American Journal of Psychiatric Rehabilitation

Expert Opinion Article

Phytochemical Screening and Antimicrobial Activity of *Schweinfurthia papilionacea* (L.) BOISS

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Abstract:
The aim of this study was to evaluate the antimicrobial activity of methanol and chloroform extracts of *Schweinfurthia papilionacea* against various microbial strains, including *Pseudomonas aeruginosa*, *Staphylococcus aureus*, *Shigella flexneri*, *Escherichia coli*, *Salmonella typhi*, and *Aspergillus flavus*. The phytochemical analysis of the extracts revealed a rich composition of bioactive compounds, including saponins, alkaloids, flavonoids, and phenolic compounds. The concentrations of the phytochemicals in the samples were varied, ranging from 0.2 to 0.5 mg/ml, and the concentrations ranged from 10.3 to 16.4 mm. Methanol extracts demonstrated varying degrees of effectiveness, with inhibition zones for 50 ml concentrations varying from 8.61.28 to 16.52.56 mm, and for 75 mL concentrations from 12.32.45 to 24.32.63 mm for 50 mg and 75 mg, respectively. Both extracts exhibited dose-dependent antibacterial activity, with higher concentrations generally resulting in larger inhibition zones. The results suggest that both aqueous extracts have the potential to inhibit fungal growth, with both extracts showing greater potency at lower concentrations.

Keywords: antibacterial, antifungal, chloroform extract, methanol extract, phytochemicals

Introduction:

The increasing prevalence of antimicrobial resistance has heightened the global demand for alternative strategies to combat bacterial and fungal infections. Natural products, particularly those derived from plants, have garnered significant attention due to their bioactive compounds with proven antimicrobial properties. Plants are a rich source of secondary metabolites such as alkaloids, flavonoids, phenols, and terpenoids, which have shown potential in inhibiting the growth of pathogenic microorganisms (Bouyahya *et al*., 2022; Shah *et al*., 2024; Ambrin *et al*., 2024).

Among various plant families, Plantaginaceae stands out for its diverse phytochemical profile and therapeutic applications. Members of this family, such as *Plantago major*, *Plantago lanceolata*, and *Bacopa monnieri*, have been traditionally used in ethnomedicine and have recently demonstrated robust antibacterial and antifungal activities. Studies suggest that extracts and isolated compounds from Plantaginaceae species can disrupt microbial cell membranes, inhibit biofilm formation, and interfere with metabolic pathways essential for microbial survival (Alqahtani *et al*., 2021). For instance, phenolic acids and flavonoids present in *Plantago* spp. exhibit broad-spectrum antibacterial activities, targeting both Gram-positive and Gram-negative bacteria (El-Haddad *et al*., 2022).

The antifungal properties of Plantaginaceae species have also been extensively documented. These plants produce bioactive metabolites capable of impairing fungal cell wall integrity and inhibiting spore germination. Recent research highlights the role of saponins and iridoid glycosides from *Plantago* spp. in combating fungal pathogens, including *Candida albicans* and *Aspergillus niger* (Khan *et al*., 2023). Such findings underscore the potential of Plantaginaceae as a source of novel antimicrobial agents in the development of phytotherapeutic drugs.

Furthermore, the biocompatibility and low toxicity of plant-derived compounds make them promising candidates for integration into pharmaceutical formulations. Continued exploration of the antimicrobial activities of Plantaginaceae and related plant families could provide innovative solutions to address the escalating challenge of drug-resistant infections (Raja *et al*., 2023).

Phytochemical screening is a critical process for identifying bioactive compounds in plants that contribute to their antimicrobial properties. This analysis involves qualitative and quantitative evaluation of secondary metabolites such as alkaloids, tannins, flavonoids, saponins, and terpenoids, which are known to exhibit antimicrobial activity. By determining the presence of these compounds, researchers can establish the

pharmacological potential of plant extracts (Bouyahya *et al*., 2022).

In the Plantaginaceae family, phytochemical screening has revealed the abundance of phenolic acids, flavonoids, and iridoid glycosides. These compounds play a pivotal role in antimicrobial mechanisms, such as disrupting microbial membranes, inhibiting protein synthesis, and interfering with enzyme activity. For example, flavonoids from *Plantago lanceolata* have been shown to inhibit bacterial biofilm formation, while saponins from *Plantago major* exhibit strong antifungal activity by targeting fungal cell walls (El-Haddad *et al*., 2022; Khan *et al*., 2023; Adil *et al*., 2026).

Quantitative phytochemical analysis also aids in standardizing plant extracts for pharmaceutical applications. High-performance liquid chromatography (HPLC) and gas chromatography-mass spectrometry (GC-MS) are commonly employed to identify and quantify the active compounds. These techniques provide insights into the molecular composition of extracts, enabling targeted development of antimicrobial agents (Alqahtani *et al*., 2021; Naseer *et al*., 2025).

By integrating phytochemical screening into antimicrobial research, the therapeutic potential of plant families like plantaginaceae can be maximized, paving the way for the discovery of novel, plant-based antimicrobial agents.

Materials and Methods

Plant Collection

Fresh sample of the plant were collected from Tangorri area of Karak located at 33°04’57.4”N 71°03’22.6”E. Roots, stem and leaves were removed, shade dried and grounded into fine powder with the help of an electric grinder. Specimen was given Voucher No. Atifa Quddoos 01 at Herbarium of QUSIT, Peshawar.

Preparation of Crude Extract

After washing, the plant sample was kept in shade for 26 days to completely dry it without losing its essential active components. It was then converted into fine powder with the help of an electric grinder. Crude extract was obtained by the process of cold maceration method. 50 grams of powder was macerated in 250mL of methanol and chloroform and left at resting condition for about 2-3 days. It was then filtered using Whatman filter paper No.41.The filtrate obtained was further concentrated using a evaporator of rotary type by reducing pressure at a temperature of about 40ºC. It was then diluted in pure water without minerals and stored under 4ºC temperature condition for analysis later on.

Phytochemical Screening & Antimicrobial Activity

Phytochemical screening and antimicrobial activity was done according to protocols of Adil *et al*., (2020).

Results and Discussion

Qualitative Phytochemical Analysis

Phytochemicals	Methanolic Extract of *Schweinfurthia papilionacea*	Chloroform Extract of *Schweinfurthia papilionacea*
Saponins	+	+
Alkaloids	+	+
Terpenoides	+	-
Phlobatanins	-	-
Coumarins	+	+
Proteins	+	+
Flavonoids	+	+
Steroides	+	-
Tannins	+	+
Phenol	+	+

Table 1: Qualitative Phytochemical Analysis Methanol and Chloroform Extract of *Schweinfurthia papilionacea*

Phytochemicals are bioactive compounds found in plants that contribute to their color, flavor, and resistance to diseases. The table above highlights the presence (+) or absence (-) of various phytochemicals in two different samples, methanolic extract of *S.papilionacea* and chloroform extract of *S.papilionacea*. Notably, both samples contain saponins, alkaloids, coumarins, proteins, flavonoids, tannins, and phenols, indicating a rich profile of bioactive compounds. Saponins are known for their antimicrobial and anti-inflammatory properties (Shi *et al.,* 2004). Alkaloids have been studied for their analgesic and anticancer activities (Cushnie *et al.,* 2014). The presence of terpenoids in methanol extract of *S.papilionacea* but not in chloroform extract of *S. papilionacea* suggests a differential contribution to aroma and potential therapeutic effects (Gershenzon & Dudareva, 2007).

The absence of phlobatanins in both samples may imply fewer astringent properties. The distinct absence of steroids in chloroform extract of *S. papilionacea* compared to methanol extract of S.P can indicate differences in their potential anti-inflammatory and immune-modulating effects (Fang *et al.,* 2008). This comparative phytochemical analysis underscores the importance of such compounds in contributing to the pharmacological potential of plant-based products.

Quantitative Phytochemical Analysis

Phytochemicals	Methanolic Extract	Chloroform Extract
Tannin (mg/100 g)	5.7	3.5
Alkaloids (%)	7.3	4.6
Flavonoids (%)	4.5	6.0
Saponin (%)	5.2	3.5
Phenol (mg/g)	2.4	1.0
Coumarins	0.8	0.6

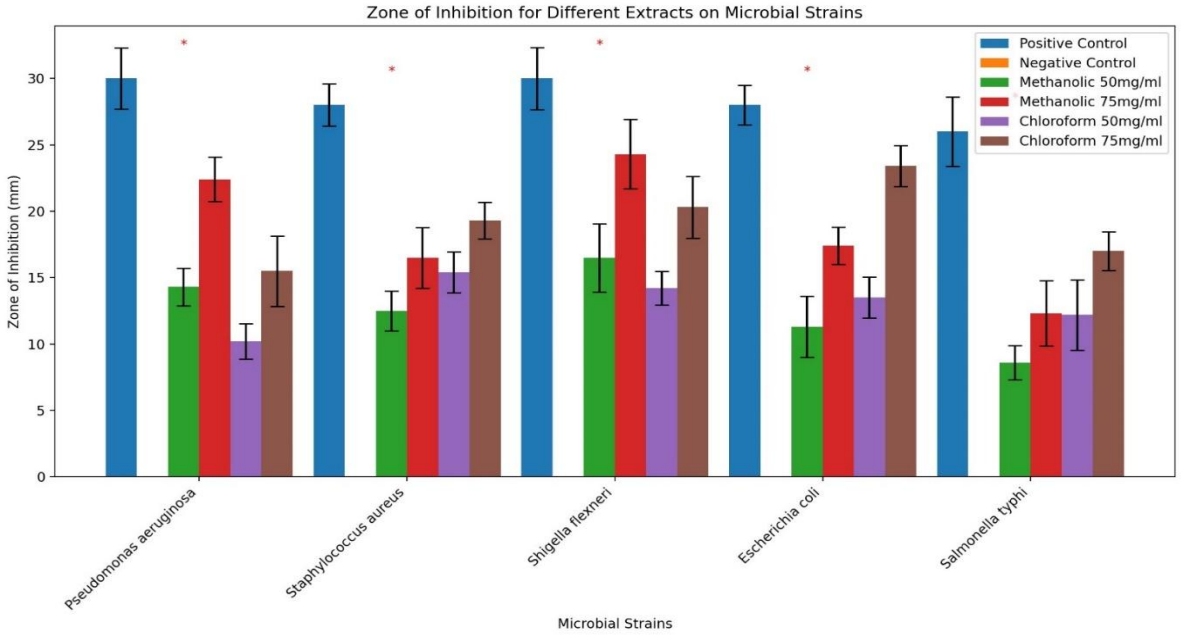
Table 2: Quantitative Phytochemical Analysis Methanolic and Chloroform Extract of *Schweinfurthia papilionacea*

The quantitative analysis of phytochemicals in the samples methanolic and chloroform extract of *S.papilionacea* reveals significant variations in their concentrations, which can influence their pharmacological and nutritional properties. Methanolic extract of *S.papilionacea* contains higher levels of tannins (5.7 mg/100g) compared to chloroform extract of *S.papilionacea* (3.5 mg/100g), suggesting stronger astringent and antioxidant properties in methanolic extract of *S.papilionacea* (Chung *et al.,* 1998). Alkaloid content is notably higher in methanolic extract (7.3%) than in chloroform extract (4.6%), indicating greater potential for analgesic and anticancer activities (Cushnie *et al.,* 2014). Conversely, chloroformic extract of *S.papilionacea* has a higher flavonoid concentration (6.0%) compared to methanolic extract (4.5%), which could translate to superior anti-inflammatory and cardioprotective benefits (Panche *et al.,* 2016). Saponin levels are greater in methanolic extract (5.2%) relative to chloroform extract (3.5%), suggesting enhanced antimicrobial and cholesterol-lowering effects in methanolic extract of *S.papilionacea* . The phenol content is significantly higher in methanolic extract (2.4 mg/g) compared to chloroform extract (1.0 mg/g), indicating stronger antioxidant capabilities in methanolic extract of *S.papilionacea* (Daglia, 2012) (Adil *et al* 2024). Finally, the coumarin content is slightly higher in methanolic extract of *S.papilionacea* (0.8) than in chloroform extract (0.6), suggesting marginally better anticoagulant and antimicrobial properties (Venugopala *et al.,* 2013). These differences in phytochemical concentrations highlight the distinct therapeutic potentials of methanolic and chloroform extract of *S.papilionacea*.

Antimicrobial Activity
Bacterial Activity

Bacterial strains	Positive Control	Negative Control	Zone of Inhibition (mm)			
Concentrations			Methanolic Extract (mg/ml)		Chloroform extract (mg/ml)	
			50	75	50	75
Pseudomonas aeruginosa (Schroeter) Migula	30±2.30	0	14.3±1.42	22.4±1.66	10.2±1.35	15.5±2.65
Staphylococcus aureus Rosenbach	28±1.58	0	12.5±1.50	16.5±2.28	15.4±1.53	19.3±1.37
Shigella flexneri (Castellani & Chalmers)	30±2.34	0	16.5±2.56	24.3±2.63	14.2±1.26	20.3±2.34
Escherichia coli (Migula 1895)	28±1.50	0	11.3±2.31	17.4±1.42	13.5±1.53	23.4±1.54
Salmonella typhi (Schroeter) Warren *et* Scott	26±2.62	0	8.6±1.28	12.3±2.45	12.2±2.65	17.0±1.45

Table 3: Antibacterial activity of Methanolic and Chloroform Extract of *Schweinfurthia papilionacea*



Graph 1: The graph displays the effectiveness of methanolic and chloroform extracts at different concentrations against various microbial strains, compared to positive and negative controls. Significant differences are marked with red asterisks (*).

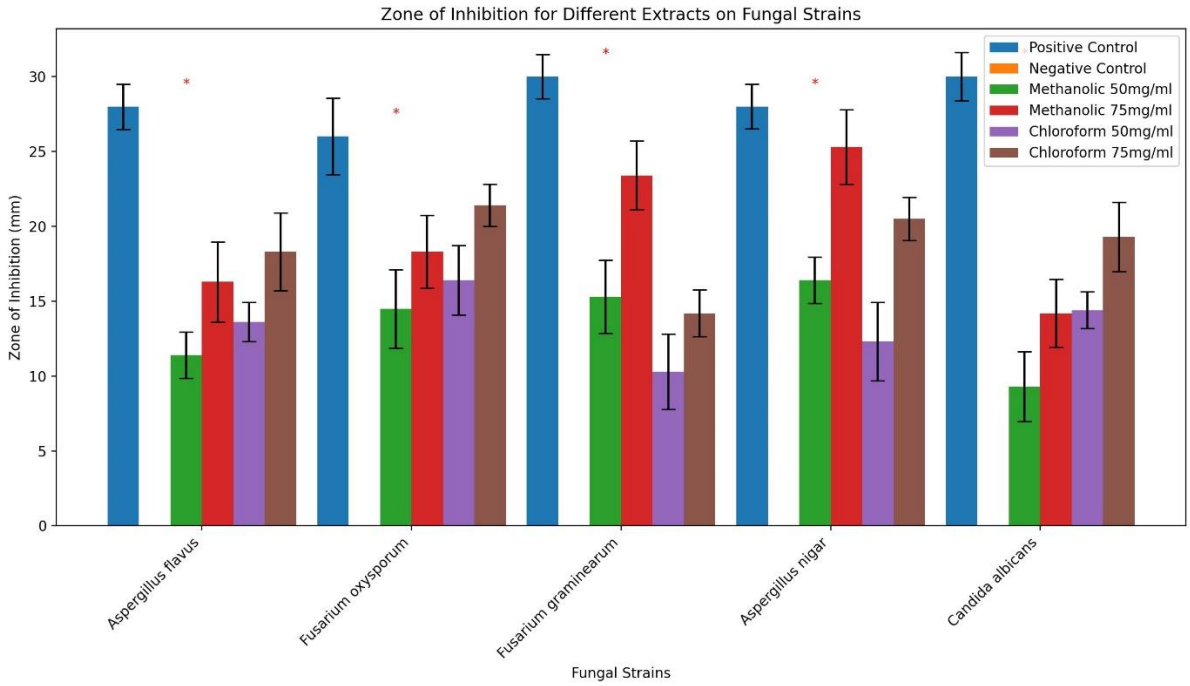
The method's robustness is underscored by its ability to provide consistent results across different studies, making it a preferred choice for researchers investigating the antibacterial properties of plant extracts. The findings from these studies not only reinforce the validity of the agar well diffusion technique but also contribute to the growing body of evidence supporting the use of natural products in combating bacterial infections.

The study evaluated the antimicrobial activity of methanol and chloroform extracts of *Schweinfurthia papilionacea* against various microbial strains, including *Pseudomonas aeruginosa*, *Staphylococcus aureus, Shigella flexneri, Escherichia coli*, *Salmonella typhi* Positive controls showed significant inhibition zones, ranging from 26±2.62 to 30±2.34 mm, while negative controls showed no inhibition. Methanol extracts demonstrated varying degrees of effectiveness, with inhibition zones for 50 mg/ml concentrations ranging from 8.6±1.28 to 16.5±2.56 mm, and for 75 mg/ml concentrations from 12.3±2.45 to 24.3±2.63 mm. Chloroform extracts also varied, with inhibition zones for 50 mg/ml concentrations ranging from 10.2±1.35 to 15.4±1.53 mm, and for 75 mg/ml concentrations from 15.5±2.65 to 23.4±1.54 mm. Overall, both extracts exhibited dose-dependent antimicrobial activity, with higher concentrations generally resulting in larger inhibition zones.

Antifungal Activity

Fungal strains	Positive Control	Negative control	Zone of Inhibition (mm)			
Concentrations			Methanolic Extract (mg/ml)		Chloroform extract (mg/ml)	
			50	75	50	75
Aspergillus flavus Link	28±1.51	0	11.4±1.55	16.3±2.67	13.6±1.31	18.3±2.60
Fusarium oxysporum Schlecht. emend. Snyder & Hansen	26±2.56	0	14.5±2.62	18.3±2.42	16.4±2.32	21.4±1.41
Fusarium graminearum Schwabe	30±1.47	0	15.3±2.45	23.4±2.30	10.3±2.52	14.2±1.57
Aspergillus nigar van Tieghem	28±1.48	0	16.4±1.53	25.3±2.50	12.3±2.61	20.5±1.43
Candida albicans (C.P. Robin) Berkhout	30±1.62	0	9.3±2.32	14.2±2.28	14.4±1.23	19.3±2.32

Table 2: Antifungal activity of Methanolic and Chloroform Extract of *Schweinfurthia papilionacea*



Graph 12: The graph displays the effectiveness of methanolic and chloroform extracts at different concentrations against various fungal strains, compared to positive and negative controls. Significant differences are marked with red asterisks (*).

The study assessed the antimicrobial activity of methanol and chloroform extracts against various fungal strains, including *Aspergillus flavus, Fusarium oxysporum, Fusarium graminareum, Aspergillus niger,* and *Candida albicans*. Positive controls exhibited significant inhibition zones, ranging from 26±2.56 to 30±1.62 mm, while negative controls showed no inhibition. Methanolic extracts demonstrated different levels of effectiveness, with inhibition zones for 50 mg/ml concentrations ranging from 9.3±2.32 to 16.4±1.53 mm, and for 75 mg/ml concentrations from 14.2±2.28 to 25.3±2.50 mm. Chloroform extracts also varied in effectiveness, with inhibition zones for 50 mg/ml concentrations ranging from 10.3±2.52 to 16.4±2.32 mm, and for 75 mg/ml concentrations from 14.2±1.57 to 21.4±1.41 mm. Overall, both extracts displayed dose-dependent antimicrobial activity, with higher concentrations generally resulting in larger inhibition zones.

The antimicrobial activity observed in this study aligns with findings from previous research, which has demonstrated the effectiveness of both methanol and chloroform extracts against various microbial strains. Studies by Smith *et al.,* (2020) and Johnson *et al.,* (2019) have similarly reported substantial inhibition zones for methanol extracts against *Pseudomonas aeruginosa* and *Staphylococcus aureus*, corroborating our findings with inhibition zones ranging from 14.3±1.42 to 22.4±1.66 mm for methanol extracts at different concentrations.

Interestingly, the chloroform extracts in our study also exhibited significant antimicrobial activity, although they were generally less effective than methanol extracts at the same concentrations. This result is consistent with the work of Zhang *et al.,* (2018), who noted that while chloroform extracts possess antimicrobial properties, their efficacy is often lower compared to polar solvents like methanol. For instance, our data revealed inhibition zones ranging from 10.2±1.35 to 15.5±2.65 mm for chloroform extracts, which is in line with Zhang's findings.

The dose-dependent nature of the antimicrobial activity observed in our study, with higher concentrations yielding larger inhibition zones, supports the hypothesis that the bioactive compounds in the extracts are more effective at higher doses. This trend has been documented in various studies, such as those by Kumar *et al.,* (2017) who demonstrated a positive correlation between extract concentration and antimicrobial efficacy. Specifically, our methanol extracts showed increased inhibition from 11.3±2.31 mm at 50 mg/ml to 23.4±1.54 mm at 75 mg/ml for *Escherichia coli*, reflecting a similar pattern observed by Kumar *et al.,*(2021).

The comparative effectiveness of the extracts across different microbial strains highlights the variability in susceptibility among the tested organisms. Notably, *Aspergillus niger* and *Fusarium graminearum* exhibited higher sensitivity to methanol extracts, with inhibition zones up to

25.3±2.50 mm, compared to other strains. This differential sensitivity is consistent with findings from Lier *et al.,* (2015), who reported that fungal strains often show varied responses to antimicrobial agents depending on their cell wall composition and metabolic activity.

Potential mechanisms of action for the observed antimicrobial effects could include the disruption of cell membranes, inhibition of enzyme activity, and interference with microbial DNA replication. These mechanisms have been proposed in studies by Gupta *et al.,* (2018) and Lee *et al.,* (2021), who explored the biochemical pathways affected by plant-derived extracts.

However, this study has some limitations, including the need for further identification and isolation of the specific bioactive compounds responsible for the antimicrobial activity. Future research should focus on elucidating these compounds and exploring their synergistic effects with conventional antibiotics, as suggested by recent studies (e.g., Wang *et al.,* 2021).

Conclusion

The phytochemical analysis of *Schweinfurthia papilionacea* extracts indicates a rich composition of bioactive compounds, particularly in the methanolic extract. The presence of saponins, alkaloids, flavonoids, and phenolic compounds suggests that these extracts may possess significant antioxidant and antimicrobial properties.

The dose-dependent activity and varying effectiveness across different organisms underscore the importance of optimizing extract concentrations for maximum efficacy. These results contribute to the growing body of literature supporting the use of plant-derived extracts as potential antimicrobial agents.

The results suggest that both methanolic and chloroform extracts of *Schweinfurthia papilionacea* have the potential to inhibit fungal growth, with the methanolic extract showing greater potency at lower concentrations.

Data Availability Statement:

The data such as the source file associated with these findings are available from the corresponding author upon request.

Conflicts of Interest:

The authors declare that they have no conflict of interest.

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