

Phytochemical Screening and Antibacterial Activity of *Gynandropsis gynandra* Against Medically Important Bacterial Isolates

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ABSTRACT

Background: The emergence and spread of antimicrobial resistance have become major public health challenges. Effective alternative treatments are needed, especially medicinal plants.

Objective: This study aimed to conduct phytochemical screening and evaluate the antimicrobial activity of *Gynandropsis gynandra* (ISOGI).

Methodology: Antibacterial activity of *Gynandropsis gynandra* extracts was evaluated in vitro using the agar well diffusion method. Methanol, petroleum ether, and distilled water extracts of leaves and stems were tested against five clinical bacterial strains (*Staphylococcus aureus* ATCC43300, *Haemophilus influenzae* ATCC9007, *Streptococcus pneumoniae* ATCC4961, *Pseudomonas aeruginosa* ATCC2785, and *Klebsiella oxytoca* ATCC700324). Zones of inhibition were measured after incubation at 37°C for 24 hours.

Results: The extract concentrations revealed varied antimicrobial activity against *Staphylococcus aureus* ATCC43300, *Haemophilus influenzae* ATCC9007, *Streptococcus pneumoniae* ATCC4961, *Pseudomonas aeruginosa* ATCC2785, and *Klebsiella oxytoca* ATCC700324 bacteria with respect to the inhibition diameters observed and measured on agar. The maximal antibacterial activity of the leafy material was observed against *Staphylococcus aureus* ATCC43300 (18.3 mm) and *Klebsiella oxytoca* ATCC700324 (18.3 mm) in distilled water and petroleum ether, respectively. The maximal antibacterial activity of the stem was observed with methanol extracts, producing a 16.3 mm inhibition zone against *Staphylococcus aureus* ATCC43300. All extracts from the leaves and stems demonstrated comparatively higher antibacterial activity against *Staphylococcus aureus* ATCC43300 than against the other tested bacterial strains.

Conclusion: Extracts of *Gynandropsis gynandra* exhibited notable antibacterial activity, particularly against *Staphylococcus aureus* and *Klebsiella oxytoca*. These findings highlight the therapeutic potential of this plant and highlight the need for further exploration of medicinal plants as alternative sources of antimicrobial agents.

BACKGROUND

Medicinal plants have been utilized for millennia as natural remedies and remain central to healthcare worldwide.¹ Their therapeutic efficacy has been well established, and crude extracts continue to serve as raw materials for pharmaceutical industries.² Research on medicinal plants has provided new therapeutic agents and valuable leads for drug synthesis based on natural product structures.² Despite advances in synthetic chemistry, modern pharmaceutical industries still rely on bioactive principles derived from plants.³ Globally, approximately 80% of the population depends on herbal medicine as a primary source of therapy,

particularly in developing countries where traditional medicine systems are deeply embedded in cultural practices.^{3,8} The World Health Organization estimates that 60 to 80% of the world's population relies chiefly on traditional medicine, with most therapies involving plant extracts and their constituents.⁹ Yet, only a small fraction of plant species has been scientifically investigated, leaving vast potential for bioassay-directed isolation studies.⁵ The presence of phytochemicals makes these plants useful for both healing and curing human diseases.⁶

Phytochemicals are naturally occurring compounds that confer therapeutic properties to plants.⁷ Large populations, especially in developing regions, depend

on these compounds to treat diverse diseases.⁸ Several hundred genera of plants are traditionally used for medicinal purposes, reflecting the breadth of botanical resources available for healthcare.⁸ This reliance highlights both cultural heritage and practical necessity, as plant-based remedies are often more accessible and affordable than synthetic drugs.

Among the many medicinal plants, *Gynandropsis gynandra* (commonly known in Rwanda as Isogi) is of particular importance. Taxonomically, it belongs to the family Capparaceae, genus *Cleome*, and species *G. gynandra*.¹⁰ The plant is widely used in indigenous medicine across countries. Leaves and seeds are applied externally to wounds to prevent sepsis; root decoctions are used to treat fevers; and leaves rich in vitamin C are consumed fresh or dried as pot herbs in soups.¹¹ The leaves also serve as disinfectants, relieve headaches through inhalation, and are used for earache and eye washing. Stems are valued for their analgesic and anti-inflammatory properties.¹² The spider plant (*Cleome gynandra* L., synonym *Gynandropsis gynandra* (L.) Briq.) is a widely distributed African leafy vegetable and medicinal plant belonging to the order Brassicales. Its secondary metabolites include alkaloids, cyanogenic glycosides, steroidal nuclei, and anthraquinones.¹³ Glucosinolates such as methylglucosinolate, cleomin, and glucocapparin yield methyl isothiocyanates upon hydrolysis.¹³ Homogenised leaves emit significant quantities of methyl isothiocyanate, propylene isothiocyanate, butyl isothiocyanate, and isobutyl isothiocyanate, along with aldehydes, terpenes, alcohols, acetates, and ketones.¹³ Traditionally, decoctions or infusions of boiled leaves and roots are administered to facilitate childbirth, treat gastrointestinal disorders, conjunctivitis, and threadworm infections. Seeds and roots also possess anthelmintic properties, while the whole plant has been used to treat malaria, infections, rheumatism, and tumors.^{14,15}

In many African communities, particularly in Eastern Africa, wild edible vegetables such as *G. gynandra* play dual roles: supplementing micronutrients and serving as sources of traditional medicine.¹⁶ Studies highlight their importance in agricultural, nutritional, and medicinal systems.¹⁷ However, modernisation and exposure to exotic products have reduced their use (18). Despite this decline, nature has remained a reservoir of medicinal agents since the beginning of human life.¹⁸ In Nigeria, nearly all plants are considered medicinal, and the use of medicinal plants in traditional medicine is well acknowledged and established as a viable profession. Extraction of bioactive compounds allows demonstration of physiological activity and facilitates pharmacological studies, leading to the synthesis of more potent drugs with reduced toxicity.¹⁹

In Rwanda, renewed recognition of the value of edible plants has raised hopes for increased public awareness of their nutritional and medicinal importance. More than 210 species of traditional leafy vegetables grow naturally in Rwanda, though not all have been fully utilized.^{16,20} Among these, *G. gynandra* is one of the most widely used species, serving as both food and medicine. Its leaves and stems are employed to treat respiratory problems, scurvy, and diarrhoea, and it is recommended for pregnant and lactating women to reduce dizziness.¹⁶ Across Africa,

medicinal plants have long been exploited for the treatment of infectious diseases, and Rwandans similarly continue to rely on plant-based therapies.¹⁶ Despite the widespread traditional use and recognised therapeutic potential of *G. gynandra*, scientific information on the phytochemical composition and bioactive properties of Rwandan specimens remains limited. Most existing studies have focused on its nutritional value or ethnomedicinal applications in other African regions, while comprehensive laboratory-based investigations in Rwanda are still scarce. This lack of locally generated scientific evidence hinders validation of its traditional uses and limits its potential development as a source of therapeutic agents. Therefore, the present study aimed to investigate the phytochemical constituents and evaluate the biological activities of *Gynandropsis gynandra* collected in Rwanda, in order to provide scientific evidence supporting its medicinal applications and potential pharmaceutical value.

MATERIALS AND METHODS

Preparation of Plant Material

Samples were collected using sterile gloves and scissors, placed in sterile plastic bags, and transported under ambient conditions. Environmental control was ensured by avoiding uprooting whole plants to preserve the habitat. Leaves and stems were airdried at room temperature (22–25°C) with relative humidity between 55 and 65%, under shade to avoid direct sunlight.

Preparation of Crude Extracts

A total of 25 g of dry powdered plant (leaf and stem) material was extracted with 250 ml of different solvents, such as distilled water, 90% petroleum ether and 99.8% methanol, for 7 days of maceration.²¹ The extracts obtained were cooled, and the pH was measured via a pH meter to evaluate the effects of solvents on microorganisms, as an acidic pH may increase the activity of plant extracts.²² The extracts were concentrated via a rotary evaporator under vacuum at low temperatures of 45°C and 120 revolutions per minute (rpm) to avoid the induction of oxidation and reduction reactions, which might occur because different conditions produce different grams of extracts. A seven-day maceration period was selected based on established ethnopharmacological protocols to maximise extraction yield for *G. gynandra*. Although shorter durations produce lower yields, the possibility of compound degradation during prolonged extraction is acknowledged as a limitation. The extraction yields, expressed as grams of dried extract obtained per solvent, were determined and included to improve reproducibility and facilitate comparison with other studies.

Phytochemical Screening of Plants

This was done on different extracts to ascertain the presence of bioactive components present in the leaves and stems of *G. gynandra*. The presence of saponins, glycosides, tannins, and phenols was determined following standard protocols.¹⁴ Phytochemical screening was conducted qualitatively in triplicate, incorporating both positive and negative controls to ensure reliability. Quantitative analysis of metabolite concentrations was not performed and is acknowledged as a limitation, to be addressed in future studies. Quantitative analysis of

metabolite concentrations was not performed, which is acknowledged as a limitation and is recommended for investigation in future studies.

Test for Tannins

Approximately 0.5 g of plant extract was dissolved in 2.5 ml of distilled water, the mixture was mixed well, and the filtrate was then divided into two parts. In the first part, 1% lead acetate was added to produce a white precipitate as a positive result, while in the second part, 1% ferric chloride solution was added, resulting in a bluish-green colouration as a positive test.

Test for Phenols

A total of 0.06 ml of 1% ferric chloride solution was added to 0.1 ml of plant extract, and the mixture was mixed well. The formation of a bluish-green colour indicated the presence of phenolics.

Test for Glycosides

Approximately 10 ml of 50% H₂SO₄ was added to 1 ml of plant extract; the mixture was mixed well and boiled in water for 15 min, after which 10 ml of Fehling's solution was added to the mixture. A brick-red precipitate was observed, indicating the presence of glycosides.

Test for saponins

Approximately 5 drops of extract were added to water and shaken well, and the formation of foam, which was stable for 15 min or more, was observed to indicate the presence of saponins.

Test Organisms

Five human pathogenic bacteria, consisting of two gram-positive bacteria (*Staphylococcus aureus* and *Streptococcus pneumoniae*) and three gram-negative bacteria (*Haemophilus influenzae*, *Pseudomonas aeruginosa* and *Klebsiella oxytoca*), were obtained from the National Reference Laboratory. Using a sterile inoculating wire loop, microorganisms were cultured on prepared culture media such as MacConkey agar, mannitol salt agar, xylose lysine deoxycholate agar (XLD) and blood agar (made by HiMedia Laboratories Pvt. Ltd, Mumbai, India) according to the manufacturer's instructions, and the streak method was performed. The plates were subsequently incubated at 37°C for 24 hrs. A drop of normal saline was placed on a clean glass slide, and a pure colony from the culture plate was transferred using a sterile inoculating loop to prepare a smear. The smear was heatfixed and subjected to Gram staining for bacterial identification. The Gram stain procedure involved the sequential application of crystal violet (primary stain), iodine (mordant), ethanol (decolouriser), and safranin (counterstain). After airdrying, the slides were examined under oil immersion at ×100 magnification to differentiate Grampositive and Gramnegative bacteria based on cell wall characteristics. After Gram staining, biochemical tests, such as the hydrogen peroxide (H₂O₂) test, Sulphur, Indole and Motility test (SIM), urease test, citrate test, Optochin test, oxidase test, Kliger's iron agar (KIA) from HiMedia Laboratories Pvt. Ltd, Mumbai, India, CAMP test, and coagulase test, were performed.

Antimicrobial Activity by the Agar Well Diffusion Method

A sterile inoculating wire loop was used, and the bacteria were emulsified in sterile normal saline and mixed gently. Bacterial suspensions were standardised to 0.5 McFarland (~1.5 × 10⁸ CFU/mL), agar thickness was maintained at 4 mm, and all assays were conducted in triplicate to ensure consistency. The antimicrobial activities of the crude extracts were assayed against *S. aureus*, *H. influenzae*, *S. pneumoniae*, *P. aeruginosa*, and *K. oxytoca*, which mainly cause diseases. The agar well diffusion method for antimicrobial susceptibility testing was performed according to the standard.²² A sterile cotton swab was used to distribute the bacteria on the entire surface of Mueller–Hinton agar (MHA), different concentrations of the plant extracts were applied, and antibiotic susceptibility testing was performed using discs with the following concentrations: levofloxacin (5 µg), doxycycline (30 µg), vancomycin (30 µg), amoxicillin (25 µg), and ampicillin (10 µg). These acted as positive controls and were placed on the plate using sterile forceps, while a blank disc containing solvent without a bioactive agent was used as a negative control. The plates were subsequently incubated at 37°C for 24 hours. The diameters of the zones of inhibition were measured by a ruler.²³

Minimum Inhibitory Concentrations (MICs)

The minimum inhibitory concentrations were assessed on the basis of the part of the plant that was found to have effective antimicrobial activity. The MICs of the extracts were determined by diluting the plant extracts to different concentrations (75%, 50%, 25%, and 12.5%). Unfortunately, an inhibition zone was observed in only 75% of the samples. The volume of distilled water was mixed with the concentration of extract. The antimicrobial activity of the obtained solution was tested, and the plates were incubated at 37°C for 24 h. Antimicrobial activity was assessed using crude extracts at varying concentrations, with significant activity observed only at 75%, highlighting the need for further purification and concentration of active compounds to enhance efficacy.

Statistical Analysis

Microsoft Excel 2016 and the Statistical Package for the Social Sciences (SPSS), version 24.0 (IBM Corporation, Armonk, NY, USA), were used for analysis and data recording. Descriptive statistics (mean ± SD) were calculated for inhibition zones. One-way ANOVA was used to compare extract activities across bacterial strains, followed by post-hoc Tukey tests where appropriate.

RESULTS

Appearance and Volume of the Plant Extract

Table 1 shows the extraction solvents, where 13 ml of distilled water produced a dark yellow colour, 18 ml of methanol produced a dark green colour, and 10 ml of petroleum ether produced a yellow colour. The variation in extract volumes reflects differences in solvent extraction efficiency, with methanol yielding the highest volume, suggesting greater solubility of phytochemicals in polar solvents. The observed that the colours (dark green, yellow, and dark yellow) may indicate the presence of compounds such as chlorophylls and phenolic constituents, which are known to influence biological activity.

TABLE 1: Colour and Volume (in Millimetres) of Extracts from Three Solvents

Extracting solvents	Colour of extract	Volume of extract(ml)
Distilled water	Dark Yellow	13
Methanol	Dark green	18
Petroleum ether	Yellow	10

Phytochemical Screening of Leaves and Stems of *Gynandropsis gynandra*

This study employed qualitative phytochemical screening to establish the presence of key secondary metabolites. However, the absence of quantitative or semi-quantitative measurements limits the ability to correlate concentration with biological activity. Future studies should incorporate quantitative assays to determine metabolite levels. Table 2 shows the phytosubstances screened from extracts of plant leaves and stems, where phenolic compounds and glycosides were present in both the leaves and stems, whereas saponins and tannins were present in the leaves and absent in the stems.

TABLE 2: Phytosubstances Screened from *G. gynandra* Leaf and Stem Extracts.

Secondary metabolites	Leaves	Stem
Phenolic	+	+
Glycosides	+	+
Saponin	+	-

Antibacterial Activities of *Gynandropsis gynandra* Leaves and Stems

For the leaf extracts, the methanol preparation showed the highest antibacterial activity against *Pseudomonas aeruginosa* (16.6 mm), followed by *Staphylococcus aureus* (15 mm), *Klebsiella oxytoca* (14 mm), and *Haemophilus influenzae* (12 mm). No inhibition was observed against *Streptococcus pneumoniae*. With petroleum ether leaf extracts, *Klebsiella oxytoca* showed the highest sensitivity (18.3 mm), followed by *Haemophilus influenzae* (14 mm) and *Pseudomonas aeruginosa* (13.6 mm). No inhibition was observed for *Staphylococcus aureus* or *Streptococcus pneumoniae*. For stem extracts, petroleum ether produced greater inhibition against *Pseudomonas aeruginosa* (14.6 mm) compared to *Haemophilus influenzae* (14.3 mm). The distilled water extract was more sensitive to *H. influenzae* (13 mm) and *K. oxytoca* (10.3 mm), while the least sensitive extracts were *P. aeruginosa*, *S. pneumoniae* and *S. aureus* at 0.0 mm. Levofloxacin was sensitive to *S. aureus* (22 mm), *H. influenzae* (22 mm), *S. pneumoniae* (20 mm) and *K. oxytoca* (23 mm); it had intermediate effects on *P. aeruginosa* (17 mm), whereas *Staphylococcus aureus* (24 mm), *Haemophilus influenzae* (19 mm) and *Streptococcus pneumoniae* (18 mm) were sensitive to doxycycline, while *Klebsiella oxytoca* showed intermediate sensitivity (11 mm) and *Pseudomonas aeruginosa* was resistant (0.0 mm). Vancomycin demonstrated intermediate activity only against *Staphylococcus aureus* (15 mm). All the isolates were resistant to ampicillin and amoxicillin. (Table 3)

TABLE 3: Antimicrobial Activity of Different Solvent Extracts from *G. gynandra* Leaves and Stems

Extra/ Antibiotics	Mean Diameters of zones of Inhibition of bacteria in mm				
	<i>S.aureus</i> ATCC43300	<i>H.influenza</i> ATCC9007	<i>S. pneumoniae</i> ATCC4961	<i>P. aeruginosa</i> ATCC2785	<i>K. oxytoca</i> ATCC700324
MLE	15	12	0.0	16.6	14
PELE	0.0	14	0.0	13.6	18.3
DWLE	18.3	0.0	0.0	12.3	0.0
MSE	16.3	0.0	16	14.6	15.6
PESE	0.0	14.3	0.0	14.6	12.3
DWSE	0.0	13	0.0	0.0	10.3
LE	22	22	20	17	23
DOX	24	19	18	0.0	11
VA	15	0.0	0.0	0.0	0.0
AMX	0.0	0.0	0.0	0.0	0.0
AM	7	0.0	0.0	0.0	0.0

MLE=methanol leaf extract, PELE=petroleum ether leaf extract, DWLE=distilled water leaf extract, MSE=methanol stem extract, PESE=petroleum ether stem extract, DWSE=distilled water stem extract, LE=levofloxacin, DOX=doxycycline, VA=vancomycin, AMX=amoxicillin, AM=ampicillin

DISCUSSION

Phytochemicals are primarily responsible for the pharmacological activities of *G. gynandra* and thus serve as important indicators in evaluating its potential as a therapeutic agent. The findings of the qualitative phytochemical screening of the plant extracts are presented in Table 2. These results indicate the presence of glycosides, phenols, saponins, and tannins in the leaves, while the stem contains glycosides and phenols but lacks detectable levels of saponins and tannins. The therapeutic efficacy of plant-derived materials is generally attributed to the synergistic or combined effects of multiple secondary metabolites present within the plant matrix. Phytochemical constituents such as phenolic compounds are associated with biological activities such as antioxidant and scavenging potential against free radicals. For example, phenolics are known to exhibit antiallergic, anti-inflammatory, antimicrobial and anticancer activities.²⁴ Extracts of *G. gynandra* are rich in polyphenolic compounds, which may partly account for its long-standing use in traditional medicine for the management of diseases associated with oxidative stress. Tannins play a major role in the treatment of inflamed tissues and diarrhoea and in the prevention of cancer. On the other hand, saponins are characterised by their bitter taste, foaming properties, ability to bind cholesterol, and haemolytic activity toward red blood cells.²⁵ The presence of saponins in the extracts may also increase the antioxidant activities of the plant, ranging from antitumor, antimutagenic and anti-inflammatory properties.²⁶ In addition, the low concentrations of saponins and tannins observed in this study suggest low toxicity in the plant.

Aqueous extracts are generally rich in antibacterial agents; in addition, water has been reported by traditional healers and herbalists to be the most commonly used solvent to extract biologically active compounds because of its easy availability.²⁷ However, these results revealed that other methods and techniques may be applied and compared for their efficiency, as water is not always the most effective solvent for the extraction of pharmacologically active compounds in tested plants.²⁸ The present study revealed that all the solvent extracts (methanol, petroleum ether and distilled water) contained selected phytochemicals. However, compared with different solvent extracts, methanol was found to contain more active phytochemical constituents. Many of these compounds are known to possess a wide range of medicinal properties, such as antioxidant, antihepatotoxic and anticancer effects. Moreover, many antimicrobial agents may exhibit their effects through the inhibition and disruption of many cellular processes, such as nucleic acid, protein and membrane phospholipid biosynthesis.²⁹ The antimicrobial agent(s) in the extracts may inhibit microbes one way or another via some of the above mechanisms. Various chemical constituents previously reported to be isolated from *G. gynandra*, including alkaloids, phenolics, tannins, saponins and their glycosides, probably confer antimicrobial activity to the plants.³⁰

The present study revealed the presence of phytochemicals in the leaf and stem extracts that possess antibacterial properties (Table 2). A study carried out by Khuntia et al. (2022) involved preliminary phytochemical screening

of the leaves and stems of *Gynandropsis gynandra*, which revealed the presence of alkaloids, anthraquinones, cardiac glycosides, flavonoids, resins, saponins, steroids, and tannins.³¹ The phytochemical constituents identified by Kebede et al. (2021) were alkaloids, flavonoids, saponins, phenolics, tannins, terpenoids, and cardiac glycosides.³² Another study carried out in Ethiopia revealed that the phytochemical classes of compounds present were flavonoids, alkaloids, phenols, glycosides, and steroids.³³ Modilal et al. (2015), reported that the plant extract presented remarkable activity against the test organisms *P. aeruginosa* ATCC2785 and *S. aureus* ATCC43300, with zones of inhibition that are slightly greater than the results obtained in this work because of differences in the concentrations of the plant extracts used.³⁴ The similar findings revealed that the plant extracts from *G. gynandra* were active against the tested gram-positive and gram-negative bacteria, and these results suggested their use in traditional medicine. The extracts obtained were cooled, and the pH was measured using a pH meter to evaluate the effects of solvents on microorganisms as the acidic pH may increase the activity of the plant extracts.³⁵

The phytochemical screening in this study confirmed the presence of phenolics, glycosides, saponins, and tannins, compounds widely reported to exert antimicrobial activity through mechanisms such as disruption of microbial cell membranes, inhibition of enzymes, and interference with nutrient uptake. Previous metabolomic studies have also shown that *G. gynandra* contains diverse bioactive compounds, including flavonoids and phenolic derivatives, which vary depending on geographical origin and contribute to its medicinal properties.²² The antibacterial activity observed in this study is consistent with earlier reports on *G. gynandra*. For instance, a study by Sridhar et al. (2014) demonstrated that methanolic extracts of *G. gynandra* showed strong antibacterial activity, particularly against *Staphylococcus aureus*, with inhibition zones reaching approximately 22 mm.³⁶ Similarly, research conducted by Habinshuti et al. (2018), on indigenous vegetables, including *G. gynandra*, reported antimicrobial activity against pathogens such as *S. aureus* and *P. aeruginosa*, although the degree of inhibition varied depending on extraction methods and concentrations.³⁷ The relatively lower activity observed against *P. aeruginosa* in some studies is attributed to its intrinsic resistance mechanisms, including efflux pumps and low membrane permeability.³⁸ However, in the present study, *P. aeruginosa* showed notable susceptibility, especially to methanol extracts, indicating the presence of potent bioactive compounds capable of overcoming these barriers.³⁶⁻³⁸

Ethnobotanical studies further support the antimicrobial potential of *G. gynandra*, as the plant is widely used in African traditional medicine for treating infections, wounds, and inflammatory conditions. The agreement between traditional use and laboratory findings strengthens the credibility of *G. gynandra* as a medicinal plant with real therapeutic value.³⁹ *Staphylococcus aureus* is a major cause of skin, wound, and systemic infections, including drug-resistant strains such as MRSA. In this study, *S. aureus* showed moderate susceptibility to both leaf and stem extracts, particularly methanol extracts. This aligns with previous findings where *G. gynandra* demonstrated

strong activity against *S. aureus*.⁴⁰ The susceptibility of *S. aureus* may be due to its Gram-positive cell wall structure, which is more permeable to plant-derived compounds.⁴¹ Similar studies reported antimicrobial activity of *Gynandropsis gynandra* (syn. *Cleome gynandra*) extracts against Enterobacteriaceae like *Klebsiella* species and other urinary/nosocomial pathogens, aligning with moderate susceptibility to non-polar and polar solvents. Fewer studies directly test *Haemophilus influenzae*, but plant extracts show promise against respiratory pathogens, supporting traditional uses.⁴² Aqueous leaf extracts of *C. gynandra* inhibited *Klebsiella pneumoniae* (12 mm zone), *Staphylococcus aureus* (14 mm), and *Pseudomonas aeruginosa* (20 mm), with Gram-positives more susceptible overall; petroleum ether/methanol extracts were effective in related solvent studies.⁴³

The antibacterial activity observed in this study is comparable with findings from previous studies on *Gynandropsis gynandra*. In the present study, methanol leaf extract (MLE) showed notable activity against *Pseudomonas aeruginosa* and *Staphylococcus aureus*, while petroleum ether leaf extract (PELE) demonstrated strong activity against *Klebsiella oxytoca*. Similarly, distilled water leaf extract (DWLE) showed activity against *S. aureus*, whereas methanol stem extract (MSE) exhibited broad-spectrum activity, particularly against *Streptococcus pneumoniae* and *K. oxytoca*. These findings are in agreement with previous reports indicating that *G. gynandra* extracts possess moderate to strong antibacterial activity depending on the solvent used.⁴⁴ However, some variations were observed; for instance, the absence of activity against *S. pneumoniae* in certain extracts in this study contrasts with the moderate inhibition reported for stem extracts, suggesting that antibacterial efficacy may depend on plant part, extraction solvent, and concentration. Furthermore, the strong susceptibility of *P. aeruginosa* and *K. oxytoca* in this study is particularly noteworthy, as these organisms are often resistant to conventional antibiotics. This supports previous findings that plant-derived compounds from *G. gynandra* may possess mechanisms capable of overcoming bacterial resistance.⁴⁴⁻⁴⁵ Overall, the comparative results reinforce the potential of *G. gynandra* as a source of broad-spectrum antimicrobial agents, although variability across extracts highlights the need for standardisation and further investigation.

Strengths and Limitations

While the study demonstrates the antibacterial potential of *Gynandropsis gynandra* through controlled in vitro assays, providing baseline data to support its consideration as a source of plant-derived antimicrobial agents, it has several limitations. The experiments were conducted solely in vitro, and the findings may not directly reflect in vivo efficacy due to the influence of physiological factors such as metabolism and host responses. In addition, only leaf and stem extracts were examined, while other plant parts, including roots and seeds, were not investigated and may contain additional bioactive constituents. Moreover, key factors needed for therapeutic application, such as extract standardisation, bioavailability, toxicity, and overall safety, were not evaluated. These aspects are essential for understanding the clinical relevance of the findings. Future research should therefore prioritise

isolating and characterising the active compounds, assessing their toxicity and pharmacokinetic properties, and confirming their effectiveness through in vivo and clinical studies.

CONCLUSION AND RECOMMENDATION

This study demonstrates that leaf and stem extracts of *Gynandropsis gynandra* contain phytochemical constituents with notable antimicrobial activity. These findings support the potential of this plant as a source of bioactive compounds that may contribute to the development of novel antimicrobial agents. Given the growing challenge of antimicrobial resistance, plant-based compounds such as those identified in this study warrant further investigation. It is recommended that future research focus on the isolation and characterisation of the active compounds, evaluation of their mechanisms of action, and assessment of their safety and efficacy through in vivo studies.

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