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Research Article

Antioxidant and nutraceutical profiling, and GC-MS characterization of *Ficus abutilifolia* leaf extracts and essential oil

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Abstract— Medicinal plants contain bioactive compounds useful in managing various health conditions. This study evaluated the phytochemical constituents and antioxidant activities of the ethanolic crude extract and essential oil of Ficus abutilifolia leaves. Leaves were collected from Askira Uba, Borno State, Nigeria, and extracted using ethanol. Phytochemical screening revealed the presence of alkaloids, saponins, tannins, anthraquinones, steroids, glycosides, flavonoids, reducing sugars, amino acids, and terpenoids, while phytosterols were absent. Antioxidant activity was assessed using DPPH and hydrogen peroxide assays at concentrations of 2.5, 5, 7.5, and 10 µg/mL, with ascorbic acid as the standard. The crude extract showed concentration-dependent scavenging, reaching 58.2 % (DPPH) and 72.7 % (H_2O_2) at 10 µg/mL. The essential oil also demonstrated dose-dependent activity, with 50.3 % (DPPH) and 72.9 % (H_2O_2) inhibition at the same concentration. The oil obtained by steam distillation (percentage yield, 0.7 %), was analyzed via GC-MS, identifying 21 compounds, including octadecane (12.42 %), tetratetracontane (10.56 %), tetracosane (10.26 %), 1-iodo-2-methylundecane (8.78 %), heptacosane (8.09 %), heptadecane, 2-methyl (7.5 %), and caryophyllene (7.03 %). These findings indicate that F. abutilifolia possesses strong antioxidant potential, likely due to its diverse phytochemical profile.

Keywords— Phytochemical, DPPH, hydrogen peroxide, antioxidant activities, ethanol extract, percentage inhibition

Graphical Abstract

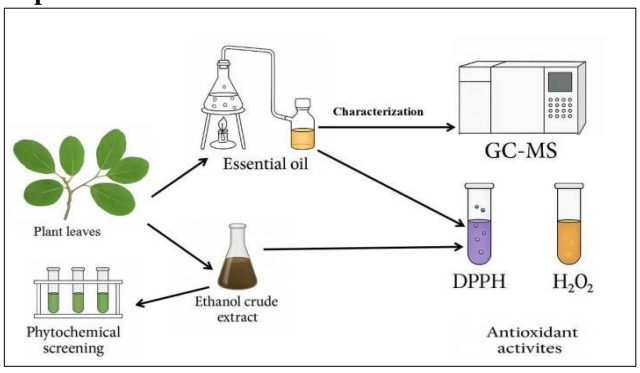

Fig.1 Graphical abstract

1. Introduction

The growing interest in natural antioxidants, especially those derived from plants, has significantly increased in recent times. As a result, various plant parts such as fruits, vegetables, seeds, bark, and leaves have become focal points in the exploration of these biologically active constituents [1]. Antioxidants are fundamentally essential for shielding cells from the harmful effects of oxidative stress. They are generally important for preserving cellular integrity and supporting overall health and physiological balance [2]. Plants serve as a major source of essential raw materials for the food, pharmaceutical, and cosmetic sectors, leading to the development of numerous products including supplements, nutraceuticals, and botanical-based cosmetics, many of which trace their use back to traditional and folk medicinal practices. Historically, medicinal herbs and teas have played a vital role in human health by offering natural treatments with healing and therapeutic potentials. These plants are rich in phytochemicals—secondary metabolites responsible for the health-promoting effects associated with herbs [3, 4]. Antioxidants derived from plants, owing to their natural abundance in active compounds, contribute both to the plant's adaptation under environmental stress and to their medicinal value in human health [5].

The genus *Ficus*, belonging to the Moraceae family, encompasses around 850 to 900 species, though some accounts suggest the number may exceed 1,000 species, making it the

largest genus within the family [6]. *Ficus abutilifolia* (Fig. 2) is a small to moderately sized tree, rarely surpassing 5 meters in height, and is often found near stream banks and broadly distributed across the African continent [7, 8]. Locally referred to as "dundeehi hooseere" in the Fulfulde language spoken in Northern Cameroon, and known in English as the "large-leaved rock fig" or "rock wild fig," this plant is traditionally employed in the management of several health conditions, including typhoid fever, persistent dysentery, sexually transmitted infections, malaria, infertility, and epilepsy [9].

1.1 Objective of the Study

While various research studies have explored different species of the genus Ficus, scientific findings on the pharmacological activities of F. abutilifolia, a dominant plant found in Askira Uba, Borno State, Nigeria, remain limited. The objective of this research is to compare the therapeutic properties of this plant with established therapeutic data of other species of the genus Ficus from the literature.

Figure 1. Images of *Ficus abutilifolia*

2. Related Work

From a chemical standpoint, *Ficus abutilifolia* is known to contain several classes of glycosides, including saponins, flavonoids, anthraquinones, alkaloids, and tannins [10]. Ajayi et al. [11] identified tannins, phlobatannins, flavonoids, cardiac glycosides, saponins, alkaloids, and steroids in the leaf extract of *Ficus exasperata*, another member of the Moraceae family. In a related study, Achi et al. [12] found that the aqueous leaf extract of *Ficus capensis* was rich in flavonoids, terpenoids, tannins, and alkaloids, while glycosides, saponins, and steroids occurred in lower concentrations. Muanda et al. [13] also detected phenolic constituents in *F. capensis*, which are believed to be responsible for its antibacterial activity. Thagriki et al. [14] observed the presence of alkaloids, tannins, saponins, flavonoids, glycosides, proteins, and phenolic compounds in the leaf extract of *Ficus sycomorus*. Similarly, Balogun et al. [15] reported reducing sugars, alkaloids, saponins, pyrocathecolic tannins, and free amino acids/amines in the aqueous ethanol extract of the stem bark of *Ficus trichopoda*.

The free radical scavenging and antibacterial activities demonstrated by extracts of *Ficus sur* and *F. sycomorus* may provide scientific validation for their traditional application in the management of sickle cell disease [16]. In Nigeria, *F. abutilifolia* has long been utilized in ethnomedicine for treating conditions such as typhoid fever, dysentery, foodborne illnesses, and sexually transmitted infections [10]. In addition, its leaves are believed to enhance fertility, its latex is traditionally applied for wart removal, and its bark is valued as a restorative tonic. Moreover, the ethanol extract of the plant's root bark has shown anticonvulsant properties in models involving maximal electroshock [8].

As part of the broader research into volatile constituents emitted by *Ficus* species and other Nigerian plants [17], the present study focuses on profiling the volatile compounds present in *Ficus abutilifolia*, one of the numerous fig species belonging to the Moraceae family. While no existing literature was found on the essential oil composition of *F. abutilifolia*, studies have documented the chemical profiles of essential oils from other *Ficus* species found in Nigeria.

For instance, Adeyemi et al. [18] reported that the dominant volatile constituents of *Ficus lutea* were acorenone B (20.7%) and phytol (16.2%), along with demethoxyageratochromene (6.0%), 6,10,14-trimethyl-2-pentadecanone (5.1%), and zingiberene (5.2%).

3. Experimental Method

3.1. Sample Collection

F. abutilifolia, a member of the Moraceae family (L.), was sourced from the bush area of Askira Uba, Borno State, Nigeria.

3.2. Preparation of Sample

The leaves of *F. abutilifolia* (L.) plants were meticulously washed and air-dried in Chemistry Laboratory 2, Science Complex of the Faculty of Science, Adamawa State University, Mubi, under shade at room temperature. The dried leaves were subsequently weighed, ground to a coarse powder using a sterile mortar and pestle, and stored in an airtight container for successive analyses [19]. For the essential oil extraction, Random leaf samples were collected and labeled accordingly, then stored in an ice cooler until transported to the laboratory for extraction and further analysis [20].

3.3. Plant Solvet Extraction

A 100 g sample of Ficus abutilifolia leaves powder was weighed and subjected to ethanol extraction in an airtight container for 24 hours. The resultant mixture underwent filtration using Whatman No. 1 filter paper under gravity. The filtrate was then dried at 60 °C on a water bath, yielding Ficus abutilifolia leaves ethanolic extract residue [21].

3.4. Steam Distillation Essential Oil Extraction

1 kg leaves of *F. abutilifolia* samples collected was used for extraction per time to prevent loss of essential oils due to the drying process. The extraction was carried out using a modified steam distillation apparatus, where the receiver end passed through another vessel containing ice. The essential oils of the plant was collected over water and later kept at 4 °C until further required. The isolation process took approximately 2½ hours [22]. This process was repeated for each plant batch until a total mass of 2.6835 kg was used for extraction. The steam distillation apparatus is Clevenger-like as described in the British Pharmacopoeia [23].

3.5. Phytochemical Screening

Phytochemical screening was conducted using standardized procedures to detect the presence of various natural product

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groups in the ethanolic extracts of Ficus abutilifolia, according to the following methods: Essential oil [24], Alkaloids [25]; Phenolic Compounds and Tannins [25]; Saponins [26]; Flavonoids [27]; Glycosides [26]; Phytosterols [26], Proteins and Amino Acids [26]; Reducing Sugars [27]; Terpenoids [27], and Anthraquinones [27].

3.6. DPPH Antioxidant Activities of Extract and Essential oil

DPPH has been widely used for measurement of free radical scavenging ability of antioxidants. This method is based on the reduction of an alcoholic DPPH solution in the presence of a hydrogen-donating antioxidant [28]. The DPPH assay was performed using a standard method with minor modification. The hydrogen atom or electron donating abilities of the compounds were measured from the bleaching of the purple colored methanol solution of DPPH. This spectrophotometric assay uses the stable free radical, DPPH as a reagent. One thousand microlitres of diverse concentrations (2.5 µL/mL) of the crude extract and essential oil in ethanol were added to 4 mL of 0.004 % methanol solution of DPPH. After a 30 min incubation period at room temperature, the absorbance was read against a blank at 517 nm and compared to the standard antioxidants, Ascorbic acid (vitamin C). The DPPH radical scavenging effect was calculated as inhibition of percentage (I %) using to the following formula [29].

$$\% \text{ Inhibition} = \frac{\text{absorbance of blank} - \text{absorbance of sample}}{\text{absorbance of blank}} \text{ X } 100$$

Where, A is blank is the absorbance of the control reaction (containing all reagents except the test compound) and A (sample) is the absorbance of the test compound. The values of inhibition were calculated for various concentrations of the extract. Tests were conceded out in triplicate.

3.7. Hydrogen Peroxide Antioxidant Activities of Extract and Essential oil

The ability of the extract to scavenge hydrogen peroxide was determined according to the method with modification. A solution of hydrogen peroxide (40 mM) was prepared in phosphate buffer (ρH = 7.4). Extracts and essential oil (2.5-25 µg/mL) in methanol were added to a H_2O_2 solution (0.6 mL, 40 mM). The absorbance value of the reaction mixture was recorded at 230 nm. Blank solution contained the phosphate buffer without H_2O_2 [30]. The percentage of H_2O_2 scavenging was calculated as:

$$\% \text{ Inhibition} = \frac{\text{Control absorbance} - \text{Sample absorbance}}{\text{Control absorbance}} \text{ X } 100$$

Where A (control) is the absorbance of the control, and A (sample) is the absorbance in the presence of the sample or standards.

3.8. Statistical Analysis

All determinations were replicated three times and results were reported in mean.

4. Results and Discussion

4.1. Phytochemical Screening of Ethanol Extract of *F. abutilifolia* Leaves

The preliminary phytochemical analysis of *Ficus abutilifolia* leaves revealed the occurrence of multiple bioactive secondary metabolites, confirmed through characteristic chemical color reactions, as presented in Table 1.

Djankou et al. [9] identified flavonoids, phenols, carbohydrates, sterols and terpenes/steroids, tannins, and anthraquinones in the methanol stem bark extract of *F. abutilifolia*, while saponins were notably absent. In contrast, Eshwarappa et al. [31] reported only flavonoids and carbohydrates in the methanol extract of *Ficus glomerata*, a finding that differs from the present study. However, the current findings show greater consistency with those reported by Taiwo et al. [7].

According to Prakash et al. [32], the methanol extract of *Ficus religiosa* contained carbohydrates, saponins, phenols, flavonoids, proteins, tannins, and terpenoids, but lacked alkaloids.

In another study examining a different *Ficus* species, the methanol extracts of both stem bark and root showed the presence of alkaloids, flavonoids, tannins, triterpenes, cardiac glycosides, steroids, saponins, phenols, and carbohydrates. Anthraquinones were detected in the root extract but absent in the stem bark [33].

In the current investigation, preliminary phytochemical screening by means of tube reactions and thin-layer chromatography (TLC) conducted on leaf extracts of *Ficus sur Forsk.* and *F. sycomorus L.* demonstrated the presence of alkaloids, flavonoids, carbohydrates, saponins, steroids, tannins, phenols, triterpenoids, anthracenosides, anthocyanins, and coumarins [16].

Similarly, Ajayi et al. [34] reported detecting alkaloids, flavonoids, saponins, steroids, tannins, phenols, terpenoids, and glycosides in the n-hexane extract of *Ficus polita* leaves. In addition, the ethanolic and ethyl acetate leaf extracts of *F. sycomorus* were shown to contain higher concentrations of total phenols, flavonoids, tannins, alkaloids, and anthocyanins than extracts obtained from the plant's fruit [35].

Table 1. Qualitative phytochemical screening of ethanolic extract of Ficus abutilifolia leaves

Phytonutrients	*Ficus abutilifolia*
Essential oil	+
Alkaloid	+
Phenol/Tannin	+
Saponin	+
Flavonoids	+
Glycosides	+
Phytosterol	-
Reducing sugar	+
Protein/amino acid	+
Terpenoids	+
Anthraquinones	+

Key: + = Present; - = Absent

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4.2. DPPH and Hydrogen Peoxide of crude extract and essential oil

From the results displayed in Figures 3 and 4 and Table 2, it is evident that the ethanolic extract and essential oil of leaves from *F. abutilifolia* (FA) exhibit potent antioxidant ability against DPPH and hydrogen peroxide, in comparison with ascorbic acid (AA) as the standard reference.

Djankou et al reported the IC_{50} antioxidant activity of the methanol extract of *F. abutilifolia* stem bark to be 0.060 mg/mL [9]. The crucial role of phenolic compounds as scavengers of free radicals is emphasized in several reports. Asha et al [36] reported a fair correlation between antioxidant activity, free radical scavenging activity, and phenolic contents. The extract of *F. religiosa* fruit and bark demonstrated antioxidant activity, assessed using the oil stability index and radical scavenging capacity against DPPH [37]. Alcoholic fruit extracts of *Ficus capensis* Thunb. showed an antioxidant potency of 13.05 % using the DPPH assay [38]. Similarly, Rathee et al reported that the methanolic extract of *F. religiosa* fruits reduces the DPPH radical to the corresponding hydrazine when it reacts with the hydrogen donors in the antioxidant principles [39].

In a related study, Etratkhah et al reported that the aerial root of *Ficus benghalensis* exhibits an IC_{50} of 54.40 µg/mL against DPPH, using vitamin C as a standard [40]. Gupta and Sharma's research results revealed a significant decrease in the concentration of DPPH radicals due to the scavenging ability of both aqueous extracts and standards. A 250 µg/mL concentration of *F. benghalensis* Linn aqueous extract and ascorbic acid (std.) exhibited 96.07 % and 90.41 % inhibition, respectively [41].

In a related research, Ojo and Akintayo revealed that the aqueous extract of *Ficus asperifolia* scavenged 78.65 % of DPPH radicals at a concentration of 5 mg/mL, against 47.03 % and 29.25 % of nitric oxide (NO) and hydroxyl (OH) radical activities, respectively [42]. This indicates that *Ficus* of the *Moraceae* family is a good source of antioxidants.

In another study, Anago et al reported the antioxidant potency of the ethanolic extract of *Ficus exasperata* Roxb. against DPPH as 23 % at 10 µg/mL [43]. Similarly, Ahoua et al [44] investigated the DPPH radical scavenging power of extracts of a group of *Ficus* species, with the following results: methanol extract of *Ficus elasticoides* leaves (96.69 %), methanol extract of *Ficus lyrata* leaves (94.53 %), methanol extract of *Ficus mucuso* leaves (94.33 %), methanol extract of *Ficus thonningii* leaves (89.86 %), methanol extract of *Ficus umbellata* fruits (74.74 %), methanol extract of *F. umbellata* leaves (73.03 %), methanol extract of *F. elasticoides* fruits (71.44 %), dichloromethane extract of *F. umbellata* leaves (28.18 %), and dichloromethane extract of *F. lyrata* leaves (26.09 %).

According to Tharini et al [45], the maximum DPPH radical scavenging activity was 75.74 % at 60 µg/mL concentration. The fruit extract of *F. benghalensis* demonstrated a high capacity to deactivate free radicals by reducing the stable 1,1-diphenyl-2-picrylhydrazyl (DPPH) radical to the yellow-colored 1,1-diphenyl-2-picrylhydrazine, and the reducing capacity increased with the concentration of the extract.

In related research involving the methanol extract of *Ficus elastica*, Preeti et al reported significant dose-dependent antioxidant activity with an IC_{50} value of 20.17 µg/mL [46]. Madeleine et al [47] reported an IC_{50} antioxidant activity of 0.06 mg/mL for the methanol extract of *F. abutilifolia* against the DPPH assay. Similarly, Boukhalfa et al [48] reported a DPPH assay inhibition of 346.2 µg/mL by *Ficus carica* leaf extract.

In a similar research, Abotsi et al [49] confirmed an IC_{50} of 0.499 mg/mL and antioxidant activity against the DPPH assay. Arun et al [50] revealed that *F. carica* extract showed 86.43 % and 77.86 % for the seed and seedless plant samples, respectively, against DPPH at the highest concentration of 80 µg/mL. Likewise, Flayyh et al reported 6.4 µg/mL EC_{50} antioxidant activity against DPPH for *F. elastica* extract [51]. Gupta and Sharma [52] reported that the extract of *F. racemosa* exhibited a hydrogen peroxide scavenging activity of 65.42 % at 1000 µg/mL. Similarly, *Ficus exasperata* demonstrated its highest scavenging activity at concentrations of 1000 µg/mL (25 %) and 750 µg/mL (19 %). Notably, *Artocarpus altilis* (breadfruit), a member of the Moraceae family, showed concentration-dependent activity: 31.6 % at 1000 µg/mL, 31.4 % at 750 µg/mL, 30.8 % at 500 µg/mL, 28.6 % at 300 µg/mL, and 9.6 % at 100 µg/mL, using the hydrogen peroxide assay [53]. These findings align with the concentration-dependent antioxidant activity observed in the present study.

Yadav et al [54] observed that the hydrogen peroxide scavenging activity of the ethanolic leaf extract of *F. racemosa* (51.28 %) was comparable to that of the standard, ascorbic acid (49.2 %). Similarly, the chloroform fruit extract of *F. sycomorus* showed a dose-dependent increase in inhibition with an IC_{50} of 117.6 µg/mL, while ascorbic acid demonstrated an IC_{50} of 4.81 µg/mL [55]. Furthermore, *Ficus dalhousie* ethyl acetate and hydroalcoholic extracts showed IC_{50} values of 86.56 µg/mL and 51.17 µg/mL, respectively [56]. These results are consistent with those reported by Putra et al [6], who observed significant antioxidant potential in *F. deltoidea* fruit extracts.

Antioxidants function by disrupting the chain reactions involved in the propagation of oxidative processes. They achieve this by donating hydrogen atoms or electrons to free radicals, stabilizing the resulting reactive species, and thereby mitigating oxidative stress. This mechanism helps inhibit lipid peroxidation, scavenge free radicals, and prevent oxidative damage, ultimately contributing to disease prevention and tissue repair [57].

The antioxidant properties observed in *F. abutilifolia* in this study are in agreement with those of other members of the *Ficus* genus. Iqbal et al [58] reported that the antioxidant activity of essential oil from the aerial roots of *F. elastica* was concentration-dependent. Atolani et al [59] further revealed that the essential oil from the white leaves (FW) of *F. microcarpa* exhibited greater antioxidant activity than that

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from green leaves (FG). Over tested concentrations, the standard ascorbic acid displayed an activity range of 15-72 %, while FG and FW exhibited ranges of 20-39 % and 45-55 %, respectively.

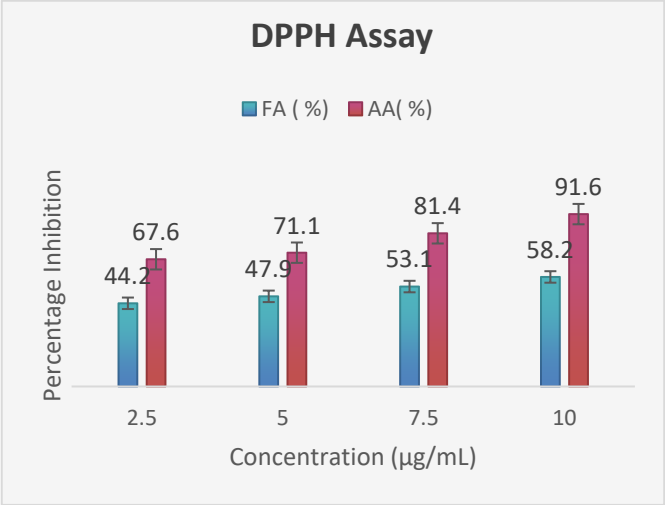

Fig. 3. Percentage Inhibition of DPPH by the plants crude extracts and Ascorbic Acid

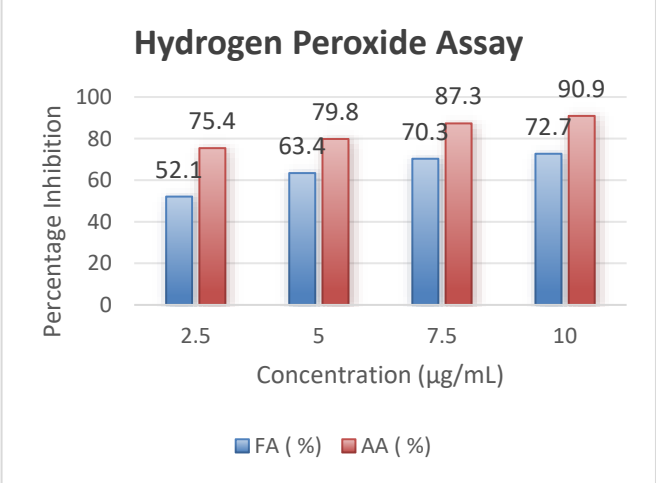

Fig. 4. Percentage Inhibition of H_2O_2 by the plants crude extracts and Ascorbic Acid

4.3. Percentage yield of essential oil

Table 3 shows that the percentage yield of *F. abutilifolia* is 0.07 %.

Plant	Weight of plant .	Weight of oil	Appearance	% Yield (WO/WP) x 100)
FA	3046 g	2.16 g	Colourless	0.07

Table 2. Percentage Inhibition of DPPH and H_2O_2 by the essential oil and Ascorbic Acid

Concentration (µL/mL)	2.5	5	7.5	10
DPPH Assay 517nm (%)	41.8	42.2	44.6	50.3
Ascorbic Acid (%)	52.56	65.26	79.06	90.40
H_2O_2 Assay at 230nm (%)	49.2	59.8	69.5	72.9
Ascorbic Acid (%)	79.13	86.59	88.71	90.12

4.4. Composition of Essential Oil of *F. abutilifolia*

In the present study, GC-MS analysis identified 14 compounds in the essential oil of *F. abutilifolia*, accounting for 99.97 % of the total oil composition, as shown in Table 4. The corresponding chromatogram is presented in Figure 5. Major constituents were identified along with their retention times (RT) and peak areas.

Romeh [60] reported the following major constituents from the vapors of *F. sycomorus* leaf extract: 1,2-benzenedicarboxylic acid, diisooctyl ester (45.06 %), n-hexadecanoic acid (7.67 %), 1H-pyrazole, 4-nitro (5.13 %), 3-hexen-1-ol, benzoate, Z (4.57 %), oleic acid (4.30 %), and hexanedioic acid, bis (2-ethylhexyl) ester (4.15 %). Similarly, Onuah et al [61] identified eight compounds in *F. sycomorus* extract via GC-MS, including 1H-indene-3-methyl, neophytadiene, hexadecanoic acid methyl ester, methyl 9-cis 11-trans-octadecadienoate, 9,12,15-octadecatrienoic acid methyl ester (Z,Z,Z), phytol, methyl stearate, and diisooctyl phthalate, present in varying concentrations.

Additionally, Radulović et al [62] reported that the essential oils of *Morus alba L.* and *M. nigra L.* leaves, obtained via hydrodistillation, were dominated by trans-phytol (7.9-71.2 %), (E,E)-geranyl linalool (0.2-8.0 %), (Z)-bovolide (8.1 %), and a mixture of n-chain alkanes (17.5-52.4 %).

This aligns with the findings of Anifowose et al [63], who reported that phytochemicals are responsible for a wide range of biological effects, including antimicrobial, antiviral, antigenotoxic, antimutagenic, antiproliferative, antitoxic, antifertility, anticonvulsant, anticancer, antitrypanosomal, antileishmanial, antihyperglycemic, antihyperlipidemic, hypocholesterolemic, anti-inflammatory, antihypertensive, antispasmodic, antioxidant, and notably, antifungal activities. These effects may involve cytotoxic actions, interference with plasma membrane integrity and function, and inhibition of enzymes within the cytoplasm and mitochondria that are essential for cell wall biosynthesis and maintaining redox and homeostatic balance in fungi. This supports the widespread use of medicinal plants in traditional health care, as also highlighted by Gawade et al [64], who emphasized that the rich natural biodiversity and ancient medicinal knowledge systems have laid a strong foundation for the use of numerous medicinal plants containing diverse bioactive compounds for managing various health challenges and common diseases affecting humans.

The variation in chemical composition observed across these studies could be attributed to differences in plant species, plant parts used, geographical location, and climatic conditions, all of which are known to influence the secondary metabolite profile of plants. Here is a paraphrased version of your statement with minimized similarity.

6. Conclusion and Future Scope

The investigation into the medicinal potential of *F. abutilifolia*, sourced from Askira Uba, Borno State, Nigeria, has revealed promising bioactive compounds through ethanol extraction of

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its leaves. The qualitative phytochemical screening identified a diverse array of compounds. The antioxidant evaluation of the crude extracts and essential oil using DPPH and hydrogen peroxide free-radical scavenging assays demonstrated concentration-dependent efficacy, with the highest concentrations exhibiting significant free radical inhibition.

In summary, the research on *F. abutilifolia* highlights its pharmacological potential, particularly in the inhibition of free radicals. The findings contribute valuable insights into the therapeutic properties of this plant, addressing the existing gap in scientific knowledge regarding the pharmacological activities of the plant in comparison to other species within the genus. The concentration-dependent increase in antioxidant activity underscores the plant's potential as a valuable source of bioactive compounds with significant implications for health and wellness. Further studies are warranted to delve deeper into the specific mechanisms of action and potential applications of the plant in addressing health challenges.

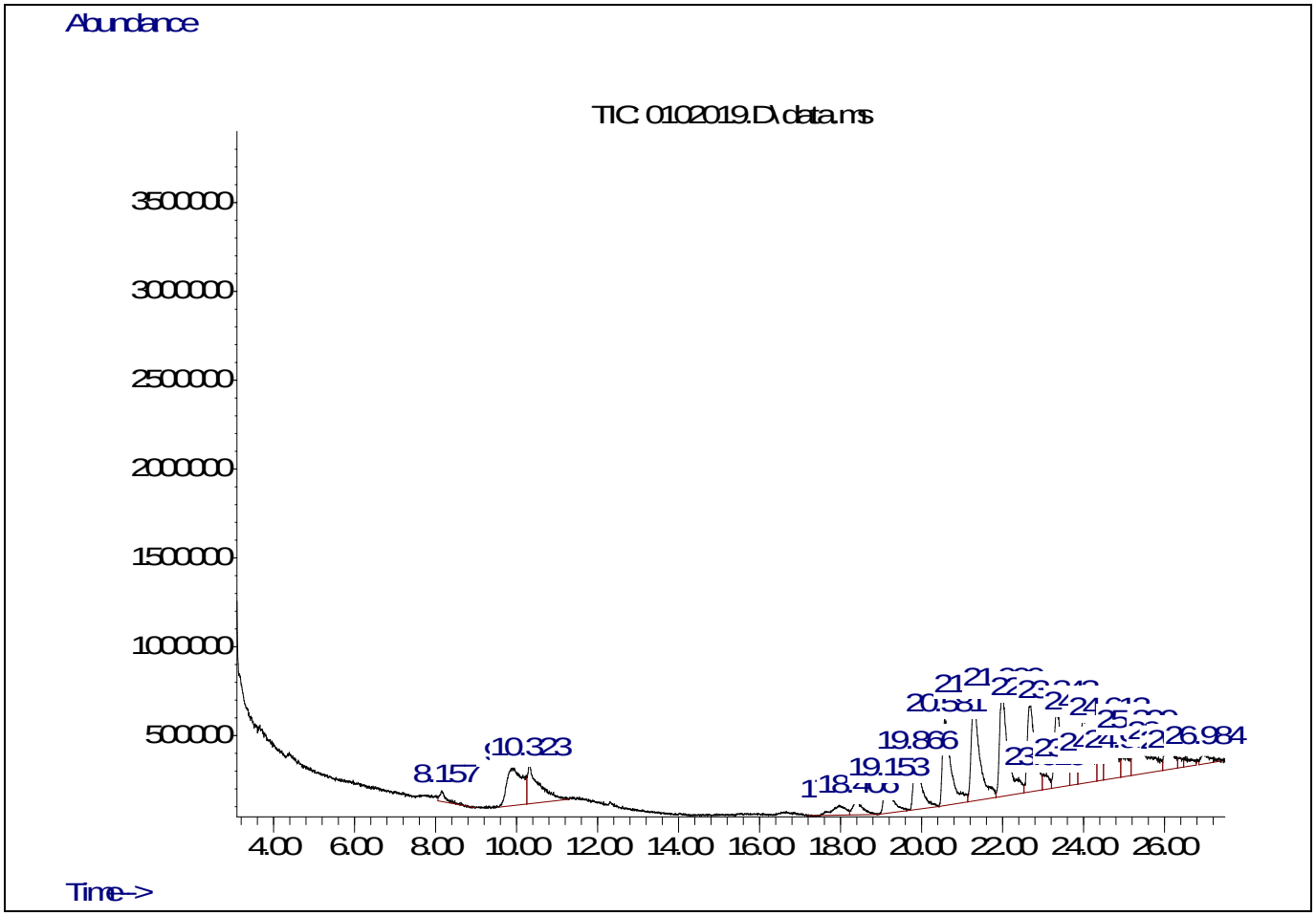
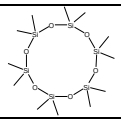
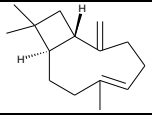
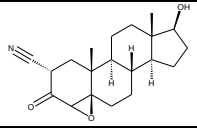
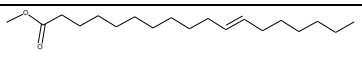


Fig. 5. GC-MS Chromatogram

Table 4. GC-MS essential oil analysis of leaves of *F. abutilifolia*

S/N	CONSTITUENTS	RT(MIN)	AREA (%)	Structure**
1	Cyclohexasiloxane, dodecamethyl-	8.159	0.80	
2	Caryophyllene	9.899	7.03	
3	Trilostane	10.323	5.59	
4	11-Octadecenoic acid, methyl ester	17.968	1.52	

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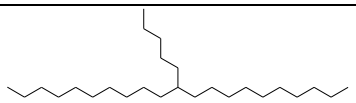
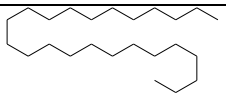
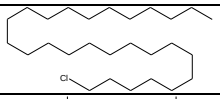
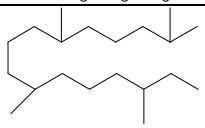
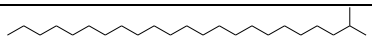
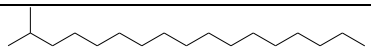
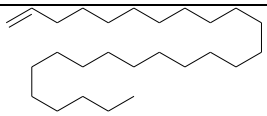
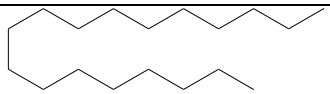
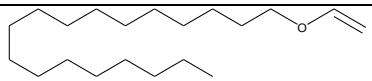
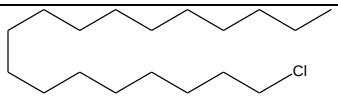
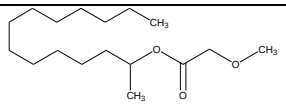
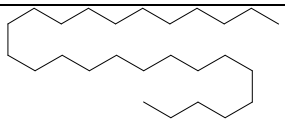
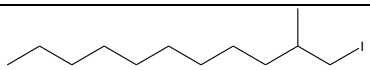
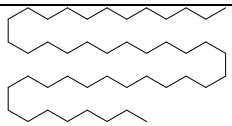
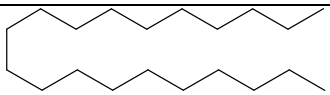
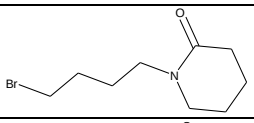
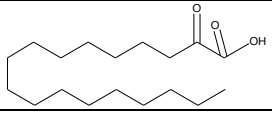
5	Heneicosane, 11-pentyl-	19.156	3.12	
6	Tetracosane	21.290	10.26	
7	Heptacosane, 1-chloro	22.683	8.09	
8	Hexadecane, 2,6,10,14-teramethyl	23.750	1.36	
9	Tricosane, 2-methyl-	23.016	1.17	
10	Heptadecane, 2-methyl-	23.342	7.51	
11	1-Hexacosene	24.992	1.96	
12	Octadecane	25.302	12.42	
13	Octadecane, 1-(ethenyloxy)-	26.551	1.36	
14	Octadecane, 1-chloro-	26.982	1.15	
15	Methoxyacetic acid, 2-tetradecyl ester	18.407	1.66	
16	Hexacosane	19.868	5.05	
17	1-Iodo-2-methylundecane	20.579	8.78	
18	Tetratetracontane	22.002	10.54	
19	Eicosane	24.000	6.86	
20	2-Piperidinone, N-[4-bromo-n-butyl]-	24.371	1.30	
21	α-Ketostearic acid	26.066	2.45	
	Total percentage area		**99.98 %**	

****Chemical structures were drawn using ChemDraw Pro 8.0**

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Data Availability

The GC-MS data supporting the findings of this study are available in a publicly accessible repository via the following Google Drive link: [https://tinyurl.com/GC-MSData]. The other data supporting the conclusion of this research are presented in the tables and graph figures in this article

Conflict of Interest

The authors declare that they have no conflict of interest.

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The authors got no funding from any agency or institution for their research.

Authors' Contributions

Authors AC, LL and JNJ designed the study, AC and LL performed the statistical analysis, wrote the protocol, and AC wrote the first draft of the manuscript. Authors LL, AC and JNJ managed the analyses of the study. Author AC managed the literature searches. All authors read and approved the final version of the manuscript.

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