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Antifungal activity of extracts from different plant parts of *Simarouba glauca* DC

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Abstract
The present study evaluated the antifungal activity of extracts obtained from different plant parts of *Simarouba glauca* DC. Leaves, bark, root, stem and fruit were extracted using chloroform, ethanol, dichloromethane (DCM) and a 1:1 DCM: ethanol solvent system. The antifungal activity of the extracts was evaluated against selected fungal organisms by measuring zones of inhibition. Considerable variation in antifungal response was observed according to plant part and extraction solvent. Leaf extracts generally exhibited greater activity than the corresponding bark, root, stem and fruit extracts. Among the extraction systems, chloroform extract showed comparatively greater activity, particularly for leaf material. The results demonstrate that *S. glauca* possesses measurable *in vitro* antifungal potential and that both plant part and solvent selection influence the observed activity. The findings provide a basis for further phytochemical investigation of the more active extracts.

Keywords: *Simarouba glauca*, antifungal activity, medicinal plant, plant extracts, phytochemicals, fungal pathogens

Introduction
Fungal infections represent an important biological and medical problem, while the development of resistance and limitations associated with some conventional antifungal agents have increased interest in natural sources of antifungal compounds. Medicinal plants contain diverse secondary metabolites, including phenolics, flavonoids, terpenoids, alkaloids and other compounds that may interfere with fungal growth [1, 3].
Simarouba glauca DC., belonging to the family Simaroubaceae, is a medicinal plant traditionally known as Lakshmi Taru. The plant has attracted scientific interest because of its diverse phytochemical composition and reported biological activities. Investigations of its leaves have demonstrated the presence of several classes of secondary metabolites, including flavonoids, phenolic compounds, steroids, terpenoids, tannins, glycosides and saponins.
Previous investigations have provided evidence for the antifungal potential of *S. glauca*. A broad-spectrum study of leaf extracts evaluated the antifungal activity of methanol and ethanol extracts against six fungal organisms. The reported fungal panel included *Aspergillus fumigatus*, Aspergillus niger, *Candida albicans*, *Mucor sp*., *Penicillium* sp. and *Rhizopus* sp., with inhibition zones varying among the organisms and extraction solvents [4, 6].
An earlier investigation specifically examined fresh and dried *S. glauca* leaves against Aspergillus parasiticus and Fusarium oxysporum. The study reported antifungal activity of both methanolic and ethanolic leaf extracts and observed differences according to extraction solvent and leaf condition.
More recently, chloroform and methanol leaf extracts of *S. glauca* were evaluated against *Candida albicans*. The chloroform extract produced inhibition zones of up to 14 mm at the tested concentration, while the methanol extract produced inhibition up to 12 mm. These findings further support the antifungal potential of *S. glauca* leaf extracts.
However, much of the published work has concentrated on leaves. Comparative evaluation of different plant parts under similar extraction conditions can provide additional information regarding the distribution of antifungal constituents within the plant [7, 11].
Therefore, the present study investigated the antifungal activity of extracts prepared from different plant parts of *S. glauca* DC. using different solvent systems. The study particularly focused on comparing the antifungal responses of leaf, bark, root, stem and fruit extracts [12].

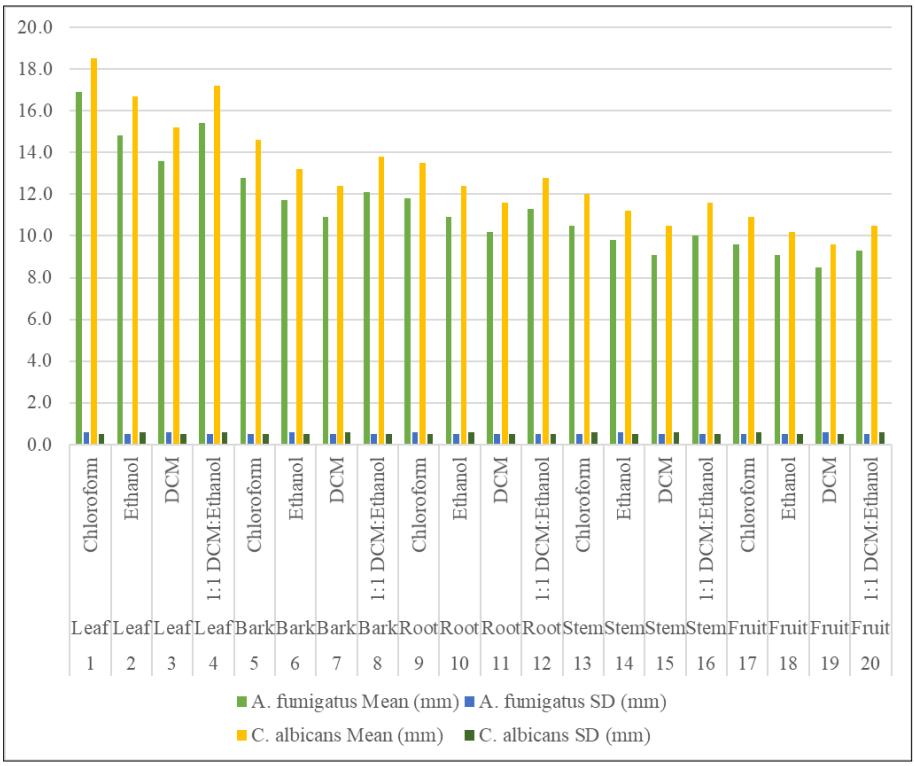
Materials and Methods
Different plant parts of *Simarouba glauca* DC., including leaves, bark, roots, stems and fruits, were collected and processed separately for extraction. The dried plant materials were powdered and subjected to solvent extraction using chloroform, ethanol, dichloromethane (DCM), and a 1:1 mixture of DCM: ethanol. The extracts obtained from each plant part were concentrated and used for biological evaluation.
The antifungal activity of the prepared extracts was evaluated against *Aspergillus fumigatus* and *Candida albicans* using the agar well-diffusion method. Appropriate concentrations of the plant extracts were introduced into wells prepared on the inoculated fungal culture medium. After incubation under suitable conditions, the diameter of the clear zone surrounding each well was measured in millimetres. All experiments were performed in triplicate, and the results were expressed as mean ± standard deviation.
The antifungal activity was compared on the basis of three parameters: plant part, extraction solvent and fungal species. The chloroform, ethanol, DCM and 1:1 DCM: ethanol extracts of each plant part were evaluated under identical experimental conditions to determine the relative antifungal response of the different extracts.

Results
The antifungal screening demonstrated that extracts of different plant parts of *Simarouba glauca* DC. exhibited varying degrees of activity against A. *fumigatus* and C.

albicans. The activity was influenced by both the plant part and extraction solvent.

Table 1: Antifungal activity of extracts from different plant parts of *Simarouba glauca* DC. Zone of inhibition (mm)

S. No.	Plant part	Extract	A. *fumigatus*	C. albicans
1	Leaf	Chloroform	16.9 ± 0.6	18.5 ± 0.5
2	Leaf	Ethanol	14.8 ± 0.5	16.7 ± 0.6
3	Leaf	DCM	13.6 ± 0.6	15.2 ± 0.5
4	Leaf	1:1 DCM: Ethanol	15.4 ± 0.5	17.2 ± 0.6
5	Bark	Chloroform	12.8 ± 0.5	14.6 ± 0.5
6	Bark	Ethanol	11.7 ± 0.6	13.2 ± 0.5
7	Bark	DCM	10.9 ± 0.5	12.4 ± 0.6
8	Bark	1:1 DCM: Ethanol	12.1 ± 0.5	13.8 ± 0.5
9	Root	Chloroform	11.8 ± 0.6	13.5 ± 0.5
10	Root	Ethanol	10.9 ± 0.5	12.4 ± 0.6
11	Root	DCM	10.2 ± 0.5	11.6 ± 0.5
12	Root	1:1 DCM: Ethanol	11.3 ± 0.5	12.8 ± 0.5
13	Stem	Chloroform	10.5 ± 0.5	12.0 ± 0.6
14	Stem	Ethanol	9.8 ± 0.6	11.2 ± 0.5
15	Stem	DCM	9.1 ± 0.5	10.5 ± 0.6
16	Stem	1:1 DCM: Ethanol	10.0 ± 0.5	11.6 ± 0.5
17	Fruit	Chloroform	9.6 ± 0.5	10.9 ± 0.6
18	Fruit	Ethanol	9.1 ± 0.5	10.2 ± 0.5
19	Fruit	DCM	8.5 ± 0.6	9.6 ± 0.5
20	Fruit	1:1 DCM: Ethanol	9.3 ± 0.5	10.5 ± 0.6



Values represent mean ± SD of triplicate observations.

The leaf extracts exhibited the highest antifungal activity among the investigated plant parts. The chloroform leaf extract showed the maximum inhibition, with zones of 16.9 ± 0.6 mm against A. *fumigatus* and 18.5 ± 0.5 mm against C. albicans. The 1:1 DCM: ethanol leaf extract also showed substantial activity, with inhibition zones of 15.4 ± 0.5 and 17.2 ± 0.6 mm, respectively.

The bark extracts showed intermediate antifungal activity. The chloroform bark extract produced inhibition zones of 12.8 ± 0.5 mm against A. *fumigatus* and 14.6 ± 0.5 mm against C. albicans. Root extracts showed a comparatively lower response, with the chloroform extract producing zones of 11.8 ± 0.6 and 13.5 ± 0.5 mm, respectively.

The stem and fruit extracts showed comparatively lower antifungal activity. Among these, the chloroform stem extract produced inhibition zones of 10.5 ± 0.5 and 12.0 ± 0.6 mm, while the chloroform fruit extract produced 9.6 ± 0.5 and 10.9 ± 0.6 mm against A. *fumigatus* and C. albicans, respectively.

Considering the plant parts, the overall antifungal response followed the order:

Leaf > Bark > Root > Stem > Fruit

Among the solvents, chloroform generally produced the greatest antifungal response, followed by 1:1 DCM: ethanol, ethanol and DCM. C. albicans showed a higher inhibition response than A. *fumigatus* for all corresponding extracts.

Discussion

The present investigation demonstrated that *Simarouba glauca* DC. possesses measurable antifungal activity, although the magnitude of activity varied considerably with plant part and extraction solvent. The leaf extracts showed the strongest overall response, while fruit and stem extracts exhibited comparatively lower activity.

The greater antifungal response of the leaf extracts may be related to the presence of biologically active secondary metabolites in the leaves. The variation among extracts prepared with different solvents further indicates that the nature of the solvent influences the recovery of compounds responsible for antifungal activity. The comparatively higher activity of chloroform extracts suggests that constituents with suitable solubility in this solvent contribute substantially to the observed response.

The difference between the two fungal organisms was also evident. C. albicans generally showed greater susceptibility than A. *fumigatus*. This organism-dependent response may be associated with differences in fungal cellular structure and the interaction of plant-derived constituents with fungal cells.

The results obtained for the leaf extracts are particularly significant because the chloroform leaf extract produced the highest inhibition against both tested fungal organisms. This finding identifies the leaf chloroform extract as an important material for further phytochemical investigation.

The progressive reduction in activity from leaf to bark, root, stem and fruit suggests that the distribution of antifungal constituents differs among the plant organs. However, inhibition-zone measurements alone cannot establish the identity or mechanism of the compounds responsible for the activity.

Overall, the results demonstrate that both plant-part selection and solvent selection are important factors in obtaining antifungal activity from *S. glauca*. The active extracts identified in this screening can be subjected to further quantitative antifungal studies, including MIC and MFC determination, as well as chromatographic and spectroscopic investigations to identify the responsible constituents.

Conclusion

The present study established the antifungal potential of extracts obtained from different plant parts of *Simarouba glauca* DC. against *Aspergillus fumigatus* and *Candida albicans*. The antifungal response varied according to plant part and extraction solvent.

Among the investigated plant materials, leaves showed the highest antifungal activity, followed by bark, root, stem and fruit. The chloroform leaf extract exhibited the maximum activity, producing inhibition zones of 16.9 ± 0.6 mm against A. *fumigatus* and 18.5 ± 0.5 mm against C. albicans. Chloroform extracts generally showed higher activity than the other extraction systems.

The results indicate that *S. glauca*, particularly its leaves, represents a promising source of antifungal constituents. The findings also provide a basis for further investigation of the active leaf extract through quantitative antifungal assays and phytochemical characterization

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