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Phytochemical Screening and In-vitro Antifungal Activity of *Balanites aegyptiaca* Extracts against *Candida albicans* and *Aspergillus flavus*

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Abstract

Fungal infections caused by Candida albicans and Aspergillus flavus pose major public health challenges, particularly in regions with limited access to effective antifungal drugs and increasing resistance to existing therapies. Although Balanites aegyptiaca is widely used in traditional medicine, its antifungal potential remains insufficiently studied. The study evaluated extracts against C. albicans, a causative agent of candidiasis, and A. flavus, a mycotoxin-producing fungus, to determine their therapeutic potential and relevance in managing fungal infections. Leaves stem bark, and root bark of B. aegyptiaca were collected from disease-free trees in Katakwi District, Uganda, washed, air-dried, pulverized, and stored under sterile conditions. Crude extracts were prepared via successive maceration using methanol, dichloromethane, and n-hexane. Qualitative phytochemical screening detected saponins, tannins, flavonoids, alkaloids, anthraquinones, coumarins, cardiac glycosides, terpenoids, and starch. Antifungal activity against C. albicans and A. flavus was evaluated using the agar-well diffusion method. Experiments were conducted in triplicate, and zones of inhibition were measured. Data were analysed using one-way ANOVA and Tukey's post hoc test in STATA 14.0, with $P < 0.05$ considered statistically significant. Methanol proved the most effective solvent for extracting phytochemicals from B. aegyptiaca, yielding higher crude extract quantities than dichloromethane and n-hexane. Phytochemical screening identified alkaloids, flavonoids, phenolics, tannins, coumarins, cardiac glycosides, and phytosterols in leaves, stem bark, and root bark, with methanolic extracts containing the broadest range of compounds. Sour varieties generally had higher phenolic content than sweet ones. Antifungal assays showed methanolic extracts had the strongest activity, producing inhibition zones up to 23.67 mm against C. albicans and 23.00 mm against A. flavus, particularly in stem and root bark. Dichloromethane (DCM) extracts exhibited moderate antifungal activity, while n-hexane was least effective, except for some moderate inhibition of A. flavus by non-polar compounds. Polar solvents, particularly methanol, efficiently extracted bioactive compounds from B. aegyptiaca, with the sweet variety yielding more than the sour. Crude extracts inhibited C. albicans and A. flavus, suggesting combined plant parts may enhance antifungal efficacy.

Keywords: *Phytochemical screening, Antifungal activity, Balanites aegyptiaca, Candida albicans, Aspergillus flavus*

Introduction

Medicinal plants remain an integral part of health care worldwide and are particularly important in the treatment of microbial and fungal infections (Khamis et al., 2020). In Uganda, a significant proportion of the population, especially individuals living with Human Immunodeficiency Virus (HIV), relies on herbal medicines to manage opportunistic and co-infections, including those caused by fungi (Anywar et al., 2021). The therapeutic value of these plants is largely attributed to their phytochemical constituents (secondary metabolites), such as phenols, polyphenols, flavonoids, alkaloids, terpenoids, and saponins, which are known to exhibit antimicrobial, anti-inflammatory, and immunomodulatory effects (Khamis et al., 2020; Makled et al., 2024).

According to the World Health Organization (WHO), *C. albicans* is the most virulent species of the genus Candida, responsible for candidiasis in both humans and animals (WHO, 2022). Domesticated livestock, including cattle, pigs, and poultry, are also susceptible to candidiasis (Zhai et al., 2015; Dadar et al., 2018; Gnat et al., 2021). Although *C. albicans* exists as a commensal organism in the nasopharynx, gastrointestinal tract, and genitalia, its pathogenicity is triggered by antibiotic use, immunosuppression, or weakened host immunity (Makled et al., 2024; Pedro et al., 2023). Another important fungal pathogen is *A. flavus*, a filamentous fungus that thrives on decaying organic matter (Parekh et al., 2023) and produces aflatoxins and other mycotoxins that contaminate food and feed, resulting in food poisoning and serious public health risks (Rank & Kathari, 2019).

B. aegyptiaca, commonly known as the "desert date," is a multipurpose tree that thrives in low-water table and semi-arid regions such as the Teso sub-region of Uganda, as well as in Egypt, Ethiopia, and parts of the Middle East (Anani et al., 2015). Belonging to the family Zygophyllaceae, the plant has long been valued in traditional medicine, with different parts (leaves, bark, roots, and fruits) used for managing various ailments (Ibrahim et al., 2022). However, it is currently considered an endangered species, necessitating sustainable utilization and conservation measures (Ibrahim et al., 2022).

Given the rising burden of fungal infections and the growing threat of antifungal resistance, there is a pressing need to explore plant-based therapeutic alternatives. Against this background, the present study investigated the secondary metabolites of *B. aegyptiaca* and evaluated the antifungal activity of its extracts against *C. albicans* and *A. flavus*.

Materials and Methods

Description of the sample collection area

The leaves, stem bark, and root bark of *B. aegyptiaca* were collected in June 2023 from disease-free trees in their natural habitat at Ajeluk village, Olela Parish, Katakwi Sub-county, Ngariam County, Katakwi District, Uganda (01°54'54.0"N, 33°57'18.0"E). This site was selected because the species grows naturally and abundantly in the semi-arid cattle corridor, ensuring availability of healthy plant material. Katakwi is ethnobotanically significant, as local communities have long used *B. aegyptiaca* in traditional medicine to treat ailments such as skin infections, stomach disorders, and fever. Sample collection from this area therefore, offered an opportunity to scientifically validate indigenous knowledge. The ecological conditions of Katakwi are favorable for the species, supporting the growth of mature, disease-free trees. The area was also easily accessible, and precise Geographical Positioning System (GPS) coordinates were documented to enhance reproducibility. Notably, no systematic phytochemical or bioactivity studies had been previously conducted in this region, highlighting the novelty of this research. The sampling site is illustrated in Figure 1.

Figure 1. The location of the samples in Katakwi district

Study design

An experimental study was conducted to investigate the antifungal activities of *B. aegyptiaca* against *C. albicans* and *A. flavus* in the laboratory (Khamis et al., 2020; Ibrahim et al., 2022). Agar-well diffusion method was used for susceptibility tests. The experiments were done in triplicates to minimize experiment errors.

Collection of plant samples and authentication

Fresh leaves, stem bark, and root bark of *B. aegyptiaca* were collected from Katakwi District, Uganda. During collection, sweet and sour leaf morphotypes were distinguished based on traditional taste recognition methods, with confirmation from local herbalists. Sweet leaves exhibited a mild taste, whereas sour leaves were distinctly acidic. The plant species was identified and authenticated by a botanist at Makerere University, Kampala. Accession numbers 51161 and 51162 were assigned to Sour *B. aegyptica* and Sweet *B. aegyptica* respectively. The collected materials were then transported to the Bioscience Research Laboratory at Kyambogo University for further processing.

Preparation of plant materials

The collected plant parts (leaves, stem bark, and root bark) were first washed thoroughly with distilled water to remove dust, soil, and other extraneous matter. After washing, the materials were cut into small pieces using sterile stainless-steel knives to facilitate uniform drying. The samples were air-dried in the shade at ambient room temperature (25 ± 5 °C) for several days until a constant weight was obtained, thereby minimizing the risk of fungal contamination and degradation of heat-sensitive phytochemicals. Direct exposure to sunlight was avoided to preserve the integrity of bioactive compounds. Once adequately dried, the plant materials were mechanically

pulverized into a coarse powder using a clean laboratory grinder. To further increase the surface area for efficient solvent penetration during extraction, the coarse powder was subsequently milled into fine particles. The powdered materials were sieved to ensure uniform particle size and stored in sterile, airtight glass containers under cool, dry conditions to prevent moisture uptake and microbial growth. The samples were kept in storage until required for the extraction and analysis of secondary metabolites.

Extraction

The maceration technique was used in the extraction process (Ibrahim et al., 2022). The fine powders (100 g) of the root bark, stem bark and leaves of *B. aegyptiaca* plants were stored in separate Erlenmeyer flasks and dipped in n-hexane, dichloromethane and methanol successively with frequent agitation. The flasks were closed properly to prevent the entry of air. The dipped plant samples were filtered through Whatman filter paper No. 1. The samples were transferred to a rotary evaporator to concentrate the extracts by evaporating the solvent. The partly concentrated plant extracts were then transferred to a water bath at 350°C to completely evaporate the solvent. The gummy concentrated extracts obtained were preserved in a refrigerator at 4°C for future use.

Qualitative phytochemical screening of the crude extracts

Crude extracts from the sweet and sour leaves, stem bark, and roots of *B. aegyptiaca* were screened for the presence of saponins, tannins, reducing compounds, alkaloids, anthraquinones, coumarins, flavonoids, steroid glycosides, terpenoids, and starch using the methods described by Dhawan and Gupta (2016) and Pandey (2014), with minor modifications.

Test organisms

American Type Culture Collection (ATCC) organisms were used. *C. albicans* (ATCC 10231) and *A. flavus* (ATCC 6275) are standard fungal strains collected from the Microbiology Laboratory of the College of Veterinary Medicine and Biosecurity of Makerere University, Kampala, Uganda, and were transported to the Bioscience Research Laboratory of Kyambogo University under the cold chain.

Agar-Well diffusion assay

The antifungal properties of the plants were assessed via the agar–well diffusion method. Initially, colonies of the test organisms were grown on Sabouraud Dextrose Agar (SDA). On an SDA plate, test organisms were sub-cultured and incubated for three days at 35°C. An inoculum was prepared by extracting the colonies from this fresh culture (3 days old) and then adding 1 mL of sterile physiological saline solution followed by a drop of Tween 20. After total dissolution, the inoculum supernatant was used for antifungal testing after being adjusted by physiological solution and the turbidity was compared to that of the 0.5 McFarland standard. Susceptibility testing was performed on SDA plates. The test organisms were inoculated uniformly on the surface of solidified SDA plates using a sterile swab. Using a sterile cork borer, four 6 mm holes were made on the surface of the SDA plates. Using a micropipette, 0.1 mL of the crude extracts at concentrations of 200, 100, and 50 mg/mL, as well as a positive control of 15 µg of ketoconazole and a negative control of 5% Dimethyl Sulphur Oxide (DMSO) and 5% Tween 80, were added to the wells.

After one hour of diffusion at room temperature, the plates were incubated. Following 48 hours of incubation at 30°C, the zone of inhibition produced by *C. albicans* was measured in four directions and recorded. For *A. flavus*, the zone of inhibition was measured after seven days of growth at room temperature. Each test was performed in triplicate, and the results are presented as the mean ± standard deviation (SD) of three independent experiments.

Data analysis

The collected data were entered into Microsoft Excel and subsequently analysed using STATA version 14.0. Differences in mean concentrations among the groups were evaluated using one-way ANOVA to determine whether statistically significant variations existed between the different treatment groups. To identify specific group differences and control for type I error, Tukey's post hoc test was applied to assess the associations between the zones of inhibition produced by the plant extracts and the positive control. A P value of <0.05 was considered statistically significant.

Ethics approval

Electronic application for permission to conduct the study titled, 'Antibacterial, Antifungal, Antiplasmodial Activity and Safety of Crude Extracts and Compounds from *B. aegyptica* (L.) DELILE ' was submitted to the Uganda National Council for Science and Technology and a reference number NS748ES was given.

Results

Percentage yield of the crude extracts

The extraction yields of *B. aegyptiaca* varied with plant part, taste type, and solvent polarity. Methanolic extracts generally gave the highest yields, with sweet leaves, stem bark, and root bark yielding 6.1%, 5.1%, and 5.4%, respectively, while sour leaves, stem bark, and root bark yielded 5.1%, 4.1%, and 4.0%. n-Hexane extracts produced the lowest yields overall, particularly for sour leaves (1%) and stem bark (1.8%), reflecting the limited solubility of non-polar compounds in these parts. Dichloromethane (DCM) extracts gave intermediate yields, with sweet stem bark showing the highest yield (7.9%), and sour root bark yielding 3.5% (Table 1).

Table 1. Results of the percentage yield of the crude extracts using methanol, dichloromethane and n-hexane solvents.

	Methanolic extract			**n-Hexane extract**			**DCM extract**		
	Weight of plant sample (g)	**Weight of crude extract (g)**	**Yield (%)**	**Weight of plant sample (g)**	**Weight of crude extract (g)**	**Yield (%)**	**Weight of plant sample (g)**	**Weight of crude extract (g)**	**Yield (%)**
Sweet leaves	500	30.5±0.01	**6.1**	500	15.4±0.15	**3.1**	500	18.8±0.10	**3.8**
Sweet stem bark	200	10.2±0.12	**5.1**	200	10.1±0.01	**5.1**	200	15.8±0.08	**7.9**
Sweet root bark	100	5.4±0.03	**5.4**	100	2.5±0.02	**2.5**	100	2.1±0.05	**2.1**
Sour leaves	500	25.6±0.010	**5.1**	500	5.2±0.01	**1**	500	20.2±0.03	**4.1**
Sour stem bark	200	8.2±0.02	**4.1**	200	3.6±0.05	**1.8**	200	7.2±0.01	**3.6**
Sour root bark	100	4.0±0.03	**4.0**	100	2.1±0.10	**2.1**	100	3.5±0.02	**3.5**

Qualitative phytochemical screening of sweet and sour *B. aegyptiaca* revealed the presence of multiple bioactive compounds across leaves, stem bark, and root bark, with sour plant parts generally exhibiting higher levels. In the leaves, sour samples showed stronger levels of alkaloids, coumarins, and anthraquinones compared to sweet leaves, whereas cardiac glycosides were more abundant in sweet leaves. For stem bark, sour samples contained higher levels of phenolics, coumarins, phytosterols, anthraquinones, and cardiac glycosides, while sweet stem bark had comparatively higher flavonoids. In the root bark, sour samples exhibited strong presence of phenolics, coumarins, anthraquinones, and cardiac glycosides, whereas sweet root bark had lower or absent levels of some compounds, such as anthraquinones and phenolics (Table 2).

Table 2. Phytochemical screening of methanol extracts from *B. aegyptiaca* leaves, stem bark and root bark.

Phytochemical group	**Alkaloids**		**Flavanoids**		**Phenolics**		**Tannins**		**Coumarins**		**Anthraquinones**		**Cardiac glycosides**	
Leaves														
Plant variety	BSw-L	BSo-L	BSw-L	BSo-L	BSw-L	BSo-L	BSw-L	BSo-L	BSw-L	BSo-L	BSw-L	BSo-L	BSw-L	BSo-L
Present	+	+++	++	++	+	++	+	+	++	+++			+++	++
Absent											+	-		
Stem bark														
Phytochemical group	**Alkaloids**		**Flavanoids**		**Phenolics**		**Coumarins**		**Phytosterols**		**Anthraquinones**		**Cardiac glycosides**	
Plant variety	BSw-S	BSo-S	BSw-S	BSo-S	BSw-S	BSo-S	BSw-S	BSo-S	BSw-S	BSo-S	BSw-S	BSo-S	BSw-S	BSo-S
Present	++	++	++	+	+	+++	++	+++	+	+++		++	+++	++
Absent											-			
Root bark														
Phytochemical group	**Alkaloids**		**Flavonoids**		**Phenolics**		**Tannins**		**Coumarins**		**Anthraquinones**		**Cardiac glycosides**	
Plant variety	BSw-R	BSo-R	BSw-R	BSo-R	BSw-R	BSo-R	BSw-R	BSo-R	BSw-R	BSo-R	BSw-R	BSo-R	BSw-R	BSo-R
Present	+		++	++		+	+++	+++	++	+++		++	+++	++
Absent		-			-						-			

BSw-L: *B. aegyptiaca* sweet leaves; BSo-L: *B. aegyptiaca* sour leaves; BSw-S: *B. aegyptiaca* sweet stem bark; BSo-S: *B. aegyptiaca* sour stem bark, BSw-R: *B. aegyptiaca* sweet root bark; BSo-R: *B. aegyptiaca* sour root bark, Phytochemical present in low concentration (+); Present in moderate concentration (++); Present in high concentration (+++).

The antifungal activity of *B. aegyptiaca* extracts against *C. albicans* varied with plant part and solvent polarity. Methanolic extracts showed the highest activity, with sweet and sour stem bark producing the largest zones of inhibition (23.67 mm), followed by sweet root bark (18.33 mm) and sour root bark (17.33 mm). Dichloromethane extracts exhibited moderate activity, particularly from sweet root bark (14.33 mm) and sour leaves (14.00 mm), while n-hexane extracts showed the lowest antifungal effects, ranging from 7.00 mm to 12.7 mm. Notably, most methanolic extracts exceeded the activity of the positive control (12.00–12.33 mm), indicating potent antifungal potential (Table 3).

Table 3. Antifungal activity of the *B. aegyptiaca* crude extracts against *C. albicans* (Mean ± S.D)

	Diameter of the zone of Inhibition (mm)					
	Sweet Leaves	Sweet root bark	Sweet stem bark	Sour leaves	Sour Root bark	Sour stem bark
n-Hexane	9.67±1.15	12.7±0.58	10.33±0.58	8.33±0.58	7.00±0.00	10.00±0.00
Dichloromethane	13.00±0.00	14.33±0.58	12.33±1.15	14.00±0.00	10.67±1.15	13.67±1.15
Methanol	13.67±0.58	18.33±0.58	23.67±1.15	14.00±1.73	17.33±0.58	23.67±1.15
Positive Control	12.00±0.00	12.33±0.58	12.00±0.00	12.00±0.00	12.00±0.00	12.00±0.00

The antifungal activity of *B. aegyptiaca* crude extracts against *A. flavus* varied with plant part and solvent polarity. Methanolic extracts exhibited the highest activity, with sweet stem bark (23.00 mm) and sweet root bark (19.33 mm) producing the largest zones of inhibition, followed by sour root bark (18.67 mm), sour stem bark (18.33 mm), and sour leaves (16.33 mm). Dichloromethane extracts showed moderate activity, particularly from sweet root bark (15.67 mm) and sour leaves and root bark (14.67 mm each), while n-hexane extracts were the least effective, with zones of inhibition ranging from 9.00 mm to 13.33 mm. Compared with the positive control (17.00–19.00 mm), methanolic extracts of sweet stem and root bark demonstrated superior or comparable antifungal activity (Table 4).

Table 4. Antifungal activity of the *B. aegyptiaca* crude extracts against *A. flavus* (Mean ± S.D)

	Diameter of the zone of Inhibition (mm)					
	Sweet Leaves	Sweet root bark	Sweet stem bark	Sour leaves	Sour Root bark	Sour stem bark
n-Hexane	10.67±0.58	13.33±0.58	11.67±0.58	11.00±1.00	9.00±1.00	11.00±1.00
Dichloromethane	13.67±1.53	15.67±0.58	12.67±1.53	14.67±0.58	14.67±0.58	13.33±0.58
Methanol	15.67±0.58	19.33±0.58	23.00±1.00	16.33±0.58	18.67±0.58	18.33±0.58
Positive Control	18.33±0.58	19.00±1.00	18.00±1.00	17.33±0.58	18.33±0.58	17.00±1.00

Discussion

The present study aimed to evaluate the phytochemical composition and antifungal potential of sweet and sour varieties of *B. aegyptiaca* leaves, stem bark, and root bark, with particular emphasis on their activity against *C. albicans* and *A. flavus*. Understanding the distribution of bioactive compounds across different plant parts and varieties is essential for validating traditional medicinal uses and identifying plant sources with the highest therapeutic potential (Vaou et al., 2022). The study found that methanol was the most effective solvent for extracting phytochemicals from *B. aegyptiaca*, yielding higher quantities than dichloromethane and n-hexane due to its polarity. Phytochemical screening revealed alkaloids, flavonoids, phenolics, tannins, coumarins, cardiac glycosides, and phytosterols across leaves, stem bark, and root bark, with sour varieties generally richer in phenolics. Antifungal assays showed methanolic extracts had the strongest activity against *C. albicans* and *A. flavus*, particularly in stem and root bark, while dichloromethane extracts were moderately active and n-hexane extracts least effective.

In line with the study objectives, methanol produced higher yields of crude extracts from *B. aegyptiaca* than dichloromethane and n-hexane. This is attributed to methanol's polarity, which effectively solubilizes the

predominantly polar phytochemical compounds present in the plant parts. As solvent polarity decreased from methanol to dichloromethane and n-hexane, the extraction efficiency correspondingly declined, resulting in lower extract yields. These findings are consistent with previous studies, which have shown that polar solvents, including methanol and water, are most effective for extracting bioactive phytochemicals from medicinal plants (Madhu et al., 2016). Similarly another study found that polar solvents (methanol, ethanol, water) efficiently extract hydrophilic compounds such as flavonoids and polyphenols, while binary solvent mixtures further improve extraction yield and bioactivity (Sun et al., 2025). The results emphasize the critical role of solvent choice in optimizing the recovery of therapeutically relevant metabolites.

The observed variations in phytochemical composition between the sweet and sour varieties of *B. aegyptiaca* may be attributed to differences in pest pressure, metabolic activity, and underlying genetic factors. Previous studies have documented that the leaves of *B. aegyptiaca* are rich in phenolics, flavonoids, alkaloids, coumarins, cardiac glycosides, and phytosterols (Murthy et al., 2021). Comparable phytochemical groups were also detected in the stem and root barks (Tables 3 and 4), suggesting that these secondary metabolites diffuse and accumulate throughout the plant as part of its defense mechanisms and metabolic regulation (Okwousa et al., 2012). Importantly, such variations in phytochemical composition between the sweet and sour varieties of *B. aegyptiaca* may significantly affect their bioactivity and therapeutic potential. The sour variety, with higher phenolic content, could exhibit stronger antioxidant and antifungal activity (Nitiema et al., 2020), while the sweet variety, richer in alkaloids and cardiac glycosides, may display enhanced antimicrobial effects through alternative mechanisms (Murthy et al., 2021; Jaheed et al., 2019). These differences in metabolite abundance explain the variation in efficacy across plant varieties and underscore their potential for selective therapeutic use. Understanding such phytochemical variability is essential for optimizing the ethnomedicinal application of *B. aegyptiaca* and guiding its future development as a source of emerging bioactive agents.

Phytochemical screening in the present study revealed that alkaloids, flavonoids, phenols, cardiac glycosides, and coumarins were abundant, suggesting that these metabolites may play a role in the plant's adaptation to adverse environmental conditions. Methanolic extracts contained the broadest spectrum of phytochemicals, whereas n-hexane extracts yielded the least, a trend attributable to solvent polarity and the predominance of polar compounds within the plant. These results are consistent with previous reports indicating that secondary metabolites are most abundant in methanolic extracts, followed by acetone and n-hexane, with saponins and tannins absent in non-polar fractions but present in polar extracts (Akhtar et al., 2022). Notably, the sour variety exhibited a higher phenolic content than the sweet variety, despite both being collected from the same environment, suggesting that underlying metabolic and genomic differences contribute to phytochemical variability. Such differences are likely to influence the pharmacological properties of the extracts, as higher phenolic concentrations may enhance antioxidant and antifungal activities, while alkaloids and cardiac glycosides could contribute more strongly to antimicrobial and metabolic effects.

Regarding antifungal activity, the susceptibility of *C. albicans* to the crude extracts followed the order methanol > dichloromethane > n-hexane. This gradient likely reflects variations in phytochemical composition extracted by solvents of differing polarity. Methanolic extracts demonstrated the strongest antifungal effect, with activity comparable to ketoconazole ($\alpha = 0.05$). The pronounced activity of these extracts can be attributed to the combined effects of phenols and polyphenols, which disrupt fungal cell membranes, along with cardiac glycosides that interfere with fungal metabolism. Notably, both sweet and sour varieties exhibited comparable antifungal activity against *C. albicans*, suggesting that the distribution of active secondary metabolites is conserved across the two varieties despite differences in overall phytochemical abundance. This observation aligns with reports that therapeutic phytochemicals are widely expressed across *B. aegyptiaca* varieties, supporting their broad-spectrum antimicrobial potential (Shi et al., 2025; Hosee et al., 2025).

The strong antifungal activity observed in the methanolic stem bark extracts may be attributed to the presence of alkaloids, which are well-documented for their membrane-disrupting properties and their ability to interfere with key metabolic pathways (Othman et al., 2019; Adjouzem et al., 2020). Notably, both the sweet and sour varieties demonstrated comparable antifungal efficacy against *C. albicans*, suggesting a conserved distribution of bioactive phytochemicals across the two varieties. This finding supports the observations of Ishaku et al. (2020), who highlighted the widespread occurrence of therapeutic metabolites across plant varieties. Conversely, n-hexane extracts displayed only marginal antifungal activity, a trend likely explained by their enrichment in non-polar constituents such as resins, which generally exhibit weak antimicrobial potential (Okwuosa et al., 2012; Nazzaro et al., 2017).

Crude leaf extracts exhibited smaller zones of inhibition compared to stem and root bark extracts, which may be attributed to the high metabolic activity of leaf tissues and the preferential accumulation of certain secondary

metabolites in stem and root tissues. This observation contrasts with previous studies that reported strong antimicrobial activity in *B. aegyptiaca* leaves (Ishaku et al., 2020), suggesting that metabolite distribution may vary depending on environmental conditions, plant variety, or developmental stage.

Interestingly, n-hexane extracts produced relatively larger zones of inhibition against *A. flavus* compared to *C. albicans*, suggesting that *A. flavus* is more susceptible to crude organic extracts. This differential susceptibility may be partly due to the lower likelihood of *A. flavus* developing resistance to antifungal agents, whereas *C. albicans* frequently encounters conventional antifungals and often exhibits increased resistance. Additionally, the activity of n-hexane extracts can be attributed to the non-polar phytochemicals, such as resins and certain terpenoids, which are more effectively extracted by non-polar solvents and may target fungal cell membranes differently than polar compounds. These findings align with previous reports indicating that *A. flavus* growth is more readily inhibited by herbal extracts than *C. albicans* (Nazzaro et al., 2017)), highlighting the importance of both solvent polarity and fungal biology in determining antifungal efficacy.

This study possesses several strengths, including the systematic evaluation of the phytochemical composition and antifungal activity of sweet and sour varieties of *B. aegyptiaca*, thereby providing scientific support for its traditional medicinal uses. The use of multiple solvents (methanol, dichloromethane, and n-hexane) enabled assessment of extraction efficiency, while analysis of different plant parts (leaves, stem bark, and root bark) helped identify tissues with the greatest therapeutic potential. Standardized in vitro assays, coupled with precise GPS documentation, enhanced the reproducibility and reliability of the findings. However, the study also has limitations. Plant samples were collected from a single geographical location, which may not capture broader phytochemical variability. Additionally, only crude extracts were tested; future studies should focus on purification and isolation of active compounds using chromatographic techniques to fully characterize the antifungal potential of *B. aegyptiaca*. Lastly, antifungal testing was limited to *C. albicans* and *A. flavus*, excluding other clinically relevant fungal pathogens.

Conclusion and Recommendations

This study demonstrated that polar solvents, particularly methanol, effectively extract bioactive compounds from different parts of *B. aegyptiaca*, with the sweet variety yielding higher extract amounts than the sour variety. Crude extracts from both varieties exhibited predominantly inhibitory effects against *C. albicans* and *A. flavus*, with some fractions showing notable fungicidal activity, suggesting that combining extracts from multiple plant parts could enhance antifungal efficacy. Stem bark from both sweet and sour varieties displayed the strongest antifungal activity, indicating its potential as the most effective component for managing *A. flavus* and *C. albicans*. Overall, all extracts demonstrated significant antifungal properties, highlighting *B. aegyptiaca* as a promising source of natural antifungal agents for candidiasis and aspergillosis. However, toxicity and safety assessments were not performed in this study. Further research is warranted to evaluate the pharmacological potential, mechanism of action, and safety profile of these extracts to support their development into therapeutic agents.

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