

Antifungal Potential of Different Extracts of Various Parts of *Justicia adhatoda* L

Anita Yadav*¹

¹ Assistant Professor, Department of Botany, Government College Jaipur - 302 015, Rajasthan, India

Received: 31 July 2026; Revised accepted: 08 Sept 2026

Abstract

Justicia adhatoda L. (family Acanthaceae), commonly known as Vasaka or Malabar nut, is an important medicinal plant widely used in traditional systems of medicine. The plant is known for its diverse pharmacological properties. The therapeutic potential of *Justicia adhatoda* is attributed to the presence of various bioactive compounds such as vasicine, vasicinone, flavonoids, phenolics, and tannins. The present study aimed to evaluate the antifungal activity of different parts of *Justicia adhatoda* L., including roots, stems, leaves, and flowers, against *Aspergillus niger*, *Penicillium chrysogenum* and *Alternaria alternata*. Methanolic, petroleum ether, and aqueous extracts of the selected plant parts were prepared and tested at concentrations ranging from 25 to 100 µg/L. Based on data presented here, Methanolic extracts exhibited greater antifungal activity than aqueous and petroleum ether extracts across all tested fungi. The findings suggest that different parts of *Justicia adhatoda*, particularly the methanolic leaf extract, possess significant antifungal potential and may serve as a promising source of natural antifungal agents for the management of fungal pathogens. Further studies are needed to isolate and characterize the active compounds responsible for the observed antifungal activity and to explore their potential applications in agriculture and medicine.

Key words: Antifungal activity, *Justicia adhatoda*, Methanolic, Petroleum ether and aqueous extracts, *Aspergillus niger*, *Penicillium chrysogenum*, *Alternaria alternata*

Medicinal plants have been used for centuries as a valuable source of therapeutic agents for the treatment of various human diseases. In recent years, there has been increasing interest in plant-based antimicrobial compounds due to the growing incidence of drug-resistant microorganisms and the adverse effects associated with synthetic drugs. Fungal infections caused by species such as *Candida albicans*, *Aspergillus flavus*, and *Cryptococcus neoformans* represent a significant health concern worldwide, creating a need for safer and more effective antifungal agents [1]. *Justicia adhatoda* L., commonly known as Vasaka or Malabar nut, belongs to the family Acanthaceae and is widely distributed throughout South and Southeast Asia. The plant has been extensively used in traditional Ayurvedic and Unani systems of medicine for the treatment of respiratory disorders, cough, asthma, bronchitis, and various infectious diseases. Its therapeutic properties are mainly attributed to the presence of bioactive phytochemicals such as alkaloids, flavonoids, phenolic compounds, tannins, terpenoids, and glycosides [2-3].

Justicia adhatoda L., commonly known as Vasaka or Malabar nut, belongs to the family Acanthaceae and is widely distributed throughout South and Southeast Asia. It is an important medicinal shrub that has been extensively used in traditional Ayurvedic and Unani systems of medicine for the management of respiratory disorders, cough, asthma, bronchitis, and various infectious diseases [4]. Different parts of the plant, particularly the leaves, roots, stems, flowers, and bark, have been traditionally utilized for their diverse

pharmacological properties. The therapeutic potential of *J. adhatoda* is largely attributed to the presence of several biologically active phytochemicals, including alkaloids, flavonoids, phenolic compounds, tannins, terpenoids, glycosides, and other secondary metabolites [5].

In recent years, increasing attention has been directed towards medicinal plants as potential sources of natural antimicrobial and antifungal agents. The extensive and sometimes indiscriminate use of synthetic fungicides has resulted in concerns related to environmental contamination, toxicity, residual effects, and the emergence of resistant fungal strains [6]. Consequently, plant-derived compounds are being explored as safer and environmentally compatible alternatives for the management of fungal pathogens. The presence of phenolics, flavonoids, alkaloids, tannins, and terpenoids in medicinal plants is often associated with their ability to inhibit fungal growth through mechanisms such as disruption of cell membranes, inhibition of essential enzymes, alteration of cellular metabolism, and interference with spore germination and mycelial development [7].

Different plant parts may vary considerably in their phytochemical composition and, consequently, in their antifungal activity. Similarly, the efficiency of extraction depends on the solvent used, as different solvents selectively extract compounds according to their polarity and chemical characteristics [8]. Extracts prepared using solvents such as methanol, ethanol, acetone, chloroform, petroleum ether, and water may therefore exhibit varying degrees of antifungal

*Correspondence to: Anita Yadav, E-mail: anitavikasyadav1990@gmail.com; Tel: +91 8619707239

Citation: Yadav A. 2026. Antifungal potential of different extracts of various parts of *Justicia adhatoda* L. Res. Jr. Agril. Sci. 17(5): 576-581.

efficacy. Comparative evaluation of extracts from different parts of *J. adhatoda* can help identify the plant part and extraction medium that provide maximum inhibition against target fungal pathogens [9]. The leaves of *J. adhatoda* are particularly rich in quinazoline alkaloids such as vasicine and related bioactive constituents, while other plant parts may contain varying concentrations of phenolics, flavonoids, tannins, and other secondary metabolites. These compounds may act individually or synergistically to produce antimicrobial effects. Although the medicinal properties of *J. adhatoda* have been widely documented, systematic comparison of the antifungal potential of extracts obtained from different plant parts using different solvents remains important for identifying promising natural antifungal sources [10].

Several studies have demonstrated that different parts of *Justicia adhatoda*, particularly the leaves, possess a wide range of biological activities including antibacterial, antioxidant, anti-inflammatory, anticancer, and antimicrobial effects. Among its major alkaloids, vasicine and vasicinone have been reported to contribute significantly to its pharmacological potential. Recent investigations have also highlighted the antifungal properties of various solvent extracts of the plant, suggesting their potential use as natural alternatives to conventional antifungal drugs [11].

The extraction solvent plays a crucial role in determining the type and quantity of phytochemicals obtained from plant materials. Different extracts such as aqueous, methanolic, ethanolic, chloroform, acetone, and n-hexane extracts may exhibit varying degrees of antifungal activity due to differences in their chemical composition [12]. Therefore, comparative evaluation of different extracts is essential for identifying the most effective solvent system and bioactive constituents responsible for antifungal action. The present study aims to investigate the antifungal potential of different extracts of *Justicia adhatoda* L. against selected fungal pathogens. The findings may contribute to the development of plant-based antifungal formulations and provide scientific validation for the traditional use of this medicinal plant in the management of fungal infections.

MATERIALS AND METHODS

Collection and processing of plant material

The components of *Justicia adhatoda* L., including roots, stems, leaves, and flowers, were collected from Jaipur, Rajasthan. Plant components were washed with running tap water and subsequently with distilled water to remove dust particles. Thereafter, the plant components were air-dried and

pulverized in a mixer grinder to yield a coarse powder and powdered material was stored for further use.

Extraction in different solvents

Plant materials were extracted utilizing several polar and non-polar solvents. The selected solvents were water (very polar), methanol (moderately polar), and petroleum ether (non-polar). For this purpose, 1 gram of each plant component (root, stem, leaves, and flowers) was separately immersed in 10 milliliters of the solvent. A total of twelve tubes were produced for this purpose. The artifacts were preserved in a shaker at ambient temperature for an overnight duration. The tubes were then centrifuged at 10,000 rpm for 10 minutes to isolate the supernatant. Supernatants were placed to pre-weighed petri dishes and permitted to evaporate the solvent. After comprehensive desiccation, the petri dishes were reweighed, and the extract weight per gram of plant material was calculated. Extracts were collected in glass jars for future use.

Antifungal activity

The antifungal activity of aqueous, methanolic, and petroleum ether extracts of different parts (root, stem, leaves and flower) of *Justicia adhatoda* evaluated against *Aspergillus niger*, *Penicillium chrysogenum* and *Alternaria alternata* using the agar well diffusion method at concentrations ranging from 25-100mg/L in Dimethyl sulfoxide (DMSO). The well diffusion method was utilized for evaluation in Potato Dextrose Agar (PDA) medium. For each extract, the inhibition zone (IZ) and activity index (AI) were assessed in comparison to the standard antibiotic drug (ketoconazole). AI was calculated as:

$$\text{Activity Index (AI)} = \frac{\text{Inhibition zone of sample}}{\text{Inhibition zone of standard}}$$

RESULTS AND DISCUSSION

Antifungal activity against *Aspergillus niger*

The antifungal effectiveness of several extracts (water, methanol, and petroleum ether) from different sections of *Justicia adhatoda* was assessed against *Aspergillus niger* at concentrations ranging from 25 to 100 mg/L. The methanolic extract of the leaves exhibited the most pronounced antifungal activity, with inhibition zone (IZ) diameters varying from 12 mm at 25 mg/L to 17 mm at 100 mg/L, yielding activity indices (AI) between 0.80 and 0.89. This indicates that the leaf methanol extract contains potent antifungal compounds capable of significantly inhibiting fungal proliferation.

Table 1 Antifungal activity of different extracts of *Justicia adhatoda* against *Aspergillus niger*

		Antifungal activity at different concentrations against <i>Aspergillus niger</i>							
		25 mg/L		50 mg/L		75 mg/L		100 mg/L	
		IZ (mm)	AI	IZ (mm)	AI	IZ (mm)	AI	IZ (mm)	AI
Root	Water	8	0.53	12	0.70	13	0.72	15	0.78
	Methanol	7	0.46	8	0.47	11	0.61	13	0.68
	Pet. Ether	7	0.46	11	0.64	13	0.72	14	0.73
Stem	Water	NA		NA		8	0.44	10	0.52
	Methanol	7	0.46	8	0.47	9	0.50	11	0.57
	Pet. Ether	7	0.46	8	0.47	9	0.50	10	0.52
Leaves	Water	NA		7	0.41	8	0.44	10	0.52
	Methanol	12	0.80	15	0.88	16	0.88	17	0.89
	Pet. Ether	7	0.53	8	0.47	9	0.50	10	0.52
Flower	Water	7	0.53	10	0.58	12	0.66	13	0.68
	Methanol	10	0.66	11	0.64	12	0.66	14	0.73
	Pet. Ether	8	0.53	9	0.52	10	0.55	11	0.57
Standard		15		17		18		19	

IZ- Inhibition zone in millimeter; AI- Activity index

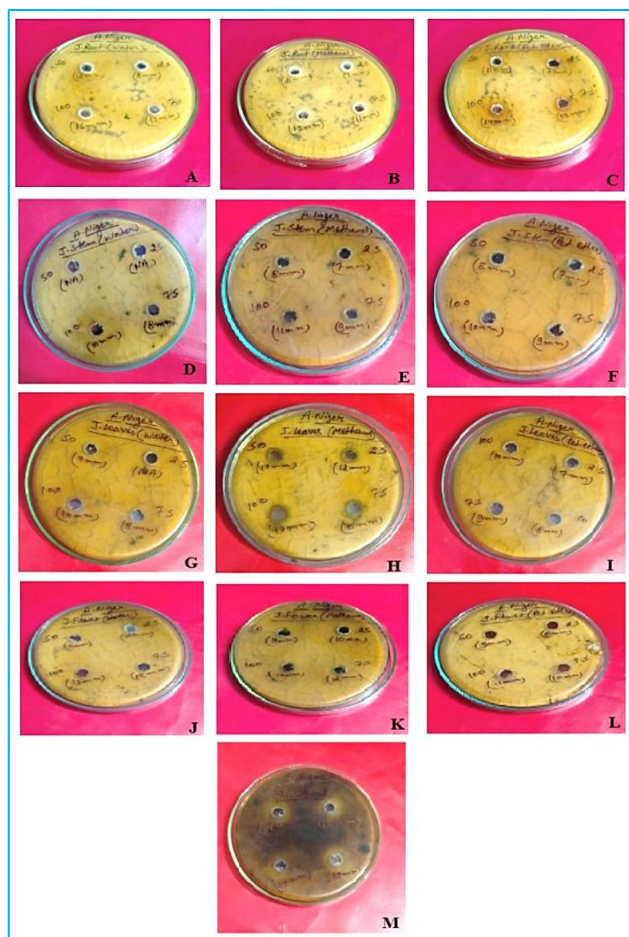


Plate 1 Antifungal activity of different extracts of *Justicia adhatoda* against *Aspergillus niger*

(A-C) for root extracts (water, methanol and pet ether respectively)
(D-F) for stem extracts (water, methanol and pet ether respectively)
(G-I) for leaves extracts (water, methanol and pet ether respectively)
(J-L) for flowers extracts (water, methanol and pet ether respectively)
(M) Standard antibiotic drug ketoconazole

Water extracts from roots and flowers demonstrated significant antifungal activity, with inhibition zones reaching

15 mm (AI 0.78) for roots and 13 mm (AI 0.68) for flowers at the highest concentration assessed. Petroleum ether extracts often shown reduced antifungal effectiveness compared to methanol and water extracts, perhaps due to their extraction of a lesser quantity of polar bioactive compounds. Stem extracts, regardless of the solvent employed, exhibited low antifungal activity, with inhibitory zones measuring only 10–11 mm and diminished activity indices, indicating a paucity or reduced efficacy of antifungal chemicals in this segment.

The antifungal efficacy of methanolic leaf extracts corresponds with the documented presence of flavonoids, alkaloids, and phenolic compounds in *Justicia adhatoda*, which are known to disrupt fungal cell walls and inhibit spore germination. The heightened efficacy of polar solvent extracts suggests that the active antifungal phytochemicals are primarily polar in composition. The standard antifungal agent demonstrated larger zones of inhibition (15–19 mm), while the positive results from the methanolic leaf extract highlight its potential as a natural antifungal source. This supports the traditional use of *Justicia adhatoda* in treating fungal infections and underscores the need for further phytochemical isolation and characterization [13-14].

Against *Penicillium chrysogenum*

The antifungal effectiveness of diverse solvent extracts (water, methanol, and petroleum ether) from various parts of *Justicia adhatoda* was evaluated against *Penicillium chrysogenum* at concentrations ranging from 25 to 100 mg/L. The methanolic extract of the stem exhibited the most pronounced antifungal activity, with inhibitory zones increasing from 8 mm at 25 mg/L to 15 mm at 100 mg/L, yielding activity indices (AI) ranging from 0.61 to 0.55. This suggests the presence of potent antifungal compounds in the stem that may be easily extracted using methanol. Similarly, methanolic and petroleum ether extracts of flowers demonstrated considerable activity, with inhibition zones reaching 14 mm (AI 0.51) at the highest dose evaluated, indicating moderate antifungal efficacy. Water extracts often demonstrated lower inhibition compared to methanol and petroleum ether extracts, particularly in roots and leaves, which showed smaller inhibition zones and activity indices [15-16].

Table 2 Antifungal activity of different extracts of *Justicia adhatoda* against *Penicillium chrysogenum*

		Antifungal activity at different concentrations against <i>Penicillium chrysogenum</i>							
		25 mg/L		50 mg/L		75 mg/L		100 mg/L	
		IZ (mm)	AI	IZ (mm)	AI	IZ (mm)	AI	IZ (mm)	AI
Root	Water	7	0.53	9	0.47	11	0.45	12	0.44
	Methanol	7	0.53	8	0.42	9	0.37	11	0.40
	Pet. Ether	7	0.53	7	0.36	8	0.33	9	0.33
Stem	Water	7	0.53	8	0.42	9	0.37	12	0.44
	Methanol	8	0.61	10	0.52	12	0.50	15	0.55
	Pet. Ether	7	0.53	8	0.42	10	0.41	12	0.44
Leaves	Water	NA		8	0.42	9	0.37	13	0.48
	Methanol	7	0.53	8	0.42	10	0.41	12	0.44
	Pet. Ether	8	0.61	9	0.47	12	0.50	13	0.48
Flower	Water	NA		8	0.42	9	0.37	14	0.51
	Methanol	10	0.76	11	0.57	13	0.54	14	0.51
	Pet. Ether	9	0.69	11	0.57	12	0.50	13	0.48
Standard		13		19		24		27	

IZ- Inhibition zone in millimeter; AI- Activity index

The leaf extracts had moderate antifungal activity, with the petroleum ether extract slightly exceeding the water and methanol extracts at higher concentrations, indicating the presence of both polar and non-polar antifungal chemicals.

Roots had the lowest activity overall, with inhibition zones ranging from 7 to 12 mm and AI values below 0.53, indicating a decreased concentration of bioactive antifungal phytochemicals in this area. Although the conventional

antifungal drug exhibited larger zones of inhibition (13–27 mm), the significant inhibitory effect of the methanol stem extract of *Justicia adhatoda* highlights its potential as a natural antifungal agent. These findings align with the plant's traditional medicinal uses and highlight the importance of methanol as an effective solvent for extracting antifungal phytochemicals, such as alkaloids, flavonoids, and phenolic compounds. The variation in antifungal effectiveness across different plant parts and solvents suggests an uneven distribution of bioactive compounds that may work together to inhibit fungal growth. These findings require further isolation and identification of the active compounds responsible for the antifungal effects [17-18].

Against *Alternaria alternata*

The antifungal activity of several extracts of *Justicia adhatoda* (root, stem, leaves, and flowers) was assessed against *Alternaria alternata* at four concentrations (25, 50, 75, and 100 mg/L). The methanolic extracts consistently demonstrated the highest antifungal activity throughout all plant sections, with inhibition zones increasing with concentration. The root methanol extract shown significant activity, with inhibition zones ranging from 9 mm at 25 mg/L to 17 mm at 100 mg/L, indicating a considerable dose-dependent antifungal effect. This suggests that the root methanolic extract contains potent antifungal compounds effective against *Alternaria alternata*. The methanolic extract of the stem and leaf exhibited notable antifungal activity, with inhibition zones of 11 mm at a concentration of 100 mg/L for both the stem and leaves. Although the zones are smaller than the root, the consistent increase in inhibition with concentration indicates the presence of bioactive antifungal chemicals in these areas as well [19-21].

Water extracts displayed moderate antifungal activity, with the flower water extract outperforming other components, achieving an inhibition zone of 12 mm and an activity index (AI) of 0.48 at a concentration of 100 mg/L. The aqueous extracts of the roots and leaves showed no activity at lower doses, but revealed a slight increase at higher levels.

Petroleum ether extracts frequently exhibited minimal activity, with insignificant inhibition zones and effects observed only at high concentrations, indicating that the antifungal compounds in *Justicia adhatoda* are probably more polar and better extracted by methanol or water. Unlike the conventional antifungal therapy, which demonstrated inhibitory

zones ranging from 18 to 23 mm, *Justicia adhatoda* extracts revealed modest effectiveness nevertheless indicate promise as natural antifungal agents, especially the methanol extract of the roots. This highlights the ethnomedicinal use of *Justicia adhatoda* and stresses the need for further phytochemical investigations to isolate and identify the antifungal compounds responsible for its reported effectiveness [22-24].

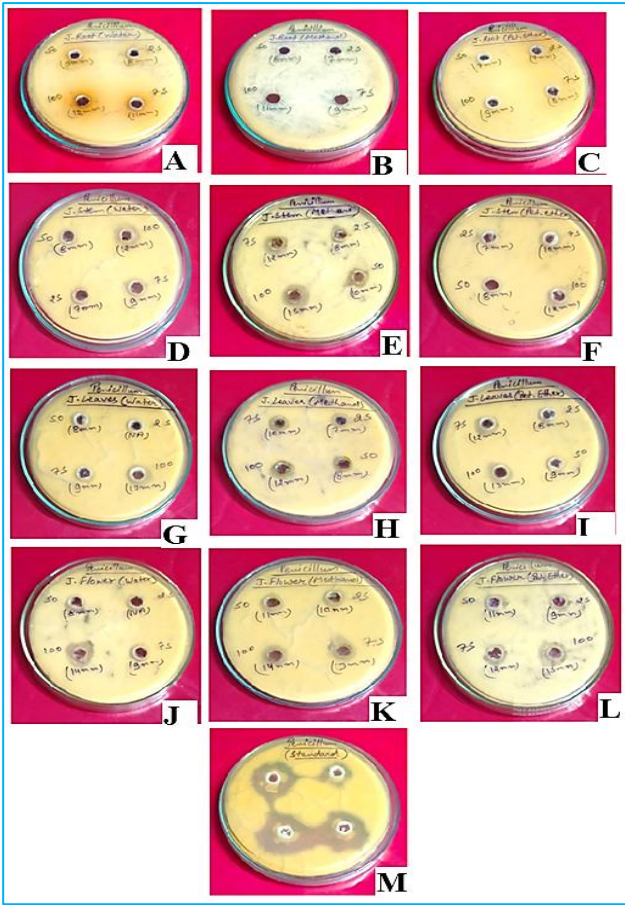


Plate 2 Antifungal activity of different extracts of *Justicia adhatoda* against *Penicillium chrysogenum*

(A-C) for root extracts (water, methanol and pet ether respectively)
(D-F) for stem extracts (water, methanol and pet ether respectively)
(G-I) for leaves extracts (water, methanol and pet ether respectively)
(J-L) for flowers extracts (water, methanol and pet ether respectively)
(M) Standard antibiotic drug ketoconazole

Table 3 Antifungal activity of different extracts of *Justicia adhatoda* against *Alternaria alternata*

		Antifungal activity at different concentrations against <i>Alternaria alternata</i>							
		25 mg/L		50 mg/L		75 mg/L		100 mg/L	
		IZ (mm)	AI	IZ (mm)	AI	IZ (mm)	AI	IZ (mm)	AI
Root	Water	NA	NA	7	0.37	8	0.38	9	0.36
	Methanol	9		11		14		17	
	Pet. Ether	NA		NA		NA		8	
Stem	Water	7	0.47	7	0.37	8	0.38	10	0.40
	Methanol	8		8		10		11	
	Pet. Ether	NA		7		7		8	
Leaves	Water	NA	NA	NA	NA	8	0.38	11	0.44
	Methanol	8		9		11		11	
	Pet. Ether	NA		7		8		8	
Flower	Water	7	0.47	9	0.47	10	0.48	12	0.48
	Methanol	8		9		11		13	
	Pet. Ether	NA		7		8		8	
Standard		18		20		21		23	

IZ- Inhibition zone in millimeter; AI- Activity index

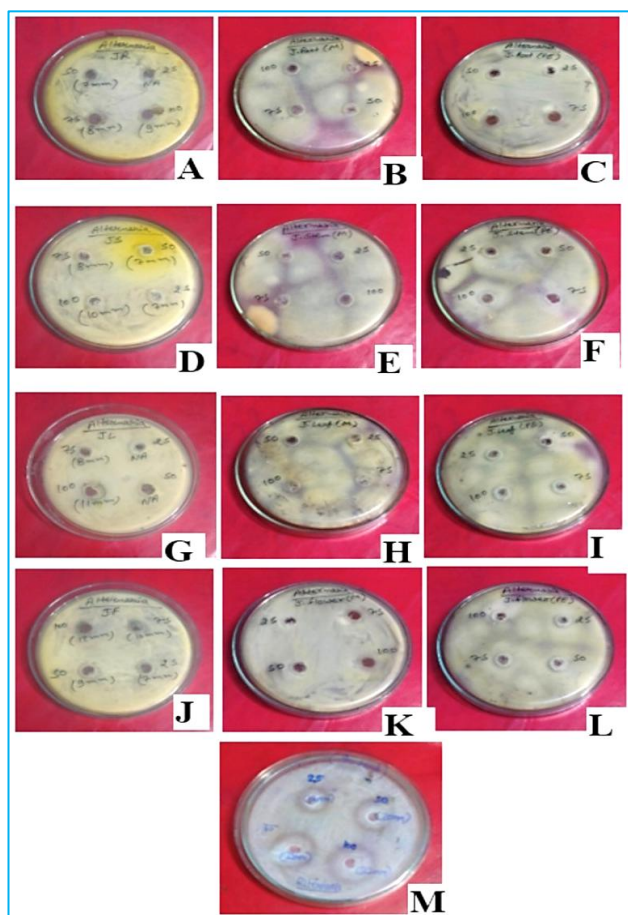


Plate 3 Antifungal activity of different extracts of *Justicia adhatoda* against *Alternaria alternata*

(A-C) for root extracts (water, methanol and pet ether respectively)
 (D-F) for stem extracts (water, methanol and pet ether respectively)
 (G-I) for leaves extracts (water, methanol and pet ether respectively)
 (J-L) for flowers extracts (water, methanol and pet ether respectively)
 (M) Standard antibiotic drug ketoconazole

Comparative analysis

Overall, methanolic extracts exhibited greater antifungal activity than aqueous and petroleum ether extracts across all tested fungi. The strongest activities were observed in the methanolic leaf extract against *Aspergillus niger*, methanolic stem extract against *Penicillium chrysogenum* and methanolic root extract against *Alternaria alternata*. The antifungal activity increased with extract concentration, indicating a dose-dependent effect. Although the standard antifungal drug ketoconazole exhibited higher inhibition zones, the significant activity of *Justicia adhatoda* extracts confirms the presence of potent bioactive compounds with antifungal potential. These findings support the traditional medicinal use of *Justicia adhatoda* and warrant further phytochemical isolation and characterization studies to identify [25].

CONCLUSION

Among the tested fungi, *Alternaria alternata* showed the highest susceptibility to the plant extracts, whereas *Aspergillus niger* and *Penicillium chrysogenum* were comparatively less sensitive. The observed antifungal activity may be attributed to the presence of bioactive phytochemicals such as alkaloids, flavonoids, phenolic compounds, and tannins *Justicia adhatoda*. Overall, the findings indicate that *Justicia adhatoda* is a promising source of natural antifungal compounds and has potential applications in the development of eco-friendly antifungal agents for agricultural and pharmaceutical purposes. Further research is recommended to isolate and characterize the active constituents responsible for the antifungal activity and to evaluate their effectiveness under field and clinical conditions.

Acknowledgement

The author is grateful to Department of Botany, University of Rajasthan for providing facilities for the work and also grateful to Biomitra Life Sciences Private Limited, Jaipur for providing assistance to complete the research work.

LITERATURE CITED

- Aladejana EB. 2023. Biological properties of polyherbal formulations: A review of their anti-microbial, anti-inflammatory, antioxidant, and toxicological activities. *Pharmacognosy Journal* 15(5): 933-963. <https://doi.org/10.5530/pj.2023.15.123>.
- Saravana Kumar A, Venkatesalu V, et al. 2012. Antimicrobial activity of leaf extracts of *Justicia adhatoda* L. in comparison with vasicine. *Asian Pacific Journal of Tropical Biomedicine* 2(Suppl. 3): S1556-S1560.
- Singh N, Verma OP. 2010. Management of Alternaria blight caused by *Alternaria alternata* in Adusa (*Adhatoda vasica*). *Indian Journal of Agricultural Sciences* 80(7).
- Sheeba JB, Selva Mohan T. 2012. Antimicrobial activity of *Adhatoda vasica* against clinical pathogens. *Asian Journal of Plant Science and Research* 2(2): 83-88.
- Ameer MR, Moghul NB, Javed A, Butt MA, Abbas HB, Khalid ZM, Khan Khattak JZ, Kiyani MM. 2023. The therapeutic potential of the medicinal plant *Justicia adhatoda* and its antibacterial and antifungal activities: A comparative study. *Alternative Therapies in Health & Medicine* 29(7): 232-237.
- Singh SP, Das AK. 2021. Vasaka: A boon to the Indian traditional system of medicine. *Journal of Medical Pharmaceutical & Allied Sciences* 10(3): 2877-2880.
- Singh SP, Das AK. 2022. Assessment of flavonoids, phenolic content, antioxidant and antimicrobial activity of methanolic extract of *Justicia adhatoda* L. whole part. *Journal of Pharmaceutical Negative Results* 13(10): 1440-1449.
- Rao KVB, Munjal M, Patnayak A, Karthik L, Kumar G. 2013. Phytochemical composition, antioxidant, antimicrobial and cytotoxic potential of methanolic extracts of *Adhatoda vasica* (Acanthaceae). *Research Journal of Pharmacy and Technology* 6(9): 1004-1009.
- Mohanty S, Pattnaik A. 2024. Evaluation of anti-obesity potential of isolated bioactive fractions from *Justicia adhatoda* leaves: An in vitro, in vivo, and 3T3-L1 cell line approach using HPTLC-MS-MSn for compound identification. *Chemistry and Biodiversity*: e202401532.
- Upadhyay RK. 2011. Plant natural products: Their pharmaceutical potential against disease and drug-resistant microbial pathogens. *Journal of Pharmacy Research* 4(4): 1179-1185.
- Ramachandran J, Sankaranarayanan S. 2013. Antifungal activity and the mode of action of alkaloid extract from the leaves of *Adhatoda vasica*. *International Journal of Ethnomedicine and Pharmacological Research* 1(1): 80-87.

12. Rachana SB, Pant M, Kumar MP, Saluja S. 2011. Review and future perspectives of using vasicine, and related compounds. *Pharmacognosy Reviews* 5(10): 146-154. <https://doi.org/10.4103/0973-7847.91115>.
13. Lakshmi MR, Kiran M, Prasanna KS. 2021. A review on natural plants for phytochemical constituents and pharmacological activities. *Journal of Drug Delivery and Therapeutics* 11(2): 232-236. <https://doi.org/10.22270/jddt.v11i2.4593>.
14. Jose AB, Priscilla N, Francis D. 2023. Antimicrobial, antioxidant, and anti-inflammatory activities of *Justicia adhatoda* L. leaf extract. *Medicinal Plants: International Journal of Phytomedicines and Related Industries* 15(3): 595-604. <https://doi.org/10.5958/0975-6892.2023.00061.3>.
15. Bansod S, Rai M. 2008. Antifungal activity of essential oils from Indian medicinal plants against human pathogenic *Aspergillus fumigatus* and *A. niger*. *World Journal of Medical Sciences* 3(2): 81-88.
16. Banerjee SB, Gupta K. 2021. *Justicia adhatoda* having multifunctional pharmacological properties can prevent COVID-19 disease. *World Journal of Pharmaceutical and Medical Research* 7(9): 71-74.
17. Ahmad S, Amin K, Ullah A, Khan H, Ullah I, Ahmed I, Khan A, Almuhayawi MS, Al Jaouni SK, Selim S, Almehayawi MS, Farid A. 2023. Assessment of the antimicrobial efficacy of different extracts and silver nanoparticles derived from *Justicia adhatoda* against multi-drug resistant bacterial and fungal strains. *Journal of Biological Regulators and Homeostatic Agents* 37(11): 5983-5993. <https://doi.org/10.26355/jbriha.v37i11.5120>.
18. Atal CK, Chandhoke N. 1980. *Chemistry and pharmacology of vasicine: A new oxytocic and abortifacient*. Regional Research Laboratory, Jammu.
19. Dhankhar S, Kaur R, Ruhil S, Balhara M, Dhankhar S, Chhillar AK. 2011. A review on *Justicia adhatoda*: A potential source of natural medicine. *African Journal of Plant Science* 5(11): 620-627. <https://doi.org/10.5897/AJPSX11.011>.
20. Sreekumar K, Abraham A. 2020. Phytochemical, antimicrobial and antioxidant evaluation of *Gulgulupanchapala choornam*. *AIP Conference Proceedings* 2263: 1-6.
21. Patil S. 2010. Study of herbal formulation consisting of various indigenous plants for their anti-asthmatic activity in experimental animals. *International Journal of Research in Ayurveda and Pharmacy* 1(2): 515-521.
22. Narasimhaji CV, Kumar V, Shanumugam M, Singh R, Singh A, Marimuthu G, et al. 2023. *Justicia adhatoda* L. vasicin and vasicinone as bioactive phytochemical compounds: Isolation, characterization, and computational studies. *Results in Chemistry* 6: 101127.
23. Nandre B, Bakliwal S, Rane B, Pawar S. 2012. A review on *Adhatoda vasica*. *Pharma Science Monitor* 3(4): 3232-3245.
24. Kumar S, Singh R, Dutta D, Chandel S, Bhattacharya A, Ravichandiran V, Sukla S. 2022. In vitro anticancer activity of methanolic extract of *Justicia adhatoda* leaves with special emphasis on human breast cancer cell line. *Molecules* 27(23): 8222. <https://doi.org/10.3390/molecules27238222>.
25. Lima MAS, Oliveira MCF, Pimentel ATÁ, Uchôa PKS. 2019. *Aspergillus niger*: A hundred years of contribution to the natural products chemistry. *Journal of the Brazilian Chemical Society* 30(10): 2029-2059.