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Antibacterial and Phytochemical Properties of Selected Ethnomedicinal Plants Used by the Mising Tribe Inhabiting Forest Fringe Villages of Nameri National Park, Assam, India

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Abstract

Background: In recent years, an increase in antimicrobial-resistant bacteria has resulted in a global health catastrophe. Plants are being explored for new drug discovery, particularly from ethnomedicinal plants used by indigenous communities. **Aim:** This study aimed to investigate the phytochemical composition and antibacterial properties of five ethnomedicinal plants (*Ficus auriculata*, *Ficus hispida*, *Amphineuron opulentum*, *Sarcochlamys pulcherrima*, and *Tetrastigma anguistifolia*) used by the Mising tribe of Assam, India. **Methods:** The ethnomedicinal plant species were subjected to qualitative and quantitative phytochemical analyses using various solvent extracts (methanol, acetone, ethyl acetate, and n-hexane). Antibacterial activity was tested against bacterial pathogens (*Bacillus anthracis* (MCC4453), *Citrobacter freundii* (MCC2409), *Pseudomonas aeruginosa* (MCC2080), *Escherichia coli* (MCC2412), *Klebsiella pneumoniae* (MCC2451), *Staphylococcus aureus* (MCC2408), *Salmonella enterica* (MCC4378), and *Shigella flexneri* (MCC4378) using the agar well diffusion method. The extract showing the highest antibacterial activity was further characterised by gas chromatography–mass spectrometry (GC–MS). **Results:** Qualitative phytochemical screening showed that phenolic chemicals were widely distributed throughout solvent extracts, whereas flavonoids, tannins, saponins, and alkaloids showed patterns specific to species and solvents. Quantitative analyses revealed that *S. pulcherrima* possessed the highest total phenolic (2.55 µg/mg) and flavonoid (2.26 mg/g) contents. Antibacterial tests demonstrated that the ethyl acetate extract of *S. pulcherrima* leaves exhibited the remarkable zones of inhibition against *C. freundii*, *S. aureus*, and *S. flexneri*. GC-MS analysis of this extract revealed the presence of twelve metabolites belonging to diverse chemical groups, which likely contribute to the antimicrobial activity. **Conclusion:** The findings highlight the significant therapeutic potential of ethnomedicinal plants used by the Mising tribe and identify *S. pulcherrima* as a promising candidate for the development of novel antimicrobial agents.

Major Findings: *Sarcochlamys pulcherrima* showed the most promising antimicrobial activity among the studied plants. Further, GC-MS analysis of the plant extract showed the presence of twelve bioactive metabolites.

Keywords: Antimicrobial Activity, Ethnomedicinal Plants, GC-MS Analysis, Mising Tribe, Phytochemicals

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1. Introduction

Over the last few decades, growing concern over antimicrobial-resistant pathogenic microbes has escalated into a global health crisis. To address this emergency, researchers have been compelled to search for more effective strategies in new drug discovery. Ethnomedicinal plants used by indigenous

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communities are widely recognised as rich sources of novel therapeutic compounds, and many antimicrobial agents currently in use have originated from such plants. Consequently, current research priorities have shifted toward studying and exploring ethnomedicinal plants as potential alternatives for combating infectious agents that have developed resistance to conventional antibiotics.

Assam, a state in Northeast India, is rich in diverse plant resources. The region is inhabited by various ethnic communities that have traditionally used these plants for food and medicine since time immemorial. Among the numerous tribes of Assam, the Mising constitute the second-largest tribal group. They predominantly reside in riparian areas along the Brahmaputra River and in forest-fringe regions, where they practice settled agriculture, an occupation that makes them especially vulnerable to frequent flooding[1]. Their traditional livelihood is closely intertwined with forest resources, reflecting their reliance on agriculture, strong work ethic, and peaceful social fabric. As a fringe tribal community, the Misings depend on forests for essential needs such as medicine, food, beverages, construction materials, and tools for fishing and farming. They possess a rich tradition of using plant resources to treat various ailments, and this knowledge is passed down through generations. Although several researchers[2-4] have documented the ethnomedicinal plants used by the Mising, there remains limited information regarding the phytochemical constituents and biological activities of these species.

In this study, five ethnomedicinal plants used by the Mising tribe inhabiting forest fringe villages of Nameri National Park**,** Assam, were investigated for their antibacterial and phytochemical properties. The selected plants were *Ficus auriculata* Lour., *Ficus hispida* L.f., *Amphineuron opulentum* (Kaulf.) Holttum (syn. *Thelypteris parasitica*), *Sarcochlamys pulcherrima* (Roxb.) Gaudich, and *Tetrastigma anguistifolia* (Roxb.) Planch. These plants were selected based on the use value and higher frequency of citation by informants against their respective disease treatment during the field survey in the study site (data not shown). The leaves and fruits of *F. auriculata*, *F. hispida*, and *S. pulcherrima* are traditionally used for the treatment of diarrhoea and dysentery by the Mising tribe of the study area. The leaves of *A. opulentum* are used as a fermented beverage additive and in skin disease treatment, whereas *T. anguistifolia* is used in the management of analgesic and anxiolytic conditions.

Taking into account the aforementioned facts, the present study was designed to conduct qualitative phytochemical screening of the five selected plants, followed by antibacterial evaluation of the solvent extracts against some clinically significant pathogens. Furthermore, the plant exhibiting the most promising antibacterial activity was characterised by GC–MS analysis.

2. Materials and Methods

2.1 Collection and Identification of Plants

Fresh and disease-free parts of the selected plants were collected from the Mising fringe villages of Nameri National Park, Assam, India, in a zipped bag and brought into the laboratory. The plant specimens were identified and authenticated with the help of taxonomists of the Department of Botany, Gauhati University, and by comparing with the deposited voucher specimens at GUBH (Gauhati University Botanical Herbarium) and the BSI (Botanical Society of India), Shillong. A voucher specimen of each plant species was submitted to the Department of Botany, Gauhati University, Guwahati. Assam, India.

2.2 Preparation of Plant Extracts

The crude metabolites of the selected plants were extracted by the Soxhlet method, as described by Yadav and Agarwala[5]. The collected leaves were washed gently to remove dirt particles and allowed to air dry. Thereafter, the dried samples were ground with a grinder, which resulted in a powder, and were stored in an airtight container at 15°C for further study. Approximately 20 g of powdered samples, evenly packed into a thimble, was extracted with 250 mL of various solvents (methanol, acetone, ethyl acetate, and n-hexane) individually. Extraction was continued until the solvent in the siphon tube of the extractor became colourless. The resulting extract was then transferred to a beaker and heated on a hot plate at a temperature of 35°C until all the solvent had evaporated. The dried extracts were stored in a refrigerator at 4°C for further experimentation.

2.3 Phytochemical Screening

Qualitative phytochemical analysis was carried out as per the methods described by Yadav and Agarwala[5].

2.4 Quantitative Phytochemical Analysis

Quantitative phytochemical analysis was carried out by following the methods of Aiyegoro and Okoh[6]. For total phenolic content estimation (Folin-Ciocalteu reagent method with modifications), 1 mL methanolic extract was mixed with 2.5 mL Folin-Ciocalteu (1N) and 2 mL of 2% Na_2CO_3, incubated for 15 min at room temperature, and measured at 765 nm; content was expressed as mg gallic acid equivalent per gram using a gallic acid standard curve. Total flavonoid content (aluminium chloride colourimetric method) involved mixing 1 mL extract with 3 mL methanol, 0.2 mL 10% $AlCl_3$, 0.2 mL 1M potassium acetate, and 5.6 mL water, standing for 30 min at room temperature, measuring absorbance at 420 nm, and expressing results as mg quercetin equivalent per gram extract.

2.5 Antibacterial Activity Test

For the determination of the antibacterial property of the selected ethnomedicinal plants against test pathogens, Mueller-Hinton agar was used as the culture medium. Plates were prepared and inoculated with the relevant bacterial test pathogens, approximately 1×10^8 CFU/mL (equivalent to 0.5 McFarland standard). Wells (agar cups) were cut into the agar, after which 100 µL/well of plant extracts were introduced into each well[7]. The plates were then incubated at 37 °C for 24 h. Following incubation, zones of inhibition were measured to assess antimicrobial activity and were compared against both control and standard antibiotics. The panel of test bacteria included *Bacillus anthracis* (MCC4453), *Citrobacter freundii* (MCC2409), *Pseudomonas aeruginosa* (MCC2080), *Escherichia coli* (MCC2412), *Klebsiella pneumoniae* (MCC2451), *Staphylococcus aureus* (MCC2408), *Salmonella enterica* (MCC4378), and *Shigella flexneri* (MCC4378). As positive controls, chloramphenicol (30 mcg) was used for *C. freundii*, *P. aeruginosa*, *S. enterica*, and *S. flexneri*, whereas kanamycin (30 mcg) was used for *B. anthracis*, *E. coli*, and *K. pneumoniae*; and vancomycin (30 mcg) for *S. aureus*.

2.6 GC-MS Analysis

The GC-MS analysis was conducted at the National Institute of Pharmaceutical Education and Research (NIPER), Guwahati, India, according to the method of Petrova *et al*[8]. Helium served as the carrier gas. The GC oven was programmed as follows: initial temperature at 60°C for 1 min, then ramped at 7°C/min to 200°C and held for 3 min, followed by a ramp at 10°C/min to 300°C and a 5 min hold at 300°C. Injector temperature was set to 280°C, with an injection volume of 1 µL, a split ratio of 10:1, solvent delay of 7 min, transfer line at 160°C, and source temperature at 150°C. The mass spectrometer was scanned from 50 to 600 Da with a column of 60.0 m × 250 µm dimensions. After analysis, the chromatogram peaks were compared using the NIST library for compound identification.

3. Results

3.1 Qualitative Phytochemical Screening

The screening of phytochemicals revealed that phenolic compounds were consistently detected in all plant extracts except those obtained using n-hexane as the solvent, highlighting the widespread prevalence of phenolics among the species and solvent systems tested (Table 1). The presence of tannin was detected in ethyl acetate extract of *F. hispida, S. pulcherrima*; methanol extract of *A. opulentum*, *F. auriculata*, *S. pulcherrima*, *T. anguistifolia*; and n-hexane extract of both *F. auriculata* and *T. opulent*, demonstrating both species and solvent-dependent variability in tannin content. Meanwhile, saponins and alkaloids were generally absent across the majority of extracts, with saponins detected only in limited methanol and acetone samples and alkaloids primarily absent, indicating selectivity in their solubility and distribution. Flavonoids were extractable exclusively from *A. opulentum* using acetone and methanol, underscoring the significant influence of both the plant species and solvent on the phytochemical profile. Overall, this screening confirms the dominance of phenolic compounds and reveals considerable diversity in the secondary metabolite content, depending on both the botanical and methodological context.

3.2 Quantitative Phytochemical Analysis

Sarcochlamys pulcherrima exhibited the highest phenolic content (2.55 µg/mg), followed by *F. auriculata*

(1.97 µg/mg), *A. opulentum* (1.62 µg/mg), and *T. anguistifolia* (1.53 µg/mg) (Figure 1A). Total flavonoid content showed a similar pattern, with *S. pulcherrima* again highest (2.26 mg/g), followed by *F. auriculata* (1.5 mg/g), *F. hispida* (1 mg/g), *A. opulentum* (1.12 mg/g), and *T. anguistifolia* (0.57 mg/g) (Figure 1B).

FA-EtAc: Ethyl acetate extract of *F. auriculata*; AO-EtAc: Ethyl acetate extract of *A. opulentum* leaves, SP-EtAc: Ethyl acetate extract of *S. pulcherrima*, FA-Hex: n-hexane extract of *F. auriculata* leaves, AO-Hex: n-hexane extract of *A. opulentum* leaves, SP-Hex: n-hexane extract of *S. pulcherrima*. ND: not detected the zone of inhibition. Values are mean (n = 3), error bars indicate standard Deviation (SD).

3.3 Antimicrobial Activity of Plant Extracts

The ethyl acetate extract of *S. pulcherrima* exhibited remarkable antimicrobial activity against a broad spectrum of bacterial pathogens (Table 2), demonstrating the highest levels of inhibition across all tested strains. Notably, it produced significant zones of inhibition against *C. freundii* (22.67 mm), *S. aureus* (20.53 mm), and *S. flexneri* (21.68 mm), indicating potent bacteriostatic or bactericidal effects (Figure 2). Comparatively, the ethyl acetate extracts generally showed stronger antimicrobial properties than the hexane extracts, with *S. pulcherrima*'s ethyl acetate fraction matching or even surpassing standard antibiotics in certain cases. The hexane extracts from different plants exhibited limited or negligible activity, particularly against pathogens such as *K. pneumoniae*, *C. freundii*, *S. flexnari*, and *E. coli*, although moderate inhibition was noted against other strains. Notably, all plant extracts, especially the ethyl acetate extract of *S. pulcherrima*, demonstrated greater inhibition against *C. freundii* than the positive control antibiotics, underscoring their considerable antibacterial potential. However, none of the extracts achieved universal efficacy against all tested pathogens, highlighting the specificity of bacterial susceptibilities and variability in metabolite extraction efficiencies dependent on solvent choice and plant species. These findings justify further exploration of *S. pulcherrima* as a promising source of novel antimicrobial agents.

3.4 GC-MS Analysis

Based on the results of the antimicrobial activity tests, the ethyl acetate extract of *S. pulcherrima* was selected

Table 1. Qualitative phytochemical screening of the selected plants with different solvents

Phyto chemical	Ethyl acetate					Acetone					Methanol					n-Hexane				
	FH	FA	AO	SP	TA	FH	FA	AO	SP	TA	FH	AO	FA	SP	TA	FH	FA	AO	SP	TA
Tannin	+	-	-	+	-	-	-	-	-	-	-	+	+	+	+	-	+	+	-	-
Saponins	-	-	-	-	+	+	-	-	-	+	+	-	-	-	+	+	-	-	-	+
Alkaloids	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-
Flavonoids	-	-	-	-	-	-	-	+	-	-	-	+	-	-	-	-	-	-	-	-
Phenols	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	-	-	-	-	-

FH: *F. hispida*, FA: *F. auriculata*, AO: *A. opulentum*, SP: *S. pulcherrima,* TA: *T. anguistifolia*. + presence, - absence

Table 2. Antimicrobial activity of the different extracts of the selected plants

Plant extract	*P. aeruginosa*	*S. enterica*	*S. aureus*	*K. pneumoniae*	*C. freundii*	*S. flexneri*	*B. anthracis*	*E. coli*
FA-EtAc	11.16 ± 0.15	16.45 ± 0.27	8.85 ± 0.16	12.36 ± 0.56	ND	9.22 ± 0.07	7.63 ± 0.13	9.82 ± 0.08
AO-EtAc	14.00 ± 0.30	22.1 ± 0.71	9.91 ± 0.22	12.37 ± 0.07	ND	9.35 ± 0.21	10.37 ± 0.04	10.93 ± 0.15
SP-EtAc	18.99 ± 0.17	19.27 ± 0.41	20.53 ± 0.13	22.12 ± 0.04	22.67 ± 0.00	21.68 ± 0.12	18.48 ± 0.02	10.37 ± 0.09
FA-Hex	9.37 ± 0.04	18.71 ± 0.31	7.1 ± 0.10	ND	ND	ND	7.48 ± 0.13	ND
AO-Hex	9.03 ± 0.06	18.63 ± 0.06	8.62 ± 0.18	ND	7.98 ± 0.11	ND	9.14 ± 0.31	ND
SP-Hex	7.49 ± 0.02	ND	7.52 ± 0.03	ND	6.86 ± 0.08	8.72 ± 0.09	8.15 ± 0.10	ND
Control (+ve)	12.36 ± 0.44	10.56 ± 0.16	17.74 ± 0.11	19.33 ± 0.43	34.72 ± 0.27	21.11 ± 0.15	17.85± 0.10	13.61 ± 0.10
Control (-ve)	ND	ND	ND	ND	ND	ND	ND	ND

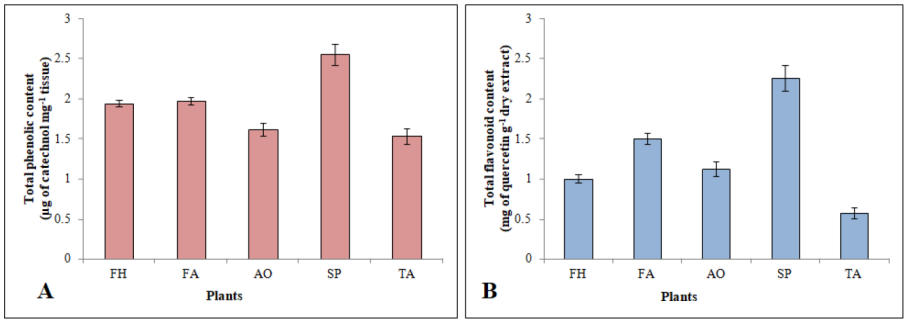


Figure 1. Total phenolic content (A) and flavonoid content (B) of the different selected plants. FH: *F. hispida*, FA: *F. auriculata*, AO: *A. opulentum*, SP: *S. pulcherrima,* TA: *T. anguistifolia*. Values are mean (n = 3), error bars indicate Standard Deviation (SD).

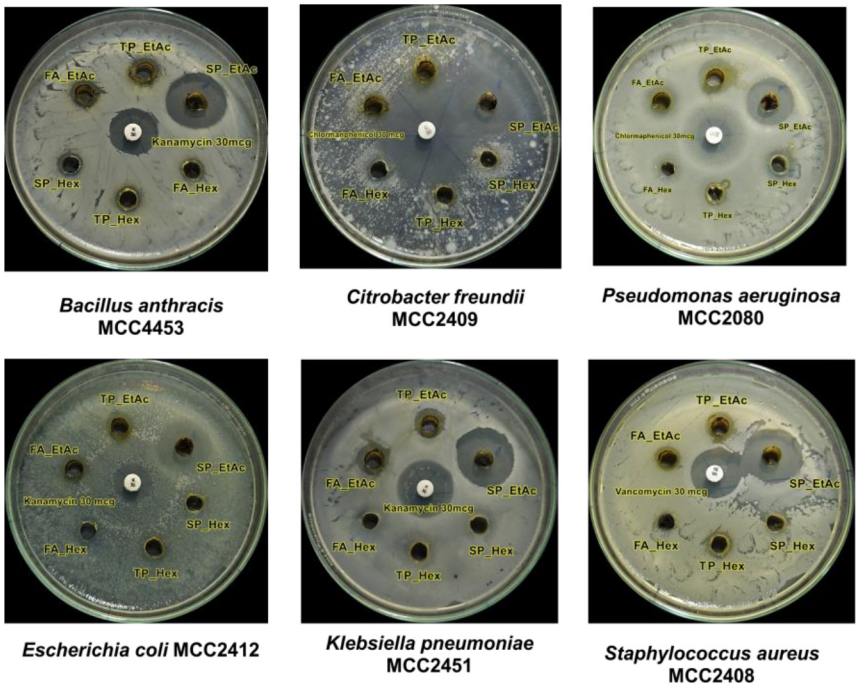


Figure 2. Inhibition zones of different extracts against test pathogens on Mueller-Hinton agar plates during the antimicrobial activity assay.

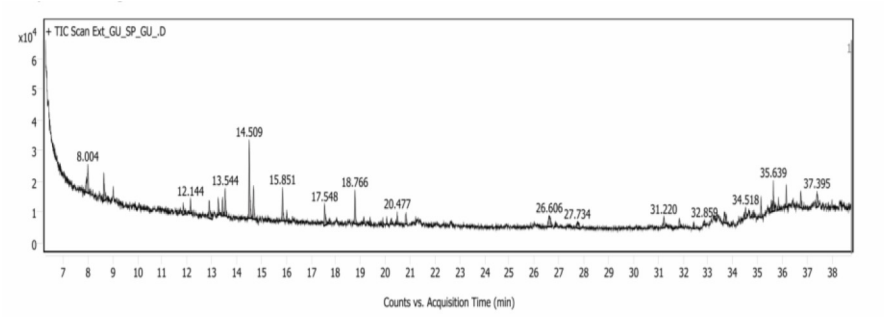


Figure 3. GC-MS chromatogram for ethyl acetate extract of *Sarcochlamys pulcherrima* leaves.

Table 3. GC-MS spectral analysis of ethyl acetate extract of *Sarcochlamys pulcherrima* leaves

Metabolite	Formula	Retention time (RT)	Molecular Weight (g/mol)
Hydroxylamine, O-2-methylpropyl (**1**)	$C_4H_{11}NO$	11.233	89.14
Pentane, 2,2,3,4- tetramethyl (**2**)	C_9H_{20}	11.717	128.26
Hexane, 2,3,4-trimethyl (**3**)	C_9H_{20}	12.067	128.26
1,3-Propanediol (**4**)	$C_3H_8O_2$	13.417	76.09
2-Pentanone, 4- hydroxy-4-methyl (**5**)	$C_6H_{12}O_2$	14.083	116.16
2,2,6,6- Tetramethylheptane (**6**)	$C_{11}H_{24}$	14.450	156.31
3,4-Hexanediol, 2,5-Dimethyl (**7**)	$C_8H_{18}O_2$	16.883	146.23
3,4-Hexanedione, 2,2,5-trimethyl (**8**)	$C_9H_{16}O_2$	17.317	156.22
Undecane, 4,7-dimethyl (**9**)	$C_{13}H_{28}$	19.750	184.37
Hexane, 3,3-dimethyl (**10**)	C_8H_{18}	22.167	114.23
Oxalic acid, allyl nonyl ester (**11**)	$C_{14}H_{24}O_4$	28.967	341.5
Heneicosane, 3-methyl (**12**)	$C_{22}H_{46}$	20.950	310.60

Note: The bold numbers (in parentheses) are assigned to the respective compounds for easy cross-reference with the corresponding description in the text.

for the GC-MS analysis. The major bioactive compounds present in the ethyl acetate extract of *S.pulcherrima* leaves were identified by GC-MS analysis (Figure 3). A total of 12 metabolites belonging to different chemical groups, such as alcohols, ketones, hydrocarbons, siloxanes, fatty acid esters, and long-chain alkanes, were identified from the leaf extract, with their Retention Time (RT), Molecular Formula (MF), and Molecular Weight (MW), as presented in Table 3. The alcohol compounds, such as hydroxylamine O-(2-methylpropyl) (**1**) and 1,3-propanediol (**2**), were detected. Three ketones, i.e., methyl-substituted hexanediones and pentanone derivatives, such as 4-hydroxy-4-methyl-2-pentanone (**3**), 3,4-hexanedione, 2,5-dimethyl (**4**), 3,4-hexanedione, 2,2,5-trimethyl (**5**), were detected. The detected hydrocarbons included pentane, 2,2,3,4-tetramethyl (**6**), hexane, 2,3,4-trimethyl (**7**), undecane, 4,7-dimethyl (8), hexane, 3,3-dimethyl (**9**), and heneicosane, 3-methyl (**10**), while long-chain alkanes included 2,2,6,6-tetramethylheptane (**11**), and fatty acid ester included oxalic acid, allyl nonyl ester (**12**).

4. Discussion

Plants continue to play a major role in fundamental healthcare, despite advances in conventional contemporary medicine. Plants are a storehouse of a wide range of structurally and functionally diverse bioactive chemicals[9]. Therefore, plants are being investigated for the discovery of new compounds with various biological activities, including antimicrobial properties. The plants are being used in traditional medicinal practices by different tribes globally in the treatment of various diseases, including stomach disorders, respiratory disorders, skin diseases, and many others. In this context, the present study was carried out to evaluate the antibacterial activities and phytochemical properties of different medicinal plants used by the Mising tribe from Assam, India.

In the present study, the qualitative phytochemical screening highlighted the impact of solvent polarity on phytochemical recovery, which showed significant diversity in metabolite composition among the various plant species and solvent extracts. The most varied metabolites were found in methanol and ethyl acetate extracts, which consistently detected phenols and flavonoids in the majority of species. Phenolic compounds were the most prevalent chemical group, demonstrating their significant affinity for polar solvents, except for extracts made in non-polar n-hexane. Only a few methanol and ethyl acetate extracts revealed saponins and tannins, which is indicative of their moderate polarity and restricted distribution among the plant species under investigation[10,11]. The occasional appearance of alkaloids suggests that either their abundance is limited or more specialised extraction conditions are needed for effective recovery[12]. Overall,

the phytochemical profile shows that the species under study have significant amounts of bioactive secondary metabolites, especially flavonoids and phenolics, which may work in concert to enhance their therapeutic potential.

The variation in the total phenolic and flavonoid contents of the studied species indicates various metabolic capacities that could be the basis for their varied biological activities. *S. pulcherrima*, which showed the highest concentrations of flavonoids and phenolics, seems to have a very active secondary metabolite biosynthesis mechanism, indicating a considerable potential for antioxidant, antimicrobial, or other bioactive qualities frequently associated with these compound families[13]. The moderate amount found in *F. auriculata*, *F. hispida*, and *A. opulentum* suggests intermediate metabolic investment in these metabolites, which may display adaptive responses to their ecological niches or evolutionary histories[14-16]. On the other hand, low phenolic and flavonoid levels in *T. anguistifolia* indicate limited accumulation of these chemicals, maybe as a result of species-specific regulatory restrictions or variations in environmental stressors[17]. Overall, the different metabolite profiles found in different species highlight the significance of phytochemical variety and lend credence to the idea that differences in polyphenol and flavonoid concentrations can have a substantial impact on the medicinal plants' functional and therapeutic potential.

Plants remain one of the main sources of therapeutic compounds in order to minimise the spread and recurrence of infectious diseases, including antimicrobials against pathogenic microorganisms. The use of ethnomedicinal plants to reduce the dissemination of infectious disease can be the most innovative, non-toxic, and eco-friendly antimicrobial strategy[18]. Our results demonstrated that *S. pulcherrima* exhibited remarkable antimicrobial activity against the tested bacterial pathogens as compared to other plants. The tested pathogens are crucial in human health, the food industry, and animal husbandry as they are linked with clinical infections, food spoilage, and food-borne diseases[19]. However, ethyl acetate extracts were found to be more effective than other extracts, with *S. pulcherrima*'s ethyl acetate fraction matching or even surpassing standard antibiotics in certain cases. Meanwhile, none of the extracts achieved universal efficacy against all tested pathogens, highlighting the specificity of bacterial susceptibilities and variability in metabolite extraction efficiencies dependent on solvent choice and plant species[20]. Thus, these findings justify further exploration of *S. pulcherrima* as a promising source of novel antimicrobial agents. Moreover, antimicrobial activity was assessed using the agar well diffusion method, which offers qualitative and semi-quantitative data on microbial growth inhibition. Therefore, future investigation should consider the determination of Minimum Inhibitory Concentration (MIC) of the extract to achieve more precise and quantitative results.

GC-MS analysis is one of the commonly used techniques to identify bioactive compounds that can be attributed to a particular biological activity. In the present investigation, a total of 12 compounds were identified from the ethyl acetate extracts of *S. pulcherrima* leaves. Several previous studies have reported that these compounds possess various biological activities, including antimicrobial activity. In this study, compounds **1** and **2** are reported to exhibit antimicrobial effects by disrupting microbial metabolism and cellular integrity[21,22]. The presence of ketones (**4** and **5**) in the extract is consistent with earlier reports showing antibacterial effectiveness[23,24]. They are well recognised for antimicrobial and antifungal effectiveness due to their ability to cross microbial cell membranes and disrupt enzymatic activities. Hydrocarbons (**6-10**), especially long-chain alkanes (**11**), have been reported to possess moderate antimicrobial activity through membrane-disrupting mechanisms[25-27]. Although hydrocarbons often exhibit moderate activity, literature surveys suggest that this molecule has antibacterial qualities[28], which may contribute to the ultimate biological activity of the extract. Furthermore, oxalic acid (**12**), also known as allyl nonyl ester, was found to be a fatty acid ester with potent antibacterial activity that targets membranes[29]. By strengthening the hydrophobic contacts with microbial cell walls, these esters increase the effectiveness of antibiotics. Altogether, this diversity of bioactive metabolites highlights *S. pulcherrima* as a promising source for antimicrobial agents, warranting further investigation for potential therapeutic applications.

5. Conclusion

The present study highlights the significant phytochemical richness and antibacterial potential of ethnomedicinal plants traditionally used by the Mising tribe of Assam. Among the five species investigated, *Sarcochlamys pulcherrima* demonstrated the most promising bioactivity, exhibiting the highest phenolic and flavonoid contents along with broad-spectrum antibacterial effects. GC–MS analysis further revealed a diverse array of bioactive metabolites known for their antimicrobial properties. These findings underscore the value of ethnobotanical knowledge in guiding modern drug discovery and validate the traditional healing practices of the Mising community. In particular, *S. pulcherrima* emerges as a strong candidate for further pharmacological evaluation, bioactive compound isolation, and potential development into novel antimicrobial agents. However, future research should standardise quantitative tests to determine the MIC in order to confirm and enhance the antibacterial effectiveness of the active extracts found in this study. Further, continued research on native medicinal plants from biodiversity-rich regions such as Assam may contribute significantly to addressing the escalating global challenge of antibiotic resistance.

6. References

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Author Contribution

S.N.D.: Formal analysis of the study, initial drafting of the manuscript; R.D.: data validation, preparation of the figures, and tables; K.T. and M.B.: Supervision, reviewed, and revised the manuscript. All authors have read and agreed to the published version of the manuscript.