



Antimicrobial potential of *Musa ornata* stem extract

P Radha, S K Reddy

Department of Botany and Cytogenetics, Tissue Culture and Molecular Biology Lab, Osmania University, Hyderabad, Telangana, India

Abstract

Background: *Musa ornata*, commonly known as the flowering banana, is an ornamental species with potential medicinal properties. Although various *Musa* species have demonstrated antimicrobial activity, limited studies exist on the bioactive potential of *M. ornata*. This study evaluates the phytochemical composition and antimicrobial activity of *Musa ornata* stem ethanolic extract against selected bacterial and fungal pathogens.

Methods: The antimicrobial activity of *Musa ornata* stem extract was assessed using the agar well diffusion method against *Staphylococcus aureus*, *Bacillus cereus*, *Escherichia coli*, *Enterobacter aerogenes*, *Candida albicans*, and *Aspergillus niger*. The extract was tested at concentrations of 25 mg/mL and 50 mg/mL, with Ampicillin and Ketoconazole as positive controls and DMSO as the negative control. Phytochemical analysis was performed to identify bioactive constituents responsible for antimicrobial activity.

Results: The extract exhibited a concentration-dependent inhibitory effect against bacterial and fungal strains. Gram-positive bacteria showed greater susceptibility than Gram-negative bacteria, while *C. albicans* demonstrated higher sensitivity than *A. niger*. Phytochemical analysis revealed the presence of flavonoids, phenolics, alkaloids, tannins, saponins, and terpenoids, which are known for their antimicrobial properties.

Conclusion: *Musa ornata* stem extract possesses significant antibacterial and antifungal activity, supporting its potential as a natural antimicrobial agent. The findings provide scientific validation of its traditional medicinal applications and highlight its relevance in developing alternative antimicrobial therapies. Further research on compound isolation and mechanism of action is warranted to explore its pharmaceutical potential.

Keywords: *Musa ornata*, antimicrobial activity, phytochemicals, agar well diffusion, bacterial inhibition, fungal inhibition

Introduction

Musa ornata, commonly known as the flowering banana, is a species in the *Musaceae* family and belongs to the *Rhodochlamys* section of the *Musa* genus. Native to India, Bangladesh, and Burma, it has become naturalized in tropical regions, including parts of Central and South America, where it hybridizes freely with other *Musa* species. The plant, characterized by its vibrant pink bracts and ornamental foliage, is widely cultivated for its aesthetic value rather than its inedible fruit (Saranya *et al.*, 2017) ^[1]. It typically grows between 1.5 and 3 meters in height and is favored in landscape gardening, earning the Royal Horticultural Society's Award of Garden Merit. Apart from its decorative appeal, various parts of the plant have been traditionally used in folk medicine, particularly in Ayurveda, for their potential health benefits (Pothavorn *et al.*, 2010) ^[2].

Phytochemical studies of *Musa* species indicate the presence of several bioactive compounds, including flavonoids, phenolics, alkaloids, tannins, saponins, and terpenoids. These compounds have been widely reported for their diverse pharmacological activities, such as antioxidant, antimicrobial, anti-inflammatory, and immunomodulatory effects ("Musa Ornata (Flowering Banana)," 2019) ^[3]. The phytochemical composition of *M. ornata* is expected to be similar to that of related species, given its taxonomic proximity. Recent studies have also highlighted the use of *M. ornata* flower sheath extract for synthesizing iron nanoparticles, which demonstrated antibacterial activity against multiple pathogenic bacteria, including *Staphylococcus aureus*, *Streptococcus agalactiae*,

Escherichia coli, and *Salmonella enterica*. These findings indicate that *M. ornata* possesses bioactive constituents with promising antimicrobial properties, warranting further investigation into its pharmacological potential (Sonawane *et al.*, 2024) ^[4].

Traditional medicinal uses of *Musa* species vary across regions, with applications ranging from digestive health to wound healing. In northeastern India, *M. ornata* roots have been incorporated into Ayurvedic medicine, while ash derived from the pseudostem, corm, fruiting stalk, and fruit peel has been utilized as an anti-scorbutic agent and digestive tonic (Begashaw *et al.*, 2023; Falana & Nurudeen, 2023) ^[5, 6]. The plant's male bud is consumed as a vegetable in certain cultures, and its leaves have been used for culinary and medicinal purposes (Linus *et al.*, 2023) ^[7]. These traditional applications provide a strong foundation for scientific studies aimed at validating the therapeutic potential of *M. ornata* (Al-Snafi *et al.*, 2023; Ugwuoke *et al.*, 2023) ^[8, 9]. The bioactive compounds in the plant may contribute to antimicrobial, antifungal, and anti-inflammatory effects, making it a potential candidate for alternative medicine formulations (Dash *et al.*, 2023; John Isa, 2024) ^[10-11].

The growing global concern over antimicrobial resistance has spurred interest in plant-derived compounds as alternatives to conventional antibiotics. Many medicinal plants have been identified as sources of novel antimicrobial agents due to their ability to target microbial cell walls, inhibit nucleic acid synthesis, and disrupt essential metabolic pathways (S. Veni Madhavi *et al.*, 2025) ^[12]. Phytochemicals such as flavonoids, alkaloids, and tannins

exert antibacterial effects through mechanisms that include cell membrane disruption and inhibition of bacterial quorum sensing. Similarly, terpenoids and saponins have demonstrated antifungal activity by interfering with fungal cell wall synthesis and ergosterol biosynthesis. Given these established roles of plant-derived compounds, *M. ornata* may serve as a valuable source of antimicrobial agents, particularly in the context of emerging multidrug-resistant pathogens (Allakonda *et al.*, 2024; Angelini, 2024) [13, 14].

The present study aimed to elucidate the phytochemical profile of the ethanolic extract of *Musa ornata* pseudostem and assess its antimicrobial activity against selected bacterial and fungal strains. The antimicrobial efficacy of the extract was evaluated using the agar well diffusion method against *Staphylococcus aureus*, *Bacillus cereus*,

Escherichia coli, *Enterobacter aerogenes*, *Candida albicans*, and *Aspergillus niger* (Chandra *et al.*, 2017) [15]. This research seeks to provide scientific validation of the traditional uses of *M. ornata* and contribute to the growing body of evidence supporting plant-based antimicrobial therapies. Additionally, the findings may facilitate further exploration of *M. ornata* for pharmaceutical applications, particularly in the development of natural antimicrobial formulations.

Materials and Methods

Plant material

Musa ornata was collected from the Forest areas of Khammam, Telangana, in April 2024 and authenticated by Department of Botany, Osmania University.



Fig 1. *Musa ornata*

Extraction of Plant Material

The pseudo stem of *Musa ornata* was collected, washed, and dried in the shade. Phytochemicals from the dried powder were extracted via Soxhlet extraction using ethanol at 50 °C for 48 h. Soxhlet extraction is a widely used method in phytochemical studies to efficiently extract compounds from plant materials. The crude extract was collected and filtered, and the solvent was evaporated using a rotary evaporator at 50°C. (Dokuparthi *et al.*, 2021; Sudheer *et al.*, 2021) [16, 17].

Agar Well Diffusion Method

Materials Used

The study involved six microbial test species obtained from the Microbial Type Culture Collection (MTCC), including Gram-positive bacteria *Staphylococcus aureus* (MTCC 96) and *Bacillus cereus* (MTCC 430), Gram-negative bacteria *Escherichia coli* (MTCC 443) and *Enterobacter aerogenes* (MTCC 111), and fungal species *Candida albicans* (MTCC 227) and *Aspergillus niger* (MTCC 282). The antimicrobial activity was assessed using *Musa ornata* stem ethanol extract at concentrations of 25 mg/mL and 50 mg/mL. Ampicillin served as the antibacterial positive control, while Ketoconazole was used as the antifungal standard. DMSO functioned as the negative control. The microbial strains were cultured on appropriate media, with Nutrient Agar for bacterial growth, Sabouraud Dextrose Agar for fungal growth, and Mueller-Hinton Agar if minimum inhibitory concentration (MIC) testing was required. Essential

equipment included an autoclave, a laminar airflow chamber, micropipettes with sterile tips, a cork borer of 6 mm diameter, sterile cotton swabs, Petri dishes, and an incubator set to 37°C for bacterial cultures and 28–30°C for fungal cultures (Suryanditha *et al.*, 2024) [18].

Preparation of Extract Solution and Inoculum

The ethanolic extract of *Musa ornata* stem was prepared by weighing 250 mg and 500 mg of the dried extract, which was then dissolved in 10 mL of DMSO or sterile distilled water. The solutions were filter sterilized using a 0.22 µm syringe filter when necessary and labeled according to their concentrations of 25 mg/mL and 50 mg/mL. Bacterial inocula were prepared by suspending the bacterial strains in sterile saline and adjusting their turbidity to 0.5 McFarland standard ($\sim 1.5 \times 10^8$ CFU/mL). For fungal suspensions, *C. albicans* was adjusted to $1-5 \times 10^6$ CFU/mL using sterile saline, while *A. niger* was prepared using a 0.1% Tween 80 solution and adjusted to 10^5 spores/mL (El-Kased & El-Kersh, 2022) [19].

Agar Plate Preparation and Sample Loading

Nutrient Agar and Sabouraud Dextrose Agar were prepared and autoclaved to ensure sterility. Approximately 20 mL of molten agar was poured into sterile Petri dishes and allowed to solidify before inoculation. Each test organism was evenly spread across the surface of the agar using a sterile cotton swab to create a uniform lawn. Wells of 6 mm diameter were punched into the agar using a sterile cork

borer and labeled according to their contents: W1 for *Musa ornata* extract at 25 mg/mL, W2 for *Musa ornata* extract at 50 mg/mL, W3 for the positive control (Ampicillin for bacteria and Ketoconazole for fungi), and W4 for the negative control (DMSO or sterile water). A micropipette was used to load 50 μ L of each test solution into the respective wells. The plates were left undisturbed at room temperature for 30 minutes to allow diffusion of the test solutions into the agar medium (Suleiman *et al.*, 2024) [20].

Incubation and Measurement of Antimicrobial Activity

The inoculated plates were incubated under optimal conditions for microbial growth, with bacterial cultures maintained at 37°C for 18–24 hours and fungal cultures at 28–30°C for 48–72 hours. After the incubation period, zones of inhibition—clear areas surrounding the wells—were observed and measured using a calibrated ruler or digital caliper. The inhibition zone diameters were recorded in millimeters (Tumpa *et al.*, 2024) [21].

Data Interpretation

The antimicrobial efficacy of *Musa ornata* stem extract was determined by comparing the inhibition zones of the extract with those of the positive and negative controls. A larger inhibition zone at 50 mg/mL than at 25 mg/mL indicated a

dose-dependent effect. The results were analyzed to assess whether *Musa ornata* extract exhibited significant antibacterial and antifungal activity relative to the standard antimicrobial agents.

Results

Percentage yield

The percentage yield was calculated using the above formula as 3.9%.

Phytochemical screening

Phytochemical analysis of *Musa ornata* pseudo-stem extract revealed the presence of several bioactive compounds. Carbohydrates and proteins were detected, indicating the potential nutritional value of the extract. Steroids were also present, suggesting their possible medicinal properties. Saponins and flavonoids, known to exhibit antioxidant and anti-inflammatory activities, were detected. In addition, tannins were found in the extract, which may contribute to its astringent and antimicrobial properties. However, glycosides and alkaloids were not detected in the extract, indicating their absence or presence in negligible quantities. The extract contained diverse phytochemicals, which may contribute to its various biological activities and potential health benefits (Table 1).

Table 1: Phytochemicals present in *Musa ornata*

Phytochemicals	<i>Musa ornata</i> pseudo stem extract
Carbohydrates	+
Protein	+
Steroids	+
Glycosides	-
Alkaloids	-
Saponins	+
Flavonoids	+
Tannins	+

Antibacterial activity

The antibacterial potential of *Musa ornata* stem ethanolic extract was evaluated against selected Gram-positive and Gram-negative bacterial strains using the agar well diffusion method. The extract, tested at 25 mg/mL and 50 mg/mL, exhibited a dose-dependent inhibitory effect on bacterial growth. Among the Gram-positive bacteria, *Staphylococcus aureus* showed inhibition zones of 1.3 ± 0.14 mm and 2.3 ± 0.14 mm at lower and higher concentrations, respectively, whereas *Bacillus cereus* displayed slightly larger inhibition zones of 1.4 ± 0.57 mm and 2.45 ± 0.07 mm. Gram-negative bacteria also exhibited a similar response, with *Escherichia coli* showing inhibition of 1.2 ± 0.14 mm and 2.5 ± 0.99 mm, while *Enterobacter aerogenes* demonstrated the least susceptibility with inhibition zones of 1.05 ± 0.07 mm and 1.45 ± 0.07 mm. In contrast, the standard antibiotic Ampicillin consistently produced significantly higher

inhibition across all bacterial strains, while the negative control, DMSO, exhibited negligible effects.

The variation in inhibition zones among bacterial species suggests differing sensitivities to the phytoconstituents present in the extract. *S. aureus* and *B. cereus* exhibited higher susceptibility, likely due to the direct interaction of phytochemicals with their peptidoglycan-rich cell walls. *E. coli* showed a moderate response, suggesting partial permeability to the bioactive compounds, whereas *E. aerogenes* demonstrated the highest resistance, possibly due to its robust efflux mechanisms and protective outer membrane. The results indicate that *Musa ornata* stem extract contains secondary metabolites with antibacterial properties, though their effectiveness is lower compared to standard antibiotics. Further studies on the extract's mechanism of action, synergistic potential, and compound isolation are necessary to explore its application in antibacterial therapies (Table 2; Figure 2&3).

Table 2: Effect of *Musa ornata* on bacterial growth

Test Organism	25 mg/mL (mm)	50 mg/mL (mm)	Ampicillin (mm)	DMSO (mm)
<i>S. aureus</i>	1.3 ± 0.14	2.3 ± 0.14	3.5 ± 0.42	1 ± 0
<i>B. cereus</i>	1.4 ± 0.57	2.45 ± 0.07	3.3 ± 0.71	1 ± 0
<i>E. coli</i>	1.2 ± 0.14	2.5 ± 0.99	3.7 ± 0.42	1 ± 0
<i>E. aerogenes</i>	1.05 ± 0.07	1.45 ± 0.07	4.25 ± 0.07	1 ± 0

Values are expressed as Mean \pm SD

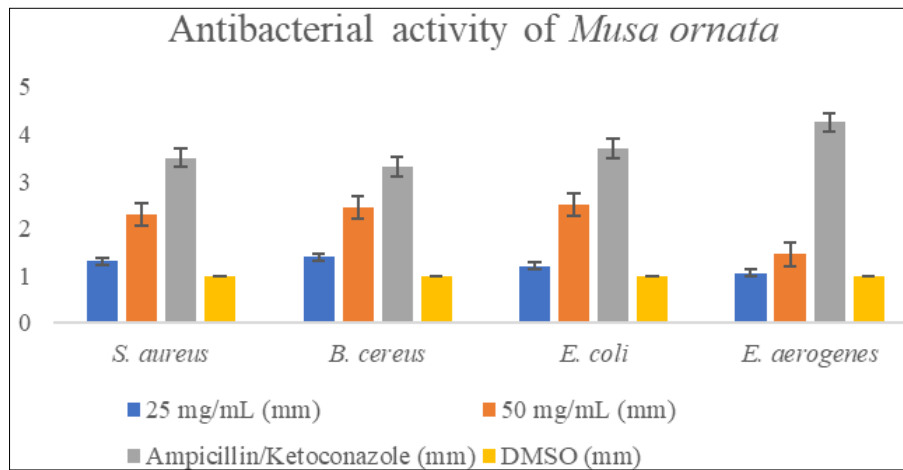


Fig 2: Antibacterial activity of *Musa ornata*

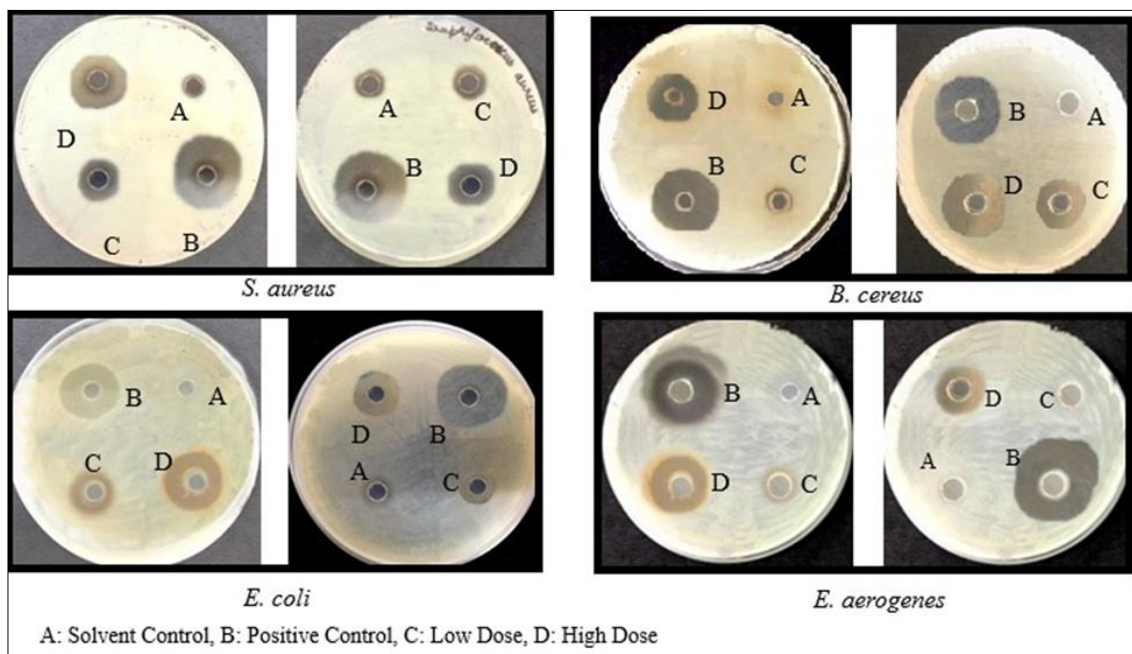


Fig 3: Zone of Inhibition of *Musa ornata* on bacterial strains

Antifungal activity

The antifungal activity of *Musa ornata* stem ethanolic extract was assessed against *Candida albicans* and *Aspergillus niger* using the agar well diffusion method. The results demonstrated a concentration-dependent inhibition of fungal growth, with *C. albicans* showing greater susceptibility than *A. niger*. At 25 mg/mL, *C. albicans* exhibited an inhibition zone of 1.65 ± 0.78 mm, which increased to 2.7 ± 1.13 mm at 50 mg/mL. In contrast, *A. niger* displayed only minimal inhibition, with 1 ± 0 mm at 25 mg/mL and 1.4 ± 0.28 mm at 50 mg/mL. Ketoconazole, used as a standard antifungal, showed significantly larger inhibition zones of 4.05 ± 0.07 mm and 2.85 ± 0.07 mm against *C. albicans* and *A. niger*, respectively, confirming its superior efficacy. The negative control, DMSO, exhibited no significant inhibition across both fungal strains,

indicating that the observed activity was due to the extract's bioactive compounds.

The limited inhibition observed in *A. niger* compared to *C. albicans* suggests that *Musa ornata* extract may be more effective against yeast-like fungi than filamentous fungi, potentially due to differences in their cellular organization and defense mechanisms. While the extract displayed moderate antifungal activity, its effectiveness remained lower than Ketoconazole, highlighting the need for further studies to optimize its potency. The presence of antifungal phytochemicals suggests potential applications in natural antifungal therapies, but additional research is necessary to explore its mechanism of action, bioavailability, and possible synergistic effects with conventional antifungal agents (Table 3; Figure 4&5).

Table 3: Effect of *Musa ornata* on Fungal growth

Test Organism	25 mg/mL (mm)	50 mg/mL (mm)	Ketoconazole (mm)	DMSO (mm)
<i>C. albicans</i>	1.65 ± 0.78	2.7 ± 1.13	4.05 ± 0.07	1 ± 0
<i>A. niger</i>	1 ± 0	1.4 ± 0.28	2.85 ± 0.07	1 ± 0

Values are expressed as Mean±SD

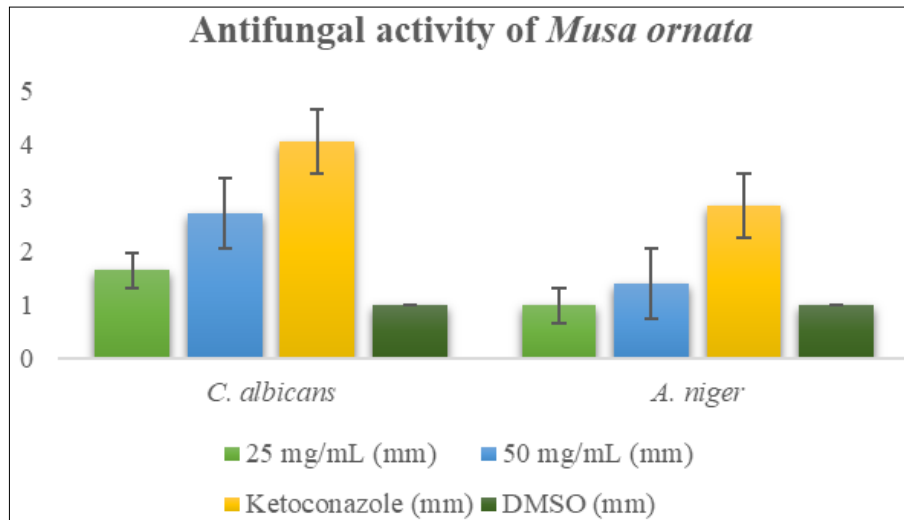


Fig 4: Antifungal activity of *Musa ornata*

The differential susceptibility between bacterial and fungal species can be attributed to structural differences in their cell walls and membranes, as well as variations in the mode of action of the phytochemicals present in *Musa ornata*. The extract contains flavonoids, phenolics, alkaloids, tannins, saponins, and terpenoids, each contributing to its antimicrobial activity. The higher inhibition observed in Gram-positive bacteria may be linked to their simpler cell wall structure, allowing better penetration of bioactive compounds. In contrast, the outer membrane of Gram-negative bacteria acts as a barrier, limiting the entry of

antimicrobial agents and making them more resistant. Similarly, the enhanced susceptibility of *C. albicans* over *A. niger* suggests that the extract is more effective against yeast-like fungi than filamentous fungi, possibly due to the greater resistance conferred by the thick chitin-rich cell wall in *A. niger*. The presence of saponins and terpenoids, known to disrupt fungal membranes and metabolic pathways, may explain the antifungal activity observed, while alkaloids and flavonoids contribute to bacterial inhibition by interfering with essential cellular functions such as DNA replication and protein synthesis.

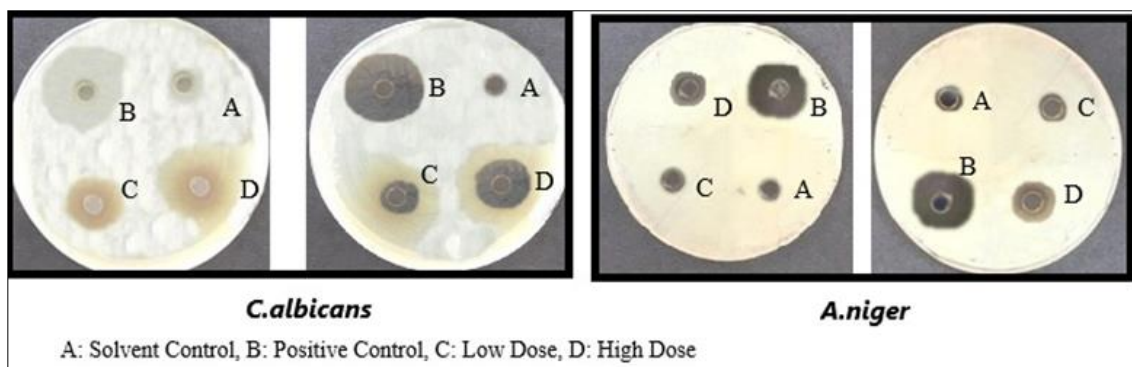


Fig 5: Zone of Inhibition of *Musa ornata* on fungal strains

Summary

The antimicrobial potential of *Musa ornata* stem ethanolic extract was evaluated against selected bacterial and fungal strains using the agar well diffusion method. The extract demonstrated dose-dependent inhibition, with bacteria generally showing higher susceptibility than fungi. Among the bacterial strains, Gram-positive bacteria exhibited greater inhibition compared to Gram-negative strains, likely due to differences in cell wall composition. In the fungal study, *Candida albicans* was more sensitive than *Aspergillus niger*, suggesting a differential response based on fungal morphology and membrane composition. While the extract displayed measurable antimicrobial activity, its effectiveness was lower than standard antibiotics and antifungals. The negative control, DMSO, showed no significant inhibition, confirming that the observed effects were due to the bioactive constituents of the extract.

The antimicrobial activity of *Musa ornata* is attributed to its rich phytochemical composition, including flavonoids, phenolics, alkaloids, tannins, saponins, and terpenoids. These compounds are known to interfere with microbial cell walls, disrupt enzymatic pathways, and inhibit essential cellular functions. The greater effectiveness against bacteria, particularly Gram-positive strains, suggests better penetration of bioactive compounds, whereas the reduced antifungal activity, especially against *A. niger*, may be due to its more robust structural defenses.

Conclusion

These findings suggest that *Musa ornata* possesses broad-spectrum antimicrobial properties, with stronger antibacterial effects. While its activity is lower than conventional antibiotics, the presence of diverse phytochemicals indicates potential for future therapeutic applications. Further research on compound isolation,

synergistic effects, and formulation development could enhance its antimicrobial efficacy and potential as a natural antimicrobial agent.

References

- Allakonda L, Potnuri AG, Kumar Dokuparthi S, Danaboina GB, Kurra S, Ranjan R. *Commelina benghalensis* attenuates cyclophosphamide-induced hepatotoxicity by preserving hepatic mitochondrial activity through upregulating pro-mitochondrial proteins. *Traditional & Kambo Medicine*,2024;11(3):230-241.
- Al-Snafi AE, Talab TA, Sales AJ. Nutritional and therapeutic values of *Musa paradisiaca* - A review. *Nativa*,2023;11(3):396-407.
- Angelini P. Plant-derived antimicrobials and their crucial role in combating antimicrobial resistance. *Antibiotics*,2024;13(8):746.
- Begashaw T, Dagne A, Yibeltal D. Review on phytochemistry, medicinal properties, and toxicities of the genus *Musa*. *Traditional Medicine*, 2023, 4(2).
- Chandra H, Bishnoi P, Yadav A, Patni B, Mishra A, Nautiyal A. Antimicrobial resistance and the alternative resources with special emphasis on plant-based antimicrobials—A review. *Plants*,2017;6(2):16.
- Dash A, Majhi T, Ratha S, Mishra SP, Pradhan B. Phytochemical and antimicrobial aspects of wild *Musa balbisiana* and *Musa acuminata*. In: *Advanced Concepts in Pharmaceutical Research*, Vol. 2. B P International, 2023, 81-92.
- Dokuparthi SK, Reddy TRM. Antioxidant and nephroprotective activity of flavonoid rich fraction of *Alphonsea sclerocarpa* Thw. *International Journal of Pharmaceutical Sciences and Drug Research*,2021;13(4):384-394.
- El-Kased RF, El-Kersh DM. GC-MS profiling of naturally extracted essential oils: Antimicrobial and beverage preservative actions. *Life*,2022;12(10):1587.
- Falana MB, Nurudeen QO. Proximate composition, phytochemical and antimicrobial activities of the fermented ripe fruit of *Musa paradisiaca*. *Journal of Science and Technology*, 2023,15(2).
- John Isa JF. Phytonutrients composition of Nigerian banana fruits (*Musa* species) and their peel extracts. *International Journal of Human and Health Sciences*,2024;8(2):170.
- Linus AU, Shagal MH, Nkafamiya II. Phytochemical screening and antimicrobial activities of *Musa acuminata* calla (banana blossom). *Journal of Chemical Society of Nigeria*, 2023, 48(5).
- Musa ornata* (flowering banana). *CABI Compendium*, 2019.
- Pothavorn P, Kitdamrongsont K, Swangpol S, Wongniam S, Atawongsa K, Svasti J, Somana J. Sap phytochemical compositions of some bananas in Thailand. *Journal of Agricultural and Food Chemistry*,2010;58(15):8782-8787.
- Saranya S, Vijayarani K, Pavithra S. Green synthesis of iron nanoparticles using aqueous extract of *Musa ornata* flower sheath against pathogenic bacteria. *Indian Journal of Pharmaceutical Sciences*, 2017, 79(5).
- Sonawane A, Bhambar R, Nehete J. A comprehensive review of the phytochemistry and pharmacological profiles of *Musa acuminata* (Family: Musaceae). *International Journal of Pharmaceutical Sciences and Drug Research*,2024;16(5):888-899.
- Sudheer Kumar D, Rama Mohan Reddy T. Antioxidant activity and hepatoprotective potential of flavonoid rich content of *Alphonsea sclerocarpa* leaves. *International Journal of Pharmaceutical Research*, 2021, 13(3).
- Suleiman AA, Shuaibu SB, Abdulmalik A, Ahmad B, Muhammad AA, Garba I, Jibril M, Abdu K, Audi HA. Antimicrobial activity of ethanol extract of *Strychnos spinosa* leaves. *Nigerian Journal of Science and Environment*, 2024, 51-59.
- Suryanditha PA, Widhidewi NW, Paramasatiari AAAL, Wedari NLP. Antibacterial activity of *Spondias pinnata* leaf extract on the *in-vitro* growth of Gram-positive and Gram-negative bacteria. *Indonesia Journal of Biomedical Science*,2024;18(1):90-94.
- Tumpa NI, Rahman MS, Manchur MA. Antimicrobial and membrane stabilization activity of plant extracts against pathogenic bacteria and fungi. *Bangladesh Journal of Microbiology*,2024;40(2):76-85.
- Ugwuoke SC, Nwanelo VO, Dawoye Y, Ugwu OC, Osuji DO, Ougufor MO, Okoro IJ, Odo CP, Nelson TN, Anosike CA. An investigation of the phytochemical richness of fresh *Musa paradisiaca* L. (plantain) stem juice and its anticonvulsant potential on pentylenetetrazole (PTZ)-challenged rats, 2023.
- Veni Madhavi S, Rames P, Sudheer Kumar D, Kiran Kuma B. Evaluation of antimicrobial efficacy of ethanolic fruit extracts of *Terminalia pallida* Brandis. *International Journal of Biosciences*,2025;26(1):2229.