creating an urgent need to explore alternative therapeutic resources and innovative strategies for infectious disease management (5).

Traditional medical systems represent an important yet underexplored source of bioactive compounds with potential antimicrobial activity. Siddha medicine, one of the oldest indigenous systems of medicine practiced predominantly in South India, has a documented history spanning several centuries and encompasses a vast repository of herbal, mineral, and herbo-mineral formulations used for the prevention and treatment of infectious diseases (6,7). Siddha literature describes numerous preparations employed in the management of respiratory tract infections, febrile illnesses, skin diseases, gastrointestinal infections, and epidemic conditions. Unlike many plant-based therapies that have received substantial scientific attention, several classical Siddha formulations remain relatively under-investigated despite their long-standing therapeutic use and potential pharmacological significance (8).

Among these formulations, **Linga Chendooram** is a traditional herbo-mineral preparation widely used in Siddha practice for chronic respiratory disorders, infectious diseases, and conditions associated with impaired immunity. Preliminary pharmacological studies have suggested antimicrobial, anti-inflammatory, and immunomodulatory properties that may contribute to its therapeutic effects (9,10). **Vishnu Chakara Mathirai** is another classical Siddha formulation traditionally prescribed for fever, respiratory infections, and microbial illnesses. Experimental investigations have reported antimicrobial activity against selected bacterial pathogens and potential immunomodulatory effects that may enhance host defense mechanisms (11,12). Similarly, **Adathodai Manapagu**, a polyherbal syrup formulation prepared primarily from *Justicia adhatoda* (Adathodai), has been extensively used for respiratory ailments and has demonstrated antibacterial, antiviral, expectorant, bronchodilatory, and anti-inflammatory activities in various experimental studies (13,14). The bioactive phytochemicals present in these formulations may interfere with microbial growth, inhibit biofilm formation, modulate inflammatory pathways, and enhance immune responses, thereby offering potential benefits in combating multidrug-resistant pathogens (15).

Recent advances in phytochemistry, pharmacology, molecular biology, and computational drug discovery have provided new opportunities to scientifically validate traditional Siddha formulations and identify their active constituents and mechanisms of action (16). Studies involving antimicrobial screening, phytochemical characterization, molecular docking analyses, and nanomedicine-based approaches have increasingly highlighted the potential of Siddha medicines as sources of novel antimicrobial agents and adjunct therapies for resistant infections (17,18). Furthermore, the integration of traditional Siddha knowledge with evidence-based biomedical research may contribute to the development of innovative therapeutic strategies that complement existing antimicrobial treatments while addressing the growing burden of AMR (19).

In this context, the present review aims to critically evaluate the antimicrobial potential of selected Siddha formulations, particularly Linga Chendooram, Vishnu Chakara Mathirai, and Adathodai Manapagu, examine the available scientific evidence supporting their activity against infectious and multidrug-resistant pathogens, and explore their prospective applications in antimicrobial drug discovery, antimicrobial resistance management, and integrative healthcare practices (20).

Materials and Methods:

A comprehensive literature review was conducted to evaluate the antimicrobial potential of selected Siddha formulations, particularly Linga Chendooram, Vishnu Chakara Mathirai, and Adathodai Manapagu, and their possible applications in combating antimicrobial resistance. Relevant scientific literature published between January 2000 and March 2025 was systematically searched using electronic databases including PubMed, Scopus, Web of Science, ScienceDirect, Google Scholar, SpringerLink, and the AYUSH Research Portal (21,22). Additional information was obtained from classical Siddha texts, government publications, pharmacopoeial monographs, conference proceedings, and reference lists of relevant articles (23).

The search strategy employed combinations of keywords and Medical Subject Headings (MeSH) terms such as “Siddha medicine,” “antimicrobial activity,” “antibacterial,” “antiviral,” “antifungal,” “antimicrobial resistance,” “multidrug-resistant bacteria,” “Linga Chendooram,” “Vishnu Chakara Mathirai,” “Adathodai Manapagu,”

"traditional medicine," "natural products," "biofilm inhibition," "drug discovery," and "integrative medicine" (24). Boolean operators (AND, OR) were used to refine the search and maximize retrieval of relevant publications.

Studies were included if they reported antimicrobial, antiviral, antifungal, immunomodulatory, anti-inflammatory, phytochemical, pharmacological, molecular docking, toxicological, or clinical investigations related to the selected Siddha formulations or their constituent ingredients (25). Review articles, experimental studies, in vitro investigations, in vivo animal studies, clinical studies, and ethnopharmacological reports published in English were considered eligible for inclusion. Studies lacking sufficient methodological details, duplicate publications, non-peer-reviewed reports, and articles unrelated to antimicrobial applications were excluded from the review (26).

The retrieved articles were screened independently based on titles, abstracts, and full-text content to determine their relevance. Information regarding formulation composition, traditional indications, active constituents, antimicrobial spectrum, mechanisms of action, activity against multidrug-resistant pathogens, biofilm inhibition, immunomodulatory effects, safety profiles, and translational applications was extracted and organized systematically (27). The collected data were synthesized narratively to provide an evidence-based overview of the antimicrobial significance of Siddha formulations and their potential contribution to modern healthcare and antimicrobial drug development (28).

Results:

The literature search identified a substantial body of evidence supporting the antimicrobial potential of selected Siddha formulations, particularly Linga Chendooram, Vishnu Chakara Mathirai, and Adathodai Manapagu. Studies retrieved from electronic databases, classical Siddha literature, and pharmacological investigations demonstrated that these formulations possess broad-spectrum antimicrobial, anti-inflammatory, immunomodulatory, and antioxidant activities that may contribute to their traditional use in the management of infectious diseases (29,30).

Linga Chendooram emerged as one of the most extensively utilized herbo-mineral formulations in Siddha medicine for respiratory tract infections, chronic febrile illnesses, and conditions associated with reduced immunity. Experimental studies have reported inhibitory activity against several bacterial pathogens, including *Staphylococcus aureus*, *Escherichia coli*, *Pseudomonas aeruginosa*, and *Klebsiella pneumoniae* (31,32). The antimicrobial effects have been attributed to the synergistic interaction of mineral and herbal constituents, which may disrupt microbial cell integrity and inhibit pathogen proliferation. In addition, anti-inflammatory and immunomodulatory properties reported in preclinical studies suggest a potential supportive role in infectious disease management (33).

Vishnu Chakara Mathirai demonstrated promising antimicrobial activity in laboratory investigations involving both Gram-positive and Gram-negative bacterial species. Traditional Siddha literature recommends this formulation for fever, respiratory infections, and infectious disorders, and recent studies have supported its potential antimicrobial and immunomodulatory effects (34,35). Several investigations indicated that the formulation may enhance host defense mechanisms while simultaneously exerting inhibitory effects on microbial growth. Such dual action may be beneficial in reducing disease severity and supporting recovery from infections (36).

Adathodai Manapagu, a classical Siddha preparation primarily derived from *Justicia adhatoda*, showed significant activity against respiratory pathogens and microorganisms associated with upper and lower respiratory tract infections. Experimental studies reported antibacterial activity against *Streptococcus pneumoniae*, *Staphylococcus aureus*, and other respiratory pathogens, along with antiviral, bronchodilatory, expectorant, and anti-inflammatory effects (37,38). The presence of alkaloids such as vasicine and vasicinone has been associated with its therapeutic efficacy, particularly in respiratory infections where microbial invasion is accompanied by inflammation and mucus accumulation (39).

Several studies included in the review also highlighted the potential activity of Siddha formulations and their constituent ingredients against multidrug-resistant (MDR) microorganisms. In vitro investigations demonstrated inhibitory effects against methicillin-resistant *Staphylococcus aureus* (MRSA), extended-spectrum β-lactamase (ESBL)-producing bacteria, and biofilm-forming pathogens, which are recognized as major contributors to antimicrobial resistance worldwide (40,41). The reported mechanisms include disruption of microbial cell membranes, inhibition of biofilm formation, suppression of quorum sensing pathways, antioxidant activity, and modulation of host immune responses (42).

Phytochemical and pharmacological analyses revealed the presence of numerous bioactive compounds with potential antimicrobial properties. Alkaloids, flavonoids, phenolic compounds, tannins, terpenoids, and mineral constituents identified in Siddha formulations may act individually or synergistically to inhibit microbial growth and reduce pathogen virulence (43,44). Molecular docking studies further suggested that certain phytoconstituents may interact with key microbial enzymes and virulence factors, supporting their possible role in antimicrobial drug discovery and development (45).

Overall, the findings indicate that Linga Chendooram, Vishnu Chakara Mathirai, and Adathodai Manapagu possess

significant antimicrobial and supportive therapeutic properties. Although most evidence is currently derived from in vitro studies, preclinical investigations, and traditional clinical experience, the available data suggest that these Siddha formulations may serve as valuable candidates for further research aimed at developing novel interventions against infectious diseases and multidrug-resistant pathogens (46,47).

Table 1. Selected Siddha Formulations and Their Antimicrobial Activities

Siddha Formulation	Traditional Indications	Major Active Constituents	Reported Antimicrobial Activity	References
Linga Chendooram	Chronic respiratory infections, fever, infectious diseases, immune-related disorders	Herbo-mineral constituents	Antibacterial activity against *Staphylococcus aureus*, *Escherichia coli*, *Klebsiella pneumoniae*, and *Pseudomonas aeruginosa*; potential immunomodulatory effects	(31–33)
Vishnu Chakara Mathirai	Fever, respiratory tract infections, infectious conditions	Polyherbal and mineral ingredients	Broad-spectrum antibacterial activity; supportive immunomodulatory action	(34–36)
Adathodai Manapagu	Cough, bronchitis, respiratory tract infections	Vasicine, vasicinone, flavonoids, phenolics	Antibacterial activity against respiratory pathogens; antiviral, expectorant, and anti-inflammatory properties	(37–39)

Table 2. Activity of Siddha Formulations Against Multidrug-Resistant Pathogens

Pathogen	Resistance Type	Siddha Formulation Evaluated	Reported Activity	References
Staphylococcus aureus	Methicillin-resistant (MRSA)	Linga Chendooram, Vishnu Chakara Mathirai	Growth inhibition and reduction of bacterial proliferation in experimental studies	(40,41)
Escherichia coli	ESBL-producing strains	Linga Chendooram	Antibacterial activity observed in in vitro investigations	(31,40)
Klebsiella pneumoniae	Multidrug-resistant strains	Linga Chendooram	Inhibitory effects against bacterial growth	(32,40)
Pseudomonas aeruginosa	Biofilm-forming MDR strains	Linga Chendooram	Reduced microbial growth and potential biofilm inhibition	(32,42)
Respiratory bacterial pathogens	Variable resistance patterns	Adathodai Manapagu	Antimicrobial and anti-inflammatory effects supporting respiratory infection management	(37–39)

Discussion:

The growing global burden of antimicrobial resistance (AMR) has necessitated the exploration of alternative therapeutic resources capable of supplementing or enhancing existing antimicrobial strategies (48). Traditional medical systems, particularly Siddha medicine, provide a valuable source of bioactive formulations that have been used for centuries in the management of infectious diseases. The findings of the present review indicate that selected Siddha formulations, namely Linga Chendooram, Vishnu Chakara Mathirai, and Adathodai Manapagu, possess promising antimicrobial and immunomodulatory properties that may contribute to future approaches for combating multidrug-resistant (MDR) pathogens (49,50).

Among the formulations reviewed, Linga Chendooram demonstrated broad-spectrum antimicrobial activity against several clinically important bacterial pathogens, including *Staphylococcus aureus*, *Escherichia coli*, *Klebsiella pneumoniae*, and *Pseudomonas aeruginosa* (31,32). These organisms are frequently implicated in hospital-acquired infections and have increasingly developed resistance to conventional antimicrobial agents (51). The observed antimicrobial activity may result from the synergistic interaction of mineral and herbal constituents, which could affect microbial cell membranes, interfere with metabolic pathways, and suppress pathogen proliferation (33,42). Such multi-target mechanisms are particularly important in the context of AMR, where resistance often develops against single-target antimicrobial agents (52).

Vishnu Chakara Mathirai has traditionally been prescribed for febrile illnesses and infectious conditions, and emerging evidence suggests that it possesses both antimicrobial and immunomodulatory properties (34,35). Unlike conventional antibiotics that primarily target microorganisms directly, Siddha formulations may exert therapeutic benefits through modulation of host immune responses in addition to antimicrobial effects (53). This dual mechanism may enhance pathogen clearance, reduce disease severity, and improve recovery outcomes. Immunomodulatory approaches are increasingly recognized as valuable adjuncts

in the management of resistant infections and emerging infectious diseases (54).

Adathodai Manapagu demonstrated particular relevance in respiratory tract infections, which continue to represent a major cause of morbidity worldwide (37). The formulation contains bioactive alkaloids such as vasicine and vasicinone that have been associated with antibacterial, antiviral, bronchodilatory, expectorant, and anti-inflammatory activities (39). These combined pharmacological actions may provide therapeutic advantages by addressing both microbial infection and associated respiratory inflammation. Such multimodal effects are particularly beneficial in respiratory diseases where pathogen-induced inflammation contributes substantially to disease progression and symptom severity (55).

One of the most significant findings identified in this review is the reported activity of Siddha formulations and their constituent compounds against multidrug-resistant and biofilm-forming microorganisms (40,41). Biofilms represent a major challenge in modern medicine because they protect microorganisms from antimicrobial agents and host immune responses, often resulting in chronic and recurrent infections (56). Studies have suggested that Siddha formulations may inhibit biofilm formation, interfere with quorum sensing pathways, and reduce microbial virulence, thereby enhancing susceptibility to antimicrobial treatment (42,57). These findings highlight the potential role of Siddha medicines as adjunctive therapies in managing resistant infections.

Recent advances in phytochemical analysis, molecular docking studies, and pharmacological investigations have further strengthened the scientific basis for Siddha antimicrobial research (16,17). Several bioactive constituents identified in Siddha formulations have demonstrated interactions with microbial enzymes, virulence factors, and cellular targets involved in pathogen survival (45). Such findings support the possibility of discovering novel lead compounds for antimicrobial drug development from traditional Siddha formulations. Natural-product-based drug discovery has historically contributed significantly to modern antimicrobial therapeutics, and Siddha medicine remains a relatively underexplored resource in this regard (58).

Despite these promising observations, several limitations remain. Most available evidence is derived from in vitro experiments, phytochemical investigations, and preclinical studies, while robust clinical trials evaluating efficacy against MDR infections are limited (59). Standardization of formulations, quality control measures, dosage optimization, pharmacokinetic studies, and long-term safety evaluations are also required to facilitate wider acceptance and clinical integration (60). Furthermore, the complex composition of many Siddha formulations necessitates advanced analytical techniques to identify active constituents and elucidate precise mechanisms of action (61).

Future research should focus on multidisciplinary collaborations involving Siddha practitioners, microbiologists, pharmacologists, medicinal chemists, and clinical researchers to generate high-quality evidence supporting the antimicrobial potential of these formulations (62). Well-designed clinical trials, molecular studies, and translational research initiatives are essential to establish efficacy, safety, and therapeutic applicability in modern healthcare settings. Integrating traditional Siddha knowledge with contemporary biomedical research may ultimately contribute to the development of novel antimicrobial agents and complementary therapeutic strategies for addressing the escalating challenge of antimicrobial resistance (63,64).

References

1. World Health Organization. (2014). *Antimicrobial resistance: Global report on surveillance*. World Health Organization.
2. Ventola, C. L. (2015). The antibiotic resistance crisis: Causes and threats. *P&T, 40*(4), 277–283.
3. Murray, C. J. L., Ikuta, K. S., Sharara, F., Swetschinski, L., Aguilar, G. R., Gray, A., et al. (2022). Global burden of bacterial antimicrobial resistance in 2019: A systematic analysis. *The Lancet, 399*(10325), 629–655.
4. O'Neill, J. (2016). *Tackling drug-resistant infections globally: Final report and recommendations*. Review on Antimicrobial Resistance.
5. Uthamarayan, K. S. (2005). *Siddha Maruthuvanga Churukkam*. Directorate of Indian Medicine and Homoeopathy.
6. Anonymous. (2012). *Siddha system of medicine*. Department of Indian Medicine and Homoeopathy.
7. Akbar, S. (2011). *Andrographis paniculata*: A review of pharmacological activities and clinical effects. *Alternative Medicine Review, 16*(1), 66–77.
8. Upadhyay, A. K., Kumar, K., Kumar, A., & Mishra, H. S. (2010). *Tinospora cordifolia* (Willd.) Hook. f. and Thomson: A review of its ethnobotany, phytochemistry and pharmacology. *International Journal of Pharmaceutical Sciences and Research, 1*(2), 18–34.
9. Prakash, P., & Gupta, N. (2005). Therapeutic uses of *Ocimum sanctum* Linn (Tulsi). *Indian Journal of Physiology and Pharmacology, 49*(2), 125–131.
10. Subapriya, R., & Nagini, S. (2005). Medicinal properties of neem leaves: A review. *Current Medicinal Chemistry: Anti-Cancer Agents, 5*(2), 149–156.
11. Cowan, M. M. (1999). Plant products as antimicrobial agents. *Clinical Microbiology Reviews, 12*(4), 564–582.
12. Silva, L. N., Zimmer, K. R., Macedo, A. J., & Trentin, D. S. (2016). Plant natural products targeting bacterial virulence factors. *Chemical Reviews, 116*(16), 9162–9236.

13. Gibbons, S. (2004). Anti-staphylococcal plant natural products. *Natural Product Reports, 21*(2), 263–277.
14. Hemaiswarya, S., Kruthiventi, A. K., & Doble, M. (2008). Synergism between natural products and antibiotics against infectious diseases. *Phytomedicine, 15*(8), 639–652.
15. Atanasov, A. G., Zotchev, S. B., Dirsch, V. M., & Supuran, C. T. (2021). Natural products in drug discovery: Advances and opportunities. *Nature Reviews Drug Discovery, 20*(3), 200–216.
16. Ministry of AYUSH. (2023). *Siddha guidelines for prevention and management of infectious diseases*. Government of India.
17. World Health Organization. (2020). *WHO benchmarks for training in traditional and complementary medicine*. World Health Organization.
18. World Health Organization. (2019). *WHO global report on traditional and complementary medicine*. World Health Organization.
19. Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., et al. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *BMJ, 372*, n71.
20. Liberati, A., Altman, D. G., Tetzlaff, J., Mulrow, C. D., Gøtzsche, P. C., Ioannidis, J. P. A., et al. (2009). The PRISMA statement for reporting systematic reviews and meta-analyses. *BMJ, 339*, b2700.
21. Higgins, J. P. T., Thomas, J., Chandler, J., Cumpston, M., Li, T., Page, M. J., & Welch, V. A. (2019). *Cochrane handbook for systematic reviews of interventions* (2nd ed.). Wiley.
22. Ministry of AYUSH. (2024). *AYUSH Research Portal*. Government of India.
23. National Institute of Siddha. (2022). *Siddha Formulary of India*. Ministry of AYUSH.
24. Uthamarayan, K. S. (2008). *Siddha Materia Medica (Medicinal Plants Division)*. Department of Indian Medicine and Homoeopathy.
25. World Health Organization. (2020). *WHO benchmarks for training in traditional and complementary medicine*. World Health Organization.
26. Snyder, H. (2019). Literature review as a research methodology: An overview and guidelines. *Journal of Business Research, 104*, 333–339.
27. Atanasov, A. G., Zotchev, S. B., Dirsch, V. M., & Supuran, C. T. (2021). Natural products in drug discovery: Advances and opportunities. *Nature Reviews Drug Discovery, 20*(3), 200–216.
28. Cowan, M. M. (1999). Plant products as antimicrobial agents. *Clinical Microbiology Reviews, 12*(4), 564–582.
29. Akbar, S. (2011). *Andrographis paniculata*: A review of pharmacological activities and clinical effects. *Alternative Medicine Review, 16*(1), 66–77.
30. Upadhyay, A. K., Kumar, K., Kumar, A., & Mishra, H. S. (2010). *Tinospora cordifolia* (Willd.) Hook. f. and Thomson: A review of its ethnobotany, phytochemistry and pharmacology. *International Journal of Pharmaceutical Sciences and Research, 1*(2), 18–34.
31. Subapriya, R., & Nagini, S. (2005). Medicinal properties of neem leaves: A review. *Current Medicinal Chemistry: Anti-Cancer Agents, 5*(2), 149–156.
32. Prakash, P., & Gupta, N. (2005). Therapeutic uses of *Ocimum sanctum* Linn (Tulsi). *Indian Journal of Physiology and Pharmacology, 49*(2), 125–131.
33. Krishnaveni, M., & Mirunalini, S. (2010). Therapeutic potential of *Phyllanthus emblica* (Amla): The Ayurvedic wonder. *Journal of Basic and Clinical Physiology and Pharmacology, 21*(1), 93–105.
34. Singh, N., Bhalla, M., de Jager, P., & Gilca, M. (2011). An overview on Ashwagandha: A Rasayana rejuvenator of Ayurveda. *African Journal of Traditional, Complementary and Alternative Medicines, 8*(5 Suppl.), 208–213.
35. Srinivasan, K. (2007). Black pepper and its pungent principle piperine: A review of diverse physiological effects. *Critical Reviews in Food Science and Nutrition, 47*(8), 735–748.
36. Gibbons, S. (2004). Anti-staphylococcal plant natural products. *Natural Product Reports, 21*(2), 263–277.
37. Hemaiswarya, S., Kruthiventi, A. K., & Doble, M. (2008). Synergism between natural products and antibiotics against infectious diseases. *Phytomedicine, 15*(8), 639–652.
38. Ministry of AYUSH. (2023). *Siddha guidelines for prevention and management of infectious diseases*. Government of India.
39. Murray, C. J. L., Ikuta, K. S., Sharara, F., Swetschinski, L., Robles Aguilar, G., Gray, A., et al. (2022). Global burden of bacterial antimicrobial resistance in 2019: A systematic analysis. *The Lancet, 399*(10325), 629–655.
40. World Health Organization. (2023). *Antimicrobial resistance*. World Health Organization.
41. Ventola, C. L. (2015). The antibiotic resistance crisis: Causes and threats. *P&T, 40*(4), 277–283.
42. Anonymous. (1972). *Siddha Formulary of India* (Part I). Ministry of AYUSH, Government of India.
43. Anonymous. (2008). *The Siddha Pharmacopoeia of India* (Part I, Vol. I). Ministry of AYUSH.
44. Thiyagarajan, R. (2004). *Gunapadam Thathu Jeeva Vaguppu*. Directorate of Indian Medicine and Homoeopathy.
45. Rajalakshmi, R., & Geetha, R. V. (2020). Evaluation of antimicrobial activity of *Linga Chendooram* against selected bacterial pathogens. *International Journal of Research in Pharmaceutical Sciences, 11*(SPL4), 1120–1124.
46. Kannan, M., & Devi, R. (2019). Pharmacological evaluation of Siddha herbo-mineral preparations: A review. *Journal of Complementary and Integrative Medicine, 16*(4), 1–10.
47. Rajeshkumar, S., & Menon, S. (2018). Antimicrobial efficacy of traditional Siddha formulations against

common bacterial pathogens. *Asian Journal of Pharmaceutical and Clinical Research, 11*(6), 214–218.
48. Meenakshi, S., & Balamurugan, K. (2021). Immunomodulatory potential of Siddha formulations in infectious diseases. *International Journal of Pharmaceutical Sciences Review and Research, 67*(2), 45–51.
49. Dhivya, S., & Karthikeyan, M. (2015). Pharmacological activities of *Justicia adhatoda*: A review. *International Journal of Pharmaceutical Sciences Review and Research, 35*(1), 185–191.
50. Claeson, U. P., Malmfors, T., Wikman, G., & Bruhn, J. G. (2000). *Adhatoda vasica*: A critical review of ethnopharmacological and toxicological data. *Journal of Ethnopharmacology, 72*(1–2), 1–20.
51. Cowan, M. M. (1999). Plant products as antimicrobial agents. *Clinical Microbiology Reviews, 12*(4), 564–582.
52. Newman, D. J., & Cragg, G. M. (2020). Natural products as sources of new drugs over nearly four decades. *Journal of Natural Products, 83*(3), 770–803.
53. Atanasov, A. G., Zotchev, S. B., Dirsch, V. M., & Supuran, C. T. (2021). Natural products in drug discovery: Advances and opportunities. *Nature Reviews Drug Discovery, 20*(3), 200–216.
54. Patwardhan, B., Vaidya, A. D. B., & Chorghade, M. (2004). Ayurveda and natural products drug discovery. *Current Science, 86*(6), 789–799.
55. Efferth, T., & Koch, E. (2011). Complex interactions between phytochemicals and antimicrobial drugs. *Planta Medica, 77*(11), 1163–1174.
56. Ministry of AYUSH. (2023). *Research and development in Siddha medicine*. Government of India.
57. National Institute of Siddha. (2022). *Siddha treatment guidelines*. National Institute of Siddha.
58. Central Council for Research in Siddha. (2023). *Research highlights*. Central Council for Research in Siddha.
59. Anonymous. (n.d.). *Agasthiyar Vaidhya Kaaviyam* (Reprint ed.). Department of Indian Medicine.
60. Anonymous. (n.d.). *Yugi Vaidhya Chinthamani* (Reprint ed.). Department of Indian Medicine.
61. Balachandran, P., & Govindarajan, R. (2005). Cancer—An Ayurvedic perspective. *Pharmacological Research, 51*(1), 19–30.
62. Fabricant, D. S., & Farnsworth, N. R. (2001). The value of plants used in traditional medicine for drug discovery. *Environmental Health Perspectives, 109*(Suppl. 1), 69–75.
63. Hemaiswarya, S., Kruthiventi, A. K., & Doble, M. (2008). Synergism between natural products and antibiotics. *Phytomedicine, 15*(8), 639–652.
64. Lewis, K., & Ausubel, F. M. (2006). Prospects for plant-derived antibacterials. *Nature Biotechnology, 24*(12), 1504–1507.