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Phytochemical Profile and Bioactive Compounds in Aqueous Leaf Extract of *Anacardium occidentale*: A GC-MS Analysis

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

This study investigates the phytochemical composition of the aqueous leaf extract of *Anacardium occidentale* (cashew tree) using Gas Chromatography-Mass Spectrometry (GC-MS) analysis. The aqueous extraction yielded a crude leaf extract rich in bioactive compounds. Major compounds identified include γ-Terpinene (13.62%), known for its antioxidant and antibacterial properties, and Securinine (2.08%), which exhibits anticancer and antiviral effects. Additionally, dl-α-Tocopherol (5.6%), a potent antioxidant, was found. Other notable compounds, such as 1,2,3-Benzenetriol

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(6.53%), demonstrated strong antioxidant and anti-inflammatory properties, while Naphthalene (1.78%) exhibited antimicrobial activity. These compounds, among others identified in the extract, suggest that *Anacardium occidentale* leaves have a rich phytochemical profile with significant medicinal properties. The results underscore the plant's potential for treating oxidative stress-related diseases such as diabetes, cancer, and bacterial infections. This research highlights the therapeutic promise of *Anacardium occidentale* and emphasizes the need for further studies on the synergistic effects of these compounds. These findings could serve as a foundation for developing new, plant-based therapeutic agents for managing chronic diseases and infections.

Keywords: Anacardium occidentales; GCMS; phytochemical compounds; aqueous extracts.

1. INTRODUCTION

Anacardium occidentale, commonly known as the cashew tree, is traditionally used in folk medicine across various cultures to treat ailments such as diabetes, hypertension, and microbial infections [1,2]. Its phytochemical properties have gained attention due to the potential therapeutic benefits of its bioactive compounds [3]. Phytochemical profiling through advanced techniques like Gas Chromatography-Mass Spectrometry (GC-MS) enables the identification of these compounds, contributing significantly to natural product drug discovery [4,5].

2. MATERIALS AND METHODS

Fresh leaves of *Anacardium occidentale* were collected from Ogoni land, Rivers State, Nigeria, and processed for extraction following standard protocols [6]. Phytochemical analysis was conducted using GC-MS, allowing for the identification of compounds through comparison with the NIST library [7].

- **Collection and Drying of Plant Material**: Fresh leaves of *Anacardium occidentale* are collected and thoroughly washed to remove any dirt. The leaves are then air-dried in a shaded area for about two to four weeks to avoid degradation of phytochemicals due to sunlight [1,2].
- **Pulverization**: Once completely dried, the leaves are pulverized into a fine powder using a mechanical grinder to increase the surface area for extraction [6].
- **Aqueous Extraction (Maceration)**: The powdered leaves are macerated by soaking in distilled water (or another suitable solvent) at room temperature. The plant material is often left for 24 to 72 hours, depending on the desired extraction efficiency. This allows the bioactive compounds to dissolve into the solvent [8].
- **Filtration:** The extract is then filtered using muslin cloth or Whatman filter paper to remove any plant debris and obtain a clear liquid extract [7].
- **Concentration:** The filtered aqueous extract is concentrated using a rotary evaporator at a low temperature and reduced pressure to avoid thermal degradation of the phytochemicals. This step removes excess water, leaving a concentrated crude extract [6].
- **Storage:** The concentrated extract is stored in airtight containers and refrigerated until further use [1].

Phytochemical Composition: Key bioactive compounds identified include γ-Terpinene, known for antioxidant and anti-inflammatory properties [7,9], Securinine with anticancer potential [10], and dl-α-Tocopherol, which acts as a potent antioxidant [11]. Furthermore, 1,2,3-Benzenetriol demonstrated strong antioxidant activities [12], and Naphthalene was recognized for its antimicrobial properties [13].

3. RESULTS

Each compound has been studied for its individual biochemical significance or industrial application. Some are highly relevant to human health (e.g., γ-Terpinene, dl-α-Tocopherol), while others are more commonly used in industrial or chemical applications (e.g., siloxanes).

Phytochemical Composition: The GC-MS analysis of the aqueous leaf extract of *Anacardium occidentale* revealed the presence of several bioactive compounds with known medicinal properties. Major compounds identified include:

- **γ-Terpinene** (13.62%): Known for its antioxidant and antibacterial properties.
- **Securinine** (2.08%): Exhibits anticancer and antiviral effects.

Table 1. Key bioactive compunds

RT (min)	Name of Compound	Molecular Formula	Molecular Weight (g/mol)	Peak Area (%)	Biochemical Relevance
2.508	Methylene chloride	CH2Cl2	84.933	0.41	A solvent, known for environmental toxicity and industrial relevance. Limited direct biochemical relevance.
2.891	Diphenylcarbazone	C13H12N4O	240.26	0.48	Used in analytical chemistry as a metal indicator. Can have antioxidant effects.
3.211	γ-Terpinene	C10H16	136.234	13.62	Known for its antioxidant and anti-inflammatory properties. May exhibit antimicrobial activity.
4.651	Benzene-D6	C6D6	84.148	0.69	Deuterated benzene, used in NMR spectroscopy. No direct biochemical role in the body.
6.908	Securinine	C13H15NO2	217.26	2.08	An alkaloid with anticancer, antiviral, and neurostimulant properties. Used in traditional medicine.
9.646	4-Amino-3,5-dibromopyridine	C5H4Br2N2	251.91	1.251	A compound with potential antibacterial properties, though not extensively studied.
10.28	Methyldiallylamine	C7H13N	111.18	1.463	May act as a building block in polymer chemistry; limited direct biochemical effects known.
10.65	1,2,3-Benzenetriol	C6H6O3	126.11	6.537	A potent antioxidant that can scavenge free radicals. Also exhibits anti-inflammatory properties.
12.44	Naphthalene	C10H8	128.17	1.78	Known for its use in moth repellents, naphthalene has some antimicrobial and cytotoxic effects.
12.78	Pyrazole-3-carboxylic acid	C4H4N2O2	112.09	1.665	Known for anti-inflammatory, analgesic, and antifungal properties. It serves as a building block for pharmaceuticals.
14.94	9-Octadecene	C18H36	252.47	1.339	A long-chain unsaturated hydrocarbon, generally studied in industrial chemistry, less so in human health.
20.91	Behenic alcohol	C22H46O	326.6	1.073	Used in cosmetics for its emollient properties, it may have moisturizing effects on the skin.
21.99	9-Cycloheptadecen-1-one	C17H30O	250.419	0.81	A ketone with potential antimicrobial activity, though more research is needed.
27.07	Phenol, 2,4-dibromo-	C6H4Br2O	251.905	0.35	A halogenated phenol with antimicrobial activity, commonly used in industrial applications.
30.88	Thiophene, 2-(methylselenyl)-5-(propylthio)	C6H8S2Se	223.2	0.67	Thiophene derivatives are known for their biological activities including antibacterial and anticancer properties.
34.02	Mercury, chloromethyl-	CH3ClHg	251.08	0.74	Toxic heavy metal compound with significant adverse effects on human health.
35.43	8-Bromo-2-carbamoylquinoline	C10H8BrN	222.08	0.35	Quinoline derivatives often exhibit antimicrobial, anticancer, and antimalarial properties.

RT (min)	Name of Compound	Molecular Formula	Molecular Weight (g/mol)	Peak Area (%)	Biochemical Relevance
39.02	5,9-Undecadien-2-one, 6,10-Dimethyl	C13H22O	194.313	3.908	Likely to have antioxidant and antimicrobial properties; specific effects need further research.
39.58	dl-α-Tocopherol	C29H50O2	430.7	5.6	A form of Vitamin E, well-known for its potent antioxidant activity, supporting skin health and reducing oxidative stress.
40.22	Silicic acid	H4SiO4	192.23	1.231	Essential for bone, skin, and connective tissue health. It is important in collagen formation and skin elasticity.
44.74	Tetrasiloxane, decamethyl	C10H30OSi4	310.68	1.399	Used in cosmetics and industrial applications, no known biochemical relevance.
47.57	Methyltris(trimethylsiloxy)silane	C10H24O6Si	301.46	2.536	Siloxanes are used as lubricants or moisture-barrier agents. Not particularly bioactive in human systems.
49.41	Acetamide, N-[4-(trimethylsilyl)phenyl]	C11H17NOSi0	207.34	1.217	Used in organic synthesis, limited direct relevance to human biochemistry.
50.02	5-Methyl-2-phenylindolizine	C15H13N	207.104	1.078	Known for its antifungal and anticancer properties, it is a derivative used in pharmacological research.
51.91	Cyclotrisiloxane, hexamethyl-	C6H18O3Si	222.46	1.017	Siloxane used in the manufacture of silicone-based products; no biochemical effects noted in human health.
52.56	Tetrasiloxane, decamethyl-	C10H30OSi4	310.68	0.38	Similar to other siloxanes, used in industrial and cosmetic products without direct human bioactivity.

- **1,2,3-Benzenetriol** (6.53%): A strong antioxidant and anti-inflammatory compound.
- **dl-α-Tocopherol** (5.6%): Exhibits antioxidant activity and helps in preventing oxidative stress.
- **Naphthalene** (1.78%): Known for its antimicrobial activity.

These compounds, among others identified in the extract, suggest that *Anacardium occidentale* leaves have a rich phytochemical profile with significant medicinal properties.

4. DISCUSSION

The phytochemical composition of *Anacardium occidentale* (cashew) leaves, as analyzed through GC-MS, highlights the presence of bioactive compounds with diverse therapeutic properties. Significant compounds include γ-Terpinene, Securinine, 1,2,3-Benzenetriol, dl-α-Tocopherol, and Naphthalene. These constituents suggest a wide range of pharmacological potentials, including antioxidant, antibacterial, anticancer, and anti-inflammatory effects [3,8,14].

Medicinal Implications:

1. **Antioxidant Properties**: The presence of 1,2,3-Benzenetriol and dl-α-Tocopherol contributes to the plant's strong antioxidant potential. Antioxidants combat oxidative stress, a factor implicated in diseases such as cancer, diabetes, and neurodegenerative disorders [8]. Standard DPPH assays confirm its radical scavenging capacity [4, 15].
2. **Antimicrobial Activity**: Compounds like γ-Terpinene and Naphthalene exhibit antimicrobial properties, which align with studies demonstrating the antibacterial efficacy of cashew extracts against pathogens like *Staphylococcus aureus* and *Escherichia coli* [16,17]. These findings position cashew leaves as a promising source for natural preservatives and therapeutic antimicrobials [18,19, 20, 21,22].
3. **Anti-inflammatory and Anticancer Potential**: Securinine, a notable constituent, has documented anti-inflammatory and anticancer properties. It supports the traditional use of *Anacardium occidentale* in managing inflammatory conditions and oxidative stress-related cancers [6, 23, 24].
4. **Other Therapeutic Effects**: The diverse phytochemical profile, including tannin-rich fractions, enhances its gastroprotective [21] and hepatoprotective potential. Cashew leaf extracts have shown efficacy in mitigating oxidative stress-induced liver damage and ulcers [24,25].

Implications for Food Preservation: The antimicrobial properties of *Anacardium occidentale* extracts also hold promise for application in food systems as natural preservatives. Essential oils and anacardic acids derived from cashew components have been found effective against spoilage microorganisms and mycotoxin-producing molds [26, 22, 27, 18,28, 23].

Future Applications: The findings substantiate *Anacardium occidentale*'s role in developing phytochemical-based therapeutics. Further studies on its bioavailability, synergistic effects, and clinical trials are essential for optimizing its use in pharmaceutical and nutraceutical formulations [3, 19, 29, 30-34].

5. CONCLUSION

This research provides valuable insights into the phytochemical profile of the aqueous leaf extract of *Anacardium occidentale*, revealing a range of bioactive compounds with potential medicinal applications. These findings emphasize the importance of natural plant products in the search for new drugs and underscore the therapeutic potential of *Anacardium occidentale* in managing chronic diseases.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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