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Comprehensive Chemical Profiling and Pharmacological Evaluation of Two Selected Medicinal Plants Leaves (*Persea americana*, *Curcuma longa*) Using GC-MS Techniques

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ABSTRACT

Background: *Medicinal plants are important sources of therapeutic agents due to their diverse phytochemicals. While avocado (Persea americana) and turmeric (Curcuma longa) are widely studied for their fruits and rhizomes, their leaves remain underexplored. This study employed gas chromatography–mass spectrometry (GC–MS) to profile bioactive compounds in their ethanolic leaf extracts and evaluate their pharmacological relevance.*

Methods: *Fresh leaves of P. americana and C. longa were collected, authenticated, extracted with 99% ethanol, and subjected to GC–MS analysis. Compounds were identified using the NIST library and grouped by pharmacological class.*

Results: *Thirteen compounds were detected in each plant. In avocado leaves, the dominant constituents were benzenemethanamine (28.41%), benzenamine (24.33%), and benzaldehyde (19.76%), while turmeric leaves were rich in benzenemethanamine (40.74%) and benzenamine (21.52%). The identified compounds belong to classes associated with antioxidant, antimicrobial, antifungal, anti-inflammatory, and anticancer properties.*

Conclusion: *The presence of pharmacologically active compounds in avocado and turmeric leaves highlights their potential as sources of natural therapeutic agents. However, the detection of benzyl chloride and diphenylamine derivatives underscores the need for confirmatory analyses and safety evaluation. Complementary LC–MS profiling and targeted bioassays are recommended to validate the therapeutic potential and ensure the safety of these extracts. This study provides the first GC–MS profiling of P. americana and C. longa leaves in this region, strengthening the evidence that tropical plants are reservoirs of valuable bioactive compounds*

Keywords: *Persea americana, Curcuma longa, GC-MS Techniques, Chemical Profiling, Pharmacological Evaluation.*

1.0 Background of Study

Medicinal plants have long been a cornerstone of traditional medicine and modern drug discovery. With over 80% of the global population relying on plant-derived medicines for primary healthcare [1, 2], the significance of these natural resources cannot be overstated. Among the wide variety of medicinal plants, the leaves of Avocado (*Persea americana*) and Turmeric (*Curcuma longa*) are particularly notable for their therapeutic potential. These plants have a rich history in ethnomedicine and are widely used to manage diseases such as diabetes, cancer, and inflammatory conditions [3].

The exploration of medicinal plants has significantly influenced drug development. Natural products derived from plants, such as morphine, quinine, and artemisinin, have formed the basis of modern pharmaceuticals [4]. These discoveries highlight the importance of phytochemical studies in identifying novel therapeutic agents. Medicinal plants remain an important source of therapeutic compounds worldwide.

Their ethnomedicinal applications are often linked to bioactive phytochemicals such as flavonoids, alkaloids, phenolics, terpenes, and glycosides, which exhibit diverse biological activities including antioxidant, antimicrobial, anti-inflammatory, and anticancer effects [5, 6, 7].

Avocado (*Persea americana*) is a member of the Lauraceae family and is widely cultivated in tropical and subtropical regions. While its fruit is known for nutritional and medicinal benefits, the leaves have also been reported to contain bioactive compounds such as flavonoids, saponins, and tannins with antihypertensive, antioxidant, and antimicrobial properties [8, 9, 10, 11]. However, chemical profiling of avocado leaves remains limited compared to the extensively studied fruits.

Turmeric (*Curcuma longa*), belonging to the Zingiberaceae family, is traditionally used for culinary and medicinal purposes. Its rhizome has been extensively studied and is known for curcumin and other curcuminoids with potent antioxidant, anti-inflammatory, and anticancer properties [12, 13, 14].

In contrast, the leaves are less explored, though they have been reported to contain essential oils, phenolics, and terpenes with antimicrobial and antioxidant potential [15].

Despite the wide utilization of avocado and turmeric in folk medicine, limited scientific data exist on the comprehensive phytochemical profiling of their leaves, particularly using advanced analytical techniques such as GC-MS. Gas Chromatography-Mass Spectrometry (GC-MS) has emerged as a powerful analytical tool for chemical profiling due to its sensitivity, reliability, and efficiency in identifying volatile and semi-volatile compounds. The use of GC-MS in the phytochemical investigation of plant leaves provides detailed insights into their chemical composition, which is essential for understanding their pharmacological properties. The leaves of these plants have been traditionally used in various medicinal preparations, yet their chemical constituents remain underexplored.

This study, therefore, aimed to conduct a comprehensive phytochemical profiling of *Persea americana* and *Curcuma longa* leaves using GC-MS, in order to identify bioactive compounds with potential pharmacological value.

2.0 Materials and Methods

2.1 Collection of Plant Sample

Fresh leaves of Avocado (*Persea Americana*), Tumeric (*Curcuma longa*)were collected in different locations within Akwa Ibom State, Nigeria. The date of Collection was between 20 - 24th October, 2024. The plant samples were transported to Akwa Ibom State University, Obio Akpa Campus, Oruk Anam Local Government Area. The identification and authentication of the plant's material was done at the Herbarium in the Department of Botany, University of Uyo.

2.2 Preparation of Plant Material

After the identification, the leaves were washed and sun-dried. The leaves were shredded and spread on cellophaneand allowed to dry for 72 hours under room temperature. The dried leaves were pulverized (grinded) into fine powder usingawooden pestle and mortar.

2.3 Preparation of Ethanolic Extract (Maceration and Extraction) of Plant Samples

Cold extraction method (Maceration) was used in this research according to [16]. In the extraction procedure, 1000ml of 99% concentrated ethanol was used to macerate 240g of the plant materials in an airtight container and kept in the laboratory under room temperature for 72 hours (3 days). In the due date of filtration, the mixtures were filtered with a Muslin cloth to acquire the filtrates. The filtrates were further extracted using funnels, Watman filter paper,aconical flask and vacuum pump. The extracts were stored in 250ml conical flasks. The conical flask was well labelled, the mouth of the conical flask was covered with foil paper, and masking tape rapped around the mouth to ensure that it is tightly covered.

2.4 Extract Concentration

200ml of the extracted samples were transferred into 250ml beakers and was then concentrated using a water bath at a temperature of 80 °C to disintegrate the filtrate to obtain the crude extract of the plant extracts.

2.5 GC-MS Analysis of the Plant Extract

GC-MS analysis was carried out on GCMS-QP2010 PLUS SHIMADZU. The column used was Perkin Elmer Elite - 5 capillary column measuring 30m × 0.25mm with a film thickness of 0.25mm composed of 95% Dimethyl polysiloxane. The carrier gas used was Helium at a flow rate of 0.5ml / min. 1µl sample injection volume was utilized. The inlet temperature was maintained as 250 °C. The oven temperature was programmed initially at 80 °C for 4 min, thenincreased to 200 °C. And then programmed to increase to 280 °C at a rate of 20 °C ending with a 5 min. Total run time was 25 min. The MS transfer line was maintained at a temperature of 200°C. The source temperature was maintained at 180°C. GC-MS was analyzed using electron impact ionization at 70 eV and data was evaluated using total ion count (TIC) for compound identification and quantification. The spectrums of the components were compared with the database of spectrum of known components stored in the GC-MS library [17, 18, 19, 20].

3.0 Results

3.1 Bioactive compounds Identified in *Persea americana* Leaves Extract by GC-MS

A total of thirteen (13) peaks were identified from the GC-MS analysis of theethanolic fraction of *Persea americana* leaves extract, indicating the presence of 13 bioactive compounds. The chromatogram is presented in Fig.1, while the bioactive compounds with their retention time (RT), peak areas (%), peak height (%), molecular weight (MW) and molecular formula (MF) are presented in Table 1. The compounds were Benzenemethanamine (28.41) followed by Benzenamine, N, N-diphenyl- (24.33), Benzaldehyde (19.76), N-Benzyl-N-(3-phenylprop-2-en-1-yl)-tosylamide (5.62), N-Benzylformamide (4.88), Pyrazole-5-carbonitrile (3.52), 10-Undecena (3.35), Benzyl chloride (2.93), n-Hexadecanoic acid (2.23), Benzamide (1.51), N-Benzylbenzamide (1.42), Cinnamaldehyde (1.22) and 1-Pyrrolidinecarboxylic acid (0.84).Medicinal Properties and Therapeuticuses of phytocomponents identified in the ethanolic extract of *P. americana* is presented in Table 2.

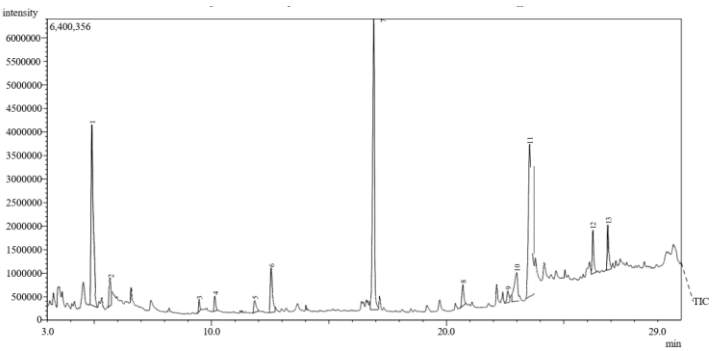

Figure 1: GC-MS analysis of Persea americana leaves extract of Ethanolic Extract: the GC-MS chromatogram showed thirteen peaks, indicating the presence of thirteen compounds

Table1: Bioactive compounds Identified in Persea americana Leaves Extract by GC-MS

Peak	Name of Compound	Retention time	% Peak Area	% Peak Height	Molecular Weight	Molecular formular
1.	Benzaldehyde	4.899	19.76	20.39	106	C_7H_6O
2.	Benzyl chloride	5.672	2.93	3.21	126	C_7H_7Cl
3.	1-Pyrrolidinecarboxylic acid	9.468	0.84	1.36	219	$C_{12}H_{13}NO_3$
4.	Cinnamaldehyde	10.137	1.22	1.68	132	C_9H_8O
5.	Benzamide	11.835	1.51	1.34	121	C_7H_7NO
6.	N-Benzylformamide	12.545	4.88	4.98	135	C_8H_9NO
7.	Benzenemethanamine	16.909	28.41	32.85	195	$C_{14}H_{13}N$
8.	n-Hexadecanoic acid	20.699	2.23	2.45	256	$C_{16}H_{32}O_2$
9.	N-Benzylbenzamide	22.617	1.42	1.36	211	$C_{14}H_{13}NO$
10.	N-Benzyl-N-(3-phenylprop-2-en-1-yl)-tosylamide	22.989	5.62	3.23	377	$C_{23}H_{23}NO_2S$
11.	Benzenamine	23.555	24.33	17.14	245	$C_{18}H_{15}N$
12.	Pyrazole-5-carbonitrile	26.242	3.52	4.95	245	$C_{16}H_{11}N_3$
13.	10-Undecena	26.885	3.35	5.04	168	$C_{11}H_{20}O$
Total			**100.0**	**100.0**		

Table 2: Medicinal Properties/Therapeutic Uses of Phytocomponents Identified in the Ethanolic extract of Persea americana

S/N	Name of Compound	Nature of Compound	Medicinal Properties/Therapeutic Uses	References
1.	Benzaldehyde	Aromatic aldehydes	antimicrobial, antioxidant, antifungal, anti-inflammatory, antitumor and insecticidal properties	[21, 22]
2.	Benzyl chloride		Analgesic, antipruritic, antimicrobial, preservative, flavoring agent and solvent	[23]
3.	1-Pyrrolidine carboxylic acid	Amino acid derivative	Antimicrobial, anticancer, antiviral, antidiabetic and anti-inflammatory	[24, 25]
4.	Benzamide	Simple aromatic amide	Anti-inflammatory, analgesic, antimicrobial, anti-cancer, anticonvulsant, antidepressant and cardiovascular activities	[26]
5.	N-Benzylformamide	Formamide and benzene class	Not reported	
6.	Benzenemethanamine	Primary amine	Antibacterial	[27]
7.	n-Hexadecanoic acid	Saturated long-chain fatty acid	Antioxidant, antifungal, antimicrobial, anti-inflammatory and anti-cancer properties	[28, 29]
8.	N-Benzylbenzamide	Benzamide derivative	antimicrobial, anti-cancer, herbicidal properties	[30, 31]
9.	Benzenamine (Aniline)	Aromatic Primary Amine	Antibacterial and antifungal	[32]
10.	N-Benzyl-N-(3-phenylprop-2-en-1-yl)-tosylamide		Not Reported	
11.	Pyrazole-5-carbonitrile	Heterocyclic nitrile	Antibacterial, anticancer, antioxidant, antidepressant, anti-inflammatory, antiviral and analgesic activity.	[33]
12.	10-Undecena	Unsaturated aldehyde	Antimicrobial, antioxidant, antifungal and flavoring.	[34, 35]
13.	Cinnamaldehyde	Unsaturated aldehyde	Antibacterial, antifungal, anticancer, antidiabetic, neuroprotective potentials and anti-inflammatory	[36, 37]

3.2. Bioactive compounds Identified in *Curcuma longa* Leaves Extract by GC-MS

The GC-MS analysis of the ethanolic extract of *Curcuma longa* leaves revealed a total of 13 bioactive compounds, as evidence by a chromatogram displaying 13 distinct peaks (Fig. 2). The analysis provided detailed information on the retention time, percentage peak area, percentage peak height, molecular weight and molecular formular of the identified compounds. The bioactive compounds identified with respect to their percentage (% peak area) include; Benzenemethanamine (40.74), Benzenamine, N, N-diphenyl- (21.52), Benzaldehyde (11.83), Pyrazole-5-carbonitrile, 1,3-diphenyl (5.82), 3-Buten-2-one (3.24), N-Benzylformamide (3.02), 1-Pyrrolidinecarboxylic acid (2.97), Benzenemethanamine, N,N-bis(phenylmethyl)- (2.82), N-Benzylbenzamide (2.13), n-Hexadecanoic acid (1.74), (E)-13-Docosenoic acid (1.69), Benzyl chloride (1.28) and Benzamide (1.21) (Table 3).Major phyto-compounds detected in *C. longa* extract and their medicinal / therapeutic uses have been tabulated in (Table 4).

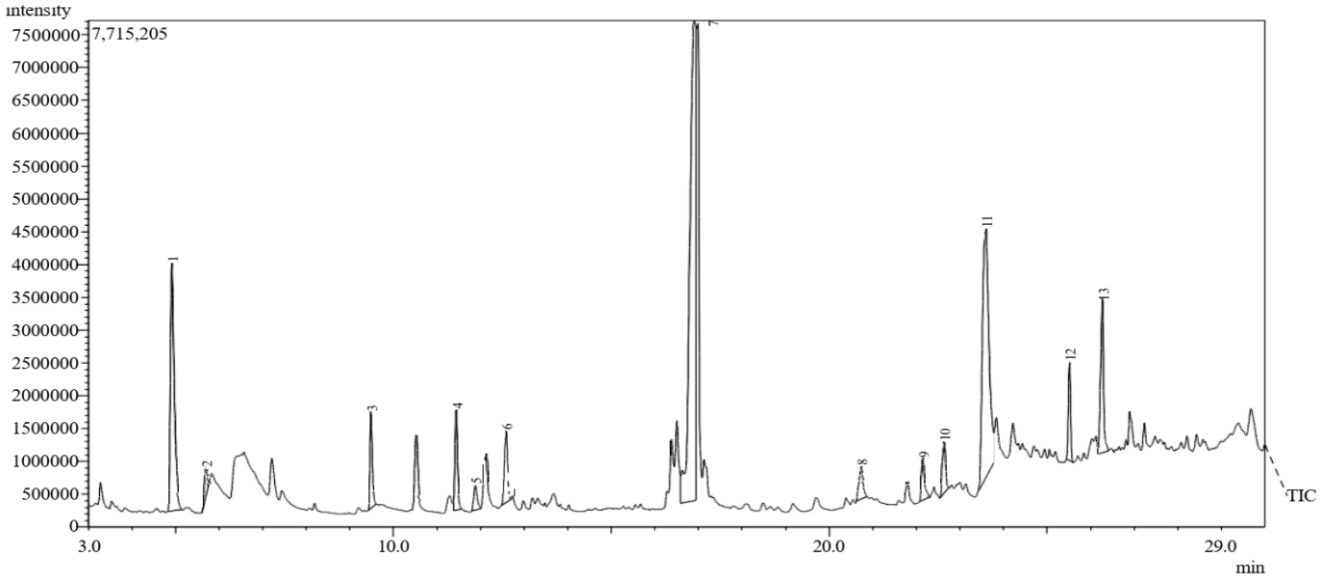

Figure 2: GC-MS analysis of Curcuma longa leaves extract of Ethanolic Extract: the GC-MS chromatogram showed thirteen peaks, indicating the presence of thirteen compounds

Table 3: Bioactive compoundsidentified in Curcuma longa Leaves Extract by GC-MS

Peak	Name of Compound	Retention time	% Peak Area	% Peak Height	Molecular Weight	Molecular formular
1.	Benzaldehyde	4.908	11.83	14.80	106	C_7H_6O
2.	Benzyl chloride	5.687	1.28	1.79	126	C_7H_7Cl
3.	1-Pyrrolidinecarboxylic acid	9.485	2.97	5.74	219	$C_{12}H_{13}NO_3$
4.	3-Buten-2-one	11.438	3.24	5.94	146	$C_{10}H_{10}O$
5.	Benzamide	11.879	1.21	1.48	121	C_7H_7NO
6.	N-Benzylformamide	12.584	3.02	4.24	135	C_8H_9NO
7.	Benzenemethanamine	16.908	40.74	28.73	195	$C_{14}H_{13}N$
8.	n-Hexadecanoic acid	20.733	1.74	1.90	256	$C_{16}H_{32}O_2$
9.	(E)-13-Docosenoic acid	22.150	1.69	2.47	338	$C_{22}H_{42}O_2$
10.	N-Benzylbenzamide	22.643	2.13	3.02	211	$C_{14}H_{13}NO$
11.	Benzenamine	23.604	21.52	14.82	245	$C_{18}H_{15}N$
12.	Benzenemethanamine, N, N-**b**is(phenylmethyl)-	25.515	2.82	5.88	287	$C_{21}H_{21}N$
13.	Pyrazole-5-carbonitrile	26.277	5.82	9.20	245	$C_{16}H_{11}N_3$
Total			**100.0**	**100.0**		

Table 4: Medicinal Properties/Therapeutic Uses of Phytocomponents Identified in the Ethanolic Extractof Curcuma longa

S/N	Name of Compound	Nature of Compound	Medicinal Properties/Therapeutic Uses	References
1.	Benzaldehyde	Aromatic aldehydes	antimicrobial, antioxidant, antifungal, anti-inflammatory, antitumor and insecticidal properties	[21, 22]
2.	Benzyl chloride	Organic compound	Analgesic, antipruritic, antimicrobial, preservative, flavoring agent and solvent	[23]
3.	1-Pyrrolidine carboxylic acid	Amino acid derivative	Antimicrobial, anticancer, antiviral, antidiabetic and anti-inflammatory	[24, 25]
4.	3-Buten-2-one	Methyl vinyl ketone	Not reported	
5.	Benzamide	Simple aromatic amide	Anti-inflammatory, analgesic, antimicrobial, anti-cancer, anticonvulsant, antidepressant and cardiovascular activities	[26]
6.	N-Benzylformamide	Formamide and benzene class	Not reported	
7.	Benzenemethanamine	Primary amine	Antibacterial	[27]
8.	n-Hexadecanoic acid	Saturated long-chain fatty acid	Antioxidant, antifungal, antimicrobial, anti-inflammatory and anti-cancer properties	[28, 29]
9.	N-Benzylbenzamide	Benzamide derivative	antimicrobial, anti-cancer, herbicidal properties	[30, 31]
10.	(E)-13-Docosenoic acid			
11.	Benzenamine (Aniline)	Aromatic Primary Amine	Antibacterial and antifungal	[32]
12.	Pyrazole-5-carbonitrile	Heterocyclic nitrile	Antibacterial, anticancer, antioxidant, antidepressant, anti-inflammatory, antiviral and analgesic activity.	[33]
13.	Benzenemethanamine, N, N-**b**is(phenylmethyl)-	amines	Not Reported	

4.0 Discussion

Gas chromatography–mass spectrometry (GC–MS) remains a standard approach for profiling volatile and semi-volatile phytochemicals because it combines high separation power with reliable mass-based identification [38]. In this study, GC–MS analysis of *Persea americana* and *Curcuma longa* leaves each revealed thirteen identifiable compounds with differing relative abundances. Major peaks in *P. americana* included benzenemethanamine (28.41%), benzenamine (24.33%) and benzaldehyde (19.76%), while *C. longa* was dominated by benzenemethanamine (40.74%) and benzenamine (21.52%). These results broadly agree with other GC–MS investigations of tropical medicinal plants [39], though the number and identity of compounds often vary between studies because of differences in plant part, extraction solvent, and instrument parameters [40, 41].

4.1 Antioxidant and biochemical relevance.

The chemical classes detected aromatic aldehydes (e.g., benzaldehyde, cinnamaldehyde), aromatic amines, pyrazole derivatives and common fatty acids are mechanistically consistent with antioxidant activity: many such small aromatics and phenolic derivatives can donate electrons or hydrogen atoms to neutralize free radicals and can chelate transition metals, thereby limiting radical propagation [42,43]. This chemical evidence supports the expectation of measurable free-radical scavenging and reducing power in these extracts, and is consistent with our prior work showing strong DPPH, H_2O_2 scavenging, and metal-chelating activity in *Dennettiatripetala* extracts [44, 45].

4.2 Antimicrobial and antifungal implications

Several identified constituents have documented antimicrobial actions. Cinnamaldehyde and related cinnamyl derivatives (present here at lower abundance) disrupt microbial membranes and inhibit respiration, producing broad antibacterial and antifungal effects; benzaldehyde and certain fatty acids (e.g., n-hexadecanoic acid) have also been reported to exert antibacterial and antifungal activities in plant extracts [43,46]. Taken together, the phytochemical profile strongly justifies targeted antimicrobial screening (MIC/MBC assays) against representative Gram-positive, Gram-negative, and fungal strains (for example, *Staphylococcus aureus, Escherichia coli,* and *Candida albicans*) and, if active, follow-up bioassay-guided fractionation to link activity to specific peaks.

4.3 Anti-inflammatory and other pharmacological considerations

Aromatic aldehydes and certain heterocyclic scaffolds (pyrazoles) are known to modulate inflammatory signalling pathways (e.g., NF-κB, COX) in cell and animal models, offering a plausible biochemical basis for traditional anti-inflammatory uses [12,33]. The co-occurrence of antioxidant and putative anti-inflammatory molecules supports the hypothesis that these leaf extracts could attenuate oxidative stress–driven inflammation, but confirmation requires targeted cellular assays (e.g., cytokine profiling, COX inhibition).

4.4 Toxicological concerns and data-validation needs

A few identifications warrant caution: benzyl chloride and certain diphenylamine-type hits can be contaminants or

industrial artifacts and have known toxicological concerns if present at appreciable levels. Similarly, assignments such as long-chain mono-unsaturated fatty acids (e.g., (E)-13-docosenoic acid), if confirmed, bear regulatory/toxicological relevance. The presenceof these compounds was confirmed inlaboratory bioassay studies involving these plants with *Clarias gariepinus* fingerlings at varying concentrations with evidence of histopathological alterations and mortality [47, 48]. Similarly, toxicological studies involving plants extracts have been reported in previous studies [49, 50,51, 52,53, 54, 55, 56; 57, 58] which confirms the need for toxicological evaluation of plantextractsdespite its promising potentials in thepharmaceutical and nutraceuticals industry. However, GC–MS library matches are putative, these signals should be validated by analytical controls (solvent and procedural blanks), authentic standards, and MS/MS fragmentation to distinguish genuine plant metabolites from contaminants or co-eluting isomers [18, 19].

4.5 Methodological limitations and recommendations

GC–MS preferentially detects volatile and semi-volatile compounds and may under-represent larger, non-volatile polyphenols and curcuminoids unless derivatized; complementary LC–MS/HPLC profiling is therefore recommended to capture the full phenolic and curcuminoid complement of the leaves [46]. Analytically, confirmatory steps should include running solvent/lab blanks, authentic standards for major peaks, and MS/MS confirmation. Biologically, follow-up should include standardized antioxidant assays, antimicrobial MIC determinations, anti-inflammatory cellular assays, cytotoxicity/safety screening, and bioassay-guided fractionation to link specific compounds to activity [39].

4.6 Conclusion

The comprehensive GC-MS analysis of the leaves of *Persea americana* and *Curcuma longa* has revealed a diverse array of bioactive compounds, each contributing to the plant's pharmacological profiles-antioxidant, antimicrobial/antifungal, and anti-inflammatory activities. Notably, compounds such as Benzenemethanamine and Benzenamine were consistently identified across these species, albeit in varying concentrations. These findings align with existing literature, underscoring the therapeutic potential of these plants. However, before therapeutic claims can be advanced, analytical confirmation and targeted pharmacological and toxicological evaluations are essential.

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