Trop J Phytochem Pharm Sci, April 2025; 4(4): 166 - 173 **ISSN 2955-1226 (Print)**
ISSN 2955-123(Electronic)

Tropical Journal of Phytochemistry & Pharmaceutical Sciences

Available online at https://www.tjpps.org

Original Research Article

Preliminary phytochemical and GC-MS Screening of Ethanol extract of *Khaya ivorensis* bark, and *Flabellaria paniculata* and *Rhapiostylis beninensis* roots

Mota'a C. Stephen[1, 2], Nwamaka H. Igbokwe[2], Abel O. Idowu[2*], Chijioke E. Ezeobiora [2]

[1] *Department of Pharmaceutical Microbiology and Biotechnology, Faculty of Pharmacy, University of Maiduguri, Borno state, Nigeria.*
[2] *Department of Pharmaceutical Microbiology and Biotechnology, Faculty of Pharmacy, University of Lagos.*

ABSTRACT

Medicinal plants are important sources for the discovery of new chemotherapeutic agents. This study investigated the phytochemical components of ethanol extracts of the roots of *Flabellaria paniculata*, *Rhapiostylis beninensis*, and the bark of *Khaya ivorensis*. Plant extraction was performed using a cold maceration method with 70% ethanol. Phytochemical screening of extracts was done using qualitative and quantitative assays and Gas Chromatography-Mass Spectrometry (GC-MS) methods. Steroids, saponins, flavonoids and terpenoids were detected in the extracts of the three plants, while alkaloids and cardiac glycosides were not. In addition, the extracts of *K. ivorensis* and *F. paniculata* also contain tannins, phenols and reducing sugar, while phlobatannins were found in the extracts of *R. beninensis*. The terpenoids and steroid content of the three plant extracts were similar, while the flavonoid content was in the order of *K. ivorensis* (109mg/100g) >*F. paniculata* (52mg/100g)> *R. beninensis* (38mg/100g), respectively. The GC-MS analysis identified 33, 37, and 33 different bioactive compounds from *K. ivorensis*, *F. paniculata*, and *R. beninensis extracts*, respectively. The most abundant compounds in the extracts are linoleic acid ethyl ester (30.76%), (E)-9-octadecanoic acid ethyl ester (17.72%), hexadecanoic acid ethyl ester (17.29%) in *K. ivorensis*, ethyl oleate (23.46%), hexadecanoic acid ethyl ester (14.55%), octadecenoic acid ethyl ester (26%) in *F. paniculata* and hexadecanoic methyl ester (19.24%), 9-octadecenoic acid (19.47%) in *R. beninensis*. The preliminary qualitative, quantitative and GC-MS assays indicated that these plants are promising sources of bioactive compounds that could be investigated for therapeutic purposes.
.

Keywords: Phytochemical components, ethanol extracts, qualitative analysis, quantitative analysis, Gas Chromatography-Mass Spectrometry

Received 4 March 2025
Revised 19 April 2025
Accepted 24 April 2025
Published online 01 May 2025

Introduction

The use of medicinal plants to treat different illnesses is as old as human history, demonstrating the significance of these plants in the drug discovery process.[1] Due to the presence of phytochemicals that have distinct pharmacological effects on humans, medicinal plants play a vital role in the development of medications.[2] In the past, some African medicinal herbs showed effective antibacterial properties,[3] thus making them medications that have become a crucial component of contemporary healthcare, useful in treating bacterial infections that were once life-threatening.[4]

*Corresponding author. Email: abelidowu@unilag.edu.ng

Tel: +2348027348864

Citation: Stephen MC, Igbokwe NH, Idowu AO, Ezeobiora CE. Preliminary phytochemical and GC-MS screening of ethanol extract of *Khaya ivorensis* bark, and *Flabellaria paniculata* and *Rhapiostylis beninensis* roots. Trop J Phytochem Pharm Sci 2025; 4 (4) 166 – 173 http://www.doi.org/10.26538/tjpps/v4i4.4

Official Journal of Natural Product Research Group, Faculty of Pharmacy, University of Benin, Benin City, Nigeria.

Rhapiostylis beninensis, which belongs to the family Metteniusaceae and is locally known as *oke ikpokrikpo* and *itá para* in Igbo and Yoruba, respectively, is a woody, glabrous, spreading or scrambling, evergreen shrub or liane that is Indigenous to tropical Africa. The Bantu people of Africa traditionally utilize it as an anti-inflammatory agent, while the bark and leaf stem root are used as laxatives. The leaf, stem, and root are used as a vermifuge, and the bark is used in treating insanity. The leaf is used to treat disorders like arthritis, rheumatism, anus haemorrhoids, eye treatments, and pulmonary problems.

Khaya ivorensis belongs to the Meliaceae family, commonly known as African mahogany. It grows widely in Angola, Gabon, Liberia, Côte d'Ivoire, Ghana, Nigeria, and Cameroon. In Nigeria, it is known as *Oganwo* in Yoruba and *madaci* in Hausa. The tree is 180 feet tall and 20 feet in diameter, but it is typically smaller, with powerful buttresses that are typically no taller than 8 feet. The scaly bark that might be grey, reddish-brown, or even dark brown with pinkish-red slashes and fruits that are larger than those of *K. senegalensis* and have thinner walls than those of *K. grandifoliola* are characteristics that help identify it as a plant that thrives in moist woods.[2] The young shoot leaf is used as a pain reliever, while the bark and root are utilized for rheumatism, arthritis, malaria, pulmonary issues, skin, mucosae, febrifuges, tumours, cancers, malnutrition, and debility.

Flabellaria paniculata belongs to the family Malpighiaceae. The sole species still alive in this genus, *F. paniculata*, may grow to a length of 3–15 meters (9.8–49.2 feet). With paniculate, lateral, and terminal

inflorescences up to 20 cm long, these plants are woody vines. Flowers have white, spatulate petals and are radially symmetrical, measuring about 1 centimetre in diameter. In equatorial Africa, *F. paniculata* is abundant in thickets, woodlands, and forests, particularly along rivers, at a height of 1,150-1,650 meters (3,770–5,410 ft). It is used to treat skin infections, wounds, ulcers and inflammation in Nigeria.

Gas chromatography-mass Spectrometry is a technique for separating organic molecules utilizing two different compound analysis methods. Alkaloids, fatty acids, terpenoids, non-polar chemicals, and lipids are all analyzed using GC-MS.[5] The identification of secondary metabolites in both plant and non-plant materials, such as phenols, steroids, and alkaloids, as well as sugars, amino acids, and fatty acids, has long been recognized as an important analytical task for gas chromatography-mass spectrometry (GC-MS). The bioactive profile may be useful for determining underlying mechanisms and connecting the key molecules required for various biological activities.[6] Phytochemical screening and GC-MS profiling extracts from these medicinal plants would form the basis for discovering pharmaceutically important compounds.

Materials and Methods

Collection and identification of plant material

The roots of *F. paniculata*, *R. beninensis* and bark of *K. ivorensis* were collected from Olosha market (Latitude: 6° 31' 59.99" N Longitude: 3° 20 59.99" E), Lagos state, in January 2022. The plants were authenticated at the Department of Botany, University of Lagos. Voucher numbers LUH 9076, LUH 10056, and LUH 9055 for the bark of *K. ivorensis*, roots of *F. paniculata* and *R. beninensis*, respectively, were deposited at the Department of Botany for further reference.

Preparation of Extracts

The roots of *F. paniculata*, *R. beninensis* and the bark of *K. ivorensis* collected were dried by air at room temperature and ground into coarse powder using a mill. 3 kg each of *K. ivorensis* and *F. paniculata*, and 2.2 kg of *R. beninensis* were weighed and soaked in 5 L, 17.5 L and 9.5 L of 70% ethanol, respectively and exhaustively macerated at room temperature through percolation for 72h. The extract was filtered through cotton wool and Whatmann No. 1 filter paper and then concentrated to dryness by a rotary evaporator operating at 40 °C .[7]

Phytochemical Screening

Qualitative Analysis

A preliminary qualitative analysis to determine the presence of various phytochemical compounds, such as alkaloids, flavonoids, tannins, phlobatannins, saponins, reducing sugar, glycosides, phenol, steroids, and terpenoids, in each of the ethanol extracts of the barks of *K. ivorensis*, *F. paniculata*, and *R. beninensis* was done as follows using the methods as previously described by Abdelazem *et al*(2021).[8]

Detection of Alkaloids

Five milligrams of extract were added to 2 mL of diluted hydrochloric acid and filtered. A few drops of Dragendroff's reagent (a solution of potassium bismuth iodide) were added to the filtrate. The precipitation of a red colour showed the presence of alkaloids in the extracts. [8]

Detection of Flavonoid

Two millilitres of lead acetate were added to 5mg of the extract. The precipitation of a red colour showed the presence of flavonoids. [8]

Detection of Steroids

A mixture of 5 mg of each extract and 2 mg of H_2SO_4 was combined with 2 ml of acetic anhydride. A change in the colour of the mixture from violet to blue or green confirms the presence of steroids. [8]

Detection of Terpenoids

The Salkowski test to detect the presence of terpenoids was performed by mixing 2 mL of chloroform with 5 mg of the test extracts and adding 3 ml of concentrated H_2SO_4 to create a layer. An appearance of reddish brown colour on the inner face confirms the presence of Terpenoids. [8]

Detection of Phenols

A few drops of ferric chloride solution were added to 5 mL of the extracts. The development of a bluish-black colour confirms the presence of phenol. [8]

Detection of Saponins

Test extract (0.5 mg) was mixed and well shaken with 5 mL of distilled water. Development of a foamy, creamy material with minute bubbles confirms the presence of saponins. [8]

Detection of Tannins

The extract was diluted with water and heated in a water bath. After filtering the mixture, iron (III) chloride was added to the filtrate. A dark green colour confirms the presence of tannins. [8]

Detection of phlobatannins

The presence of phlobatannins was determined by adding 2 mL of 1% H_2SO_4 to 1 mL of the extract, which resulted in a crimson colour. [8]

Quantitative Analysis

The quantitative phytochemical analysis was conducted to estimate the total alkaloid, steroid, flavonoid, phenol, and tannin content in the 70% ethanol extracts of *K. ivorensis* bark, *F. paniculata* roots, and *R. beninensis* roots. Alkaloid estimation followed the method of Dey *et al* (2020) with modifications,[9] where a mixture of plant extract, chloroform, phosphate buffer (pH 4.7), and bromocresol green (BCG) solution was prepared and diluted, and absorbance was measured using Spectrophotometer (Spectronic®-21, China) at 470 nm against a blank, with concentrations expressed as atropine equivalents. Steroid quantification was performed using the method of Hossain *et al*. (2013),[10] in which the extract was treated with sulfuric acid (4N), iron (III) chloride, and potassium hexacyanoferrate (III), heated at 70°C for 30 minutes, and the absorbance measured at 780 nm, with results expressed as cholesterol equivalents. Flavonoid content was determined using the aluminium chloride colourimetric method.[11] where the extract was combined with aluminium chloride (1.2%) and potassium acetate (120 mM), incubated for 30 minutes, and the absorbance read at 415 nm, with quercetin used as reference standard. Phenolic content was quantified using the Folin-Ciocalteu method, in which the extract was mixed with Folin reagent (10%) and sodium bicarbonate (7.5%), incubated at 45°C for 45 minutes, and the absorbance measured at 765 nm, and the results expressed as gallic acid equivalents.[13] Tannins were estimated using the Folin-Denis colourimetric method,[14] where the sample was extracted with distilled water, filtered, mixed with standard tannin solution or distilled water, followed by Folin reagent and sodium carbonate, incubated at 28°C for 90 minutes, and the absorbance measured at 765 nm, with the results expressed as tannic acid equivalents.

GC-MS Analysis

The GC-MS analysis was conducted at the Nigerian Institute of Medical Research (NIMR) in Lagos using a combined 7890A Gas Chromatograph system (Agilent® 19091-433HP, USA). Precisely six microliters of 1 mg/mL of extracts were injected into the GC-MS. The carrier gas, helium, flowed at a rate of 0.9 mL/min. 1.0 litres of injection volume, a 250 °C injector, and a 200 °C ion source. 250°C was the interface temperature. When the oven reached 300°C, the temperature increased by 15°C/min after being kept at 60°C for two minutes. A 45–700 a.m.u. acquisition mass range and a 70-eV electron ionization mode were programmed into the mass spectrometer and run for approximately 30 minutes. Their mass spectra were compared to those kept in the Nigerian Institute of Medical Research (NIMR) database to confirm their identity.

Statistical Analysis

Statistical analysis was carried out using Excel application version 11.0. Values reported for quantitative analysis were taken in duplicates. The mean value (X) was recorded as X±SD, where X = mean and SD = Standard deviation

ISSN 2955-1226 (Print)
ISSN 2955-123(Electronic)

Results and Discussion

Qualitative Analysis

The percentage yield obtained for the extracts was 4.3%, 2.85% and 4.46% for *K. ivorensis*, *R. beninensis* and *F. paniculata*, respectively (Table 1). The qualitative analysis shows that steroids, saponins, flavonoids and terpenoids were all contained in the extracts of *K. ivorensis*, *F. paniculata* and *R. beninensis*. The alkaloids and cardiac glycosides were absent in all. Tannins, Phenols and reducing sugars were found in *K. ivorensis* and *F. paniculata*, while phlobatannins were only found in *R. beninensis* (Table 1).

Table 1: Extraction and Phytochemical compositions of the plant extracts

	Plant		
	***K. ivorensis* bark**	***R. beninensis* root**	***F. paniculata* root**
% yield	4.3	2.85	4.46
Secondary metabolites			
Tannins	+	-	+
Phlobatannins	-	-	+
Saponin	+	+	+
Steroids	+	+	+
Alkaloids	-	-	-
Terpenoids	+	+	+
CG	-	-	-
Phenols	+	+	+
Flavonoids	+	+	+

CG stands for cardiac glycosides.
+ denotes positive; - denotes negative

Quantitative Analysis

The quantitative analysis showed that flavonoid content was highest in all three 3 plant extracts, followed by phenol, tannin, saponin, and steroids and least in terpenoids. Tannins and phenols were not detected in the extracts of *R. beninensis*. The concentration of all the phytochemicals was also highest in the extracts of *K. ivorensis*, except saponin and steroids. The extract of *R. beninensis* contains the least amount of phytochemicals among the 3 extracts studied. The flavonoid content was greater in *K. ivorensis* (109mg/100g) >*F. Paniculata* (52mg/100g)> *R. beninensis* (38mg/100g) respectively (Table 2)

Table 2: Quantitative Analysis of ethanol extracts of *K. ivorensis*, *R. beninensis* and *F. paniculata*

Secondary metabolites (mg/100g)	**Plant**		
	***K. ivorensis* bark**	***R. beninensis* root**	***F. paniculata* root**
Tannins	39.67±4.77	-	34.36±0.97
Saponin	34.04±2.41	27±3.63	41.07±1.76
Steroids	23.15±0.47	24.47±0.70	26.36±0.70
Terpenoids	15.7±1.16	12.88±0.70	13.54±0.87
Phenols	54.53±6.57		47.23±1.33
Flavonoids	109.1±41.81	38.65±8.54	52.18±5.33

GC-MS profiling

The GC-MS profiling of the ethanol extracts of the 3 plants shows their active principles with their retention time (RT), chemical formula, quality, area and the mass spectra of the constituents which were compared to those in the NIST library are shown in Tables 3, 4, 5 and Figure 1, 2 and 3. The GC-MS analysis of the plant extracts identified 33, 37, and 33 different bioactive compounds from *K. ivorensis*, *F. paniculata*, and *R. beninensis*, respectively. The most abundant compounds in the *K. ivorensis* extracts are linoleic acid ethyl ester - (30.76%), (E)-9-octadecanoic acid ethyl ester (17.72%) and hexadecanoic acid ethyl ester (17.29%). In *F. paniculata* extracts, ethyl oleate (23.46%), hexadecanoic acid ethyl ester (14.55%) and octadecenoic acid ethyl ester (26%) were the major compounds, while *R. beninensis* extracts have hexadecanoic methyl ester (19.24%) and 9-octadecenoic acid (19.47%)

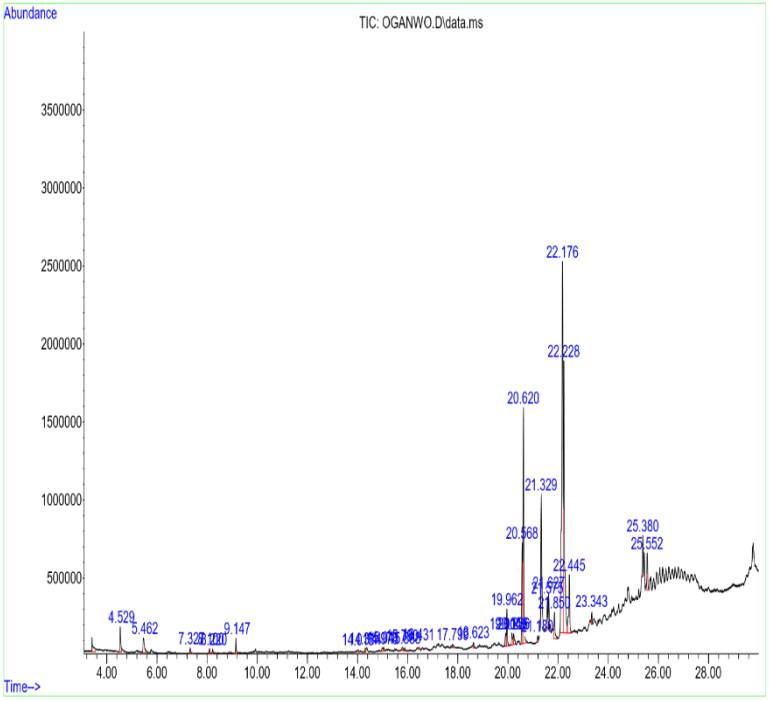

Figure 1: **GC-MS chromatogram of ethanol extract of *K. ivorensis* bark**

The major compounds found in the bark of *K. ivorensis* includes (30.76%) Linoleic acid ethyl ester, (17.72%) (E)-9-Octadecenoic acid ethyl ester, (17.29%) Hexadecanoic acid, ethyl ester, (9.34%) p-Mentha-1,5,8-triene, (4.00%) Octadecanoic acid, ethyl ester, (2.62%) Hexadecanoic acid, methyl ester, (1.79%) Piperidine, 1-[5-(1,3-benzodioxol- 5-yl)-1-oxo-2,4-pentadienyl]-, (Z, Z)-, (1.73%) Methyl stearate, (1.72%) Methyl 10-trans, 12-cis-octadecadienoate, (1.58%) Bis(2-ethylhexyl) phthalate.

The ethanol extracts of the three plants investigated were rich in steroids, saponins, flavonoids and terpenoids but devoid of alkaloids and cardiac glycosides. This is consistent with previous studies that showed that secondary metabolites such as alkaloids, tannins, flavonoids, and phenolic compounds are the most significant bioactive components of plants.[2,16,17] Characterization of plant extracts to define their phytochemical composition is important because it could yield information that could guide screening for bioactivity.

Although some of the phytoconstituents were found in the extracts of the three plants, some were unique to one or two of the plants. For instance, while *K. ivorensis* and *F. paniculata* possess tannins, flavonoids and phenols, only the extracts of *R. beninensis* possess phlobatannins. Many of these compounds have been linked with pharmacological effects that could make them useful in treating certain diseases. Flavonoids have been demonstrated to reduce the development, growth, and spread of tumours, decrease coronary heart disease and are known to have antioxidant properties.[18]

ISSN 2955-1226 (Print)
ISSN 2955-123(Electronic)

Table 3: GC-MS profiling of ethanol extract of *K. ivorensis*

S/N	RT	Area	Compound	Quality	Chemical formula
1.	3.408	1.06	Cycloprop[a]inden-6-ol	60	$C_{10}H_{10}O$
2.	4.529	1.38	Silane, triethylfluoro-	50	C_3H_9FSi
3.	5.462	1.45	Furfural	86	$C_5H_4O_2$
4.	7.327	0.35	3-Pentenoic acid	59	$C_7H_{12}O_2$
5.	8.100	0.22	Tetraethyl silicate	93	$C_8H_{20}O_4Si$
6.	8.220	0.24	Cyclotetrasiloxane	87	$C_8H_{24}O_4Si_4$;
7.	9.147	0.74	Cyclohexene	87	$C_{10}H_{16}$
8.	14.016	0.19	1,13-Tetradecadien-3-one	27	$C_{14}H_{24}O$
9.	14.314	0.22	1,2-Benzenedicarboxylic acid	46	$C_{11}H_{12}O_4$
10.	14.978	0.23	2-Bromopropionic acid	38	$C_3H_5BrO_2$
11.	15.41	0.21	O-Methoxy-.alpha.-methyl benzyl alcohol	22	$C_9H_{12}O_2$
12.	15.790	0.29	Methyl 2-oxo-5,6,7,8-tetrahydro-1H-quinoline-3-carboxylate	70	$C_{25}H_{25}NO_3$
13.	15.888	0.19	p-Butyrophenetidide	30	$C_8H_{11}NO$
14.	16.431	0.26	Undecanoic acid, ethyl ester	80	$C_{13}H_{26}O_2$
15.	17.779	0.24	1-Chloromethylene-decahedron-naphthalene	64	$C_{10}H_{18}$
16.	18.623	0.29	Ethyl 15-methyl-hexadecanoic	64	$C_{19}H_{38}O_2$
18.	19.962	2.62	Hexadecanoic acid, methyl ester	98	$C_{17}H_{34}O_2$
19.	20.156	0.74	cis-Vaccenic acid	95	$C_{18}H_{34}O_2$
20.	20.236	0.69	Oxacycloheptadec-8-en-2-one	96	$C_{16}H_{28}O_2$
22.	20.620	17.29	Hexadecanoic acid, ethyl ester	98	$C_{18}H_{36}O_2$
23.	21.180	0.30	Benzene, 2-methoxy-1,3-dimethyl-	60	$C_9H_{12}O$
24.	21.329	9.34	p-Mentha-1,5,8-triene	87	$C_{10}H_{14}$
25.	21.575	1.72	Methyl-10-trans,12-cisoctadecadienoate	99	$C_{19}H_{34}O_2$
26.	21.627	1.64	9-Octadecenoic acid (Z)-, methyl ester	99	$C_{19}H_{36}O_2$
27.	21.850	1.73	Methyl stearate	98	$C_{19}H_{38}O_2$
28.	22.176	30.76	Linoleic acid ethyl ester	99	$C_{20}H_{36}O_2$
29.	22.228	17.72	(E)-9-Octadecenoic acid ethyl ester	99	$C_{20}H_{38}O_2$
30.	22.445	4.00	Octadecanoic acid, ethyl ester	98	$C_{20}H_{40}O_2$
31.	23.343	0.52	Piperine	91	$C_{17}H_{19}NO_3$
32.	25.380	1.58	Bis(2-ethylhexyl) phthalate	76	$C_{24}H_{38}O_4$
33.	25.552	1.79	Piperidine,	97	$C_{17}H_{19}NO_3$

Table 4: GC-MS profiling of ethanol extract of *F. paniculata*

S/N	RT	Area%	Compound	Quality	Chemical formula
1.	3.459	1.15	endo-3-Methylenetricyclo	84	C_9H_{10}
2.	3.848	2.26	Propanoic acid	17	$C_3H_6O_4$
3.	3.997	0.38	Pentanoic acid methyl ester	47	$C_7H_{14}0$
4.	4.357	0.13	Acetamide	43	$C_{10}H_{12}N_2OS$
5.	4.586	2.98	Silane, triethylfluoro-	50	C_3H_9Fsi
6.	5.141	0.44	Trimethylphosphine	43	C_3H_9P
7.	5.359	0.15	2-Ethylacridine	43	$C_{15}H_{13}N$
8.	5.427	0.20	10-Undecen-1-ol	59	$C_{11}H_{22}O$
9.	5.530	1.40	Acetic acid methyl ester	38	$C_5H_{10}O4$
10.	5.805	1.01	2-Cyclopenten-1-one	86	C_5H_6O
11.	6.475	0.22	Benzene, isothiocyanates-	46	C_7H_5NS
12.	6.892	0.35	Cyclopentanemethanol, alpha.-dimethyl	47	$C_6H_{12}O$
13.	8.140	0.38	Tetraethyl silicate	98	$SiC_8H_20O_4$
14.	8.260	0.48	Cyclotetrasiloxane, octamethyl-	86	$C_8H_{24}O_4Si_4$
15.	8.752	0.15	Phenyl buta-2,3-dienyl ether	50	$C_{10}H_{10}O$
16.	9.816	0.17	Isopropyl tetradecyl ether	14	$C_{17}H_{36}O$
17.	15.332	0.15	Cycloheptasiloxane, tetradecamethyl-	86	$C_{14}H_{42}O_7Si_7$
18.	15.510	0.16	2,4-Di-tert-butyl-phenol	46	$C_{14}H_{22}O$
19.	16.328	1.73	Megastigmatrienone	96	$C_{13}H_{18}O$
20.	16.397	0.94	3-(4-Isopropylphenyl)-2-methyl propionaldehyde	55	$C_{13}H_{18}0$
21.	16.723	0.17	1-Hepten-3-ol, 1-phenyl-	35	$C_7H_{14}O$
24.	17.575	0.16	Cyclotridecane	90	$C_{14}H_{28}$
25.	17.827	0.36	9-Octadecen-1-ol,	64	$C_{18}H_{36}O$
26.	19.681	0.38	Docosanoic acid, ethyl ester	53 53 53	$C_{22}H_{44}O_2$
27.	19.944	0.44	Octadecanoic acid, methyl ester,	42	$C_{22}H_{36}O_2$
28.	20.597	14.55	Hexadecanoic acid, ethyl ester	98	$C_{18}H_{36}O_2$
30.	20.928	2.06	6-Methoxy-4-methyl quinoline	90	$C_{11}H_{11}NOS$
31.	20.997	5.89	2,5-di-tert-Butylaniline	80	$C_{14}H_{23}N$
32.	21.586	1.25	Ethyl 14-methyl-hexadecanoic	70	$C_{19}H_{38}O_2$
33.	21.661	0.91	9-Octadecenoic acid (Z)-, methyl ester	94	$C_{18}H_{34}O_2$
34.	21.884	0.88	Methyl stearate	90	$C_{19}H_{38}O_2$
35.	22.210	23.47	Ethyl Oleate	94	$C_{20}H_{38}O_2$
36.	22.262	26.01	(E)-9-Octadecenoic acid ethyl esters	99	$C_{20}H_{38}O_2$
37	22.479	8.64	Octadecanoic acid, ethyl ester	99	$C_{20}H_{40}O_2$

High flavonoid contents have also been associated with good antibacterial activity.[19] The quantitative assay in this study showed that the extracts of the 3 plants possess a significant amount of flavonoids, which was highest in the extracts of *K. ivorensis* extracts and the order of *K. ivorensis* (109mg/100g) >*F. Paniculata* (52mg/100g)> *R. beninensis* (38mg/g), respectively.

This suggests that the extracts of the plants and those of *K. ivorensis* would be suitable for screening as an antibacterial agent. Phlobatannins have been noted for their anti-inflammatory, analgesic, and anti-oxidant effects that can help heal wounds.[20] Saponin is useful in treating cardiovascular disease because it lowers blood cholesterol by blocking

ISSN 2955-1226 (Print)
ISSN 2955-123(Electronic)

reabsorption.[21] Additionally, it has been established that saponin has antitumor and antimutagenic activity and can reduce the risk of human cancer cells from growing. Saponin is thought to react with the cholesterol-rich cancer cell membranes, limiting their growth and visibility.[8] It is also active against cancer and hypolipidemic.[20]

The possession of these agents that have demonstrated bioactivity in certain disease conditions suggests that the extracts of the 3 plants studied are good candidates for further research to establish their bioactivity and develop them as a treatment against selected disease conditions.

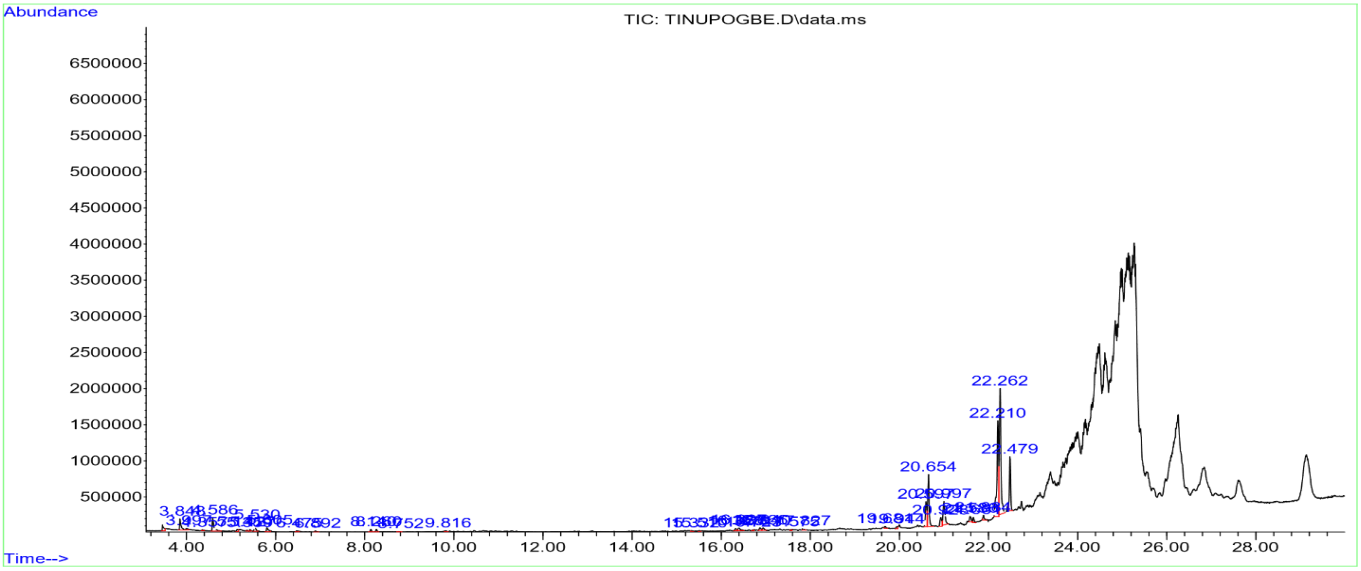

Figure 2: GC-MS chromatogram of ethanol extract of the root of *F. paniculata*

Compounds found in *F. paniculata* include (26.01%) (E)-9-Octadecenoic acid ethyl esters. (23.47%) Ethyl Oleate, (14.55%) Hexadecanoic acid, ethyl ester, (8.64%) Octadecanoic acid, ethyl ester, (5.89%) 2,5-di-tert-Butylaniline, (2.98%) Silane, triethylfluoro, (2.26%) Propanoic acid, 2,3-dihydroxy-1,5-Hexadiene, (2.06%)6-Methoxy-4-methylquinoline-2thio, (1.73%) Megastigmatrienone.

Table 5: GC-MS profiling of ethanol extract of *R. beninensis*

S/N	RT	Area	Compound	Quality	Chemical formula
1.	3.430	1.29	Benzenesulfonic acid, 4-methyl-, methyl ester	50	$C_8H_{10}O_3S$
2.	3.808	1.72	4,4-Dimethoxy-2-methyl-2-butanol	23	$C_7H_{16}O_3$
3.	4.008	0.30	Acetic acid, (ethylthio)-, methyl ester	38	$C_4H_8O_2S$
4.	4.512	6.72	Silane, triethylfluoro-	50	C_3H_9Fsi
5.	5.073	0.26	2-Ethylacridine	22	$C_{15}H_{13}N$
6.	5.445	1.63	1-(4-Bromophenyl) ethanol	38	C_8H_9BrO
7.	5.725	0.75	2-Cyclopenten-1-one	80	C_5H_6O
8.	6.675	0.14	Isosorbide Dinitrate	16	$C_6H_8N_2O_8$
9.	6.824	0.28	2-Cyclopenten-1-one	25	C_6H_8O
10.	8.048	0.47	Tetraethyl silicate	97	$C_8H_20O_4Si$
11.	8.168	1.87	Cyclotetrasiloxane	83	$C_8H_{24}O_4Si_4$
12.	9.713	0.19	Ethanedial, dioxime	38	$C_2H_4N_2O_2$
13.	10.572	0.55	Cyclopentasiloxane	90	$C_{10}H_30O_5Si_5$
14.	11.207	0.20	Propyl tetradecyl ether	30	$C_{17}H_{36}O$
15.	13.032	0.35	Cyclohexasiloxane, dodecamethyl-	87	$C_{12}H_{36}O_6Si_6$
16.	13.129	0.51	Benzenamine,	78	$C_{10}H_{14}0$
17.	13.495	0.16	Benzenepropanol	30	$C_{10}H_{14}O$
18.	15.040	0.16	Ethane, 1,1,2-trichloro-	38	$C_2H_3Cl_3$
19.	15.246	0.62	Cycloheptasiloxane	87	$C_{14}H_{42}O_7Si_7$
20.	15.510	0.27	1,3,4-Thiadiazol	46	$C_9H_9N_3S$
21.	17.192	0.29	Trimethylsilyl	25	C_3H_9Si
22.	17.793	0.40	Methyl tetradecanoate	95	$C_{15}H_{30}O_2$
23.	19.864	19.24	Hexadecanoic acid, methyl ester	98	$C_{17}H_{34}O_2$
26.	20.574	5.8	Hexadecanoic acid, ethyl ester	97	$C_{18}H_{36}O_2$
27.	21.529	19.47	9-Octadecenoic acid (Z)-, methyl ester	99	$C_{19}H_{36}O_2$
28.	21.581	15.17	11-Octadecenoic acid, methyl ester	99	$C_{19}H_{36}O_2$
29.	21.770	7.65	Methyl stearate	97	$C_{19}H_{38}O_2$
31.	22.136	3.51	14-Methyl-8-hexadecyl-1-ol	98	$C_{17}H_{32}O$
32.	22.182	6.21	(E)-9-Octadecenoic acid ethyl ester	99	$C_{20}H_{38}O_2$
33.	22.405	3.82	Octadecanoic acid, ethyl ester	92	$C_{20}H_{40}O_2$

ISSN 2955-1226 (Print)
ISSN 2955-123(Electronic)

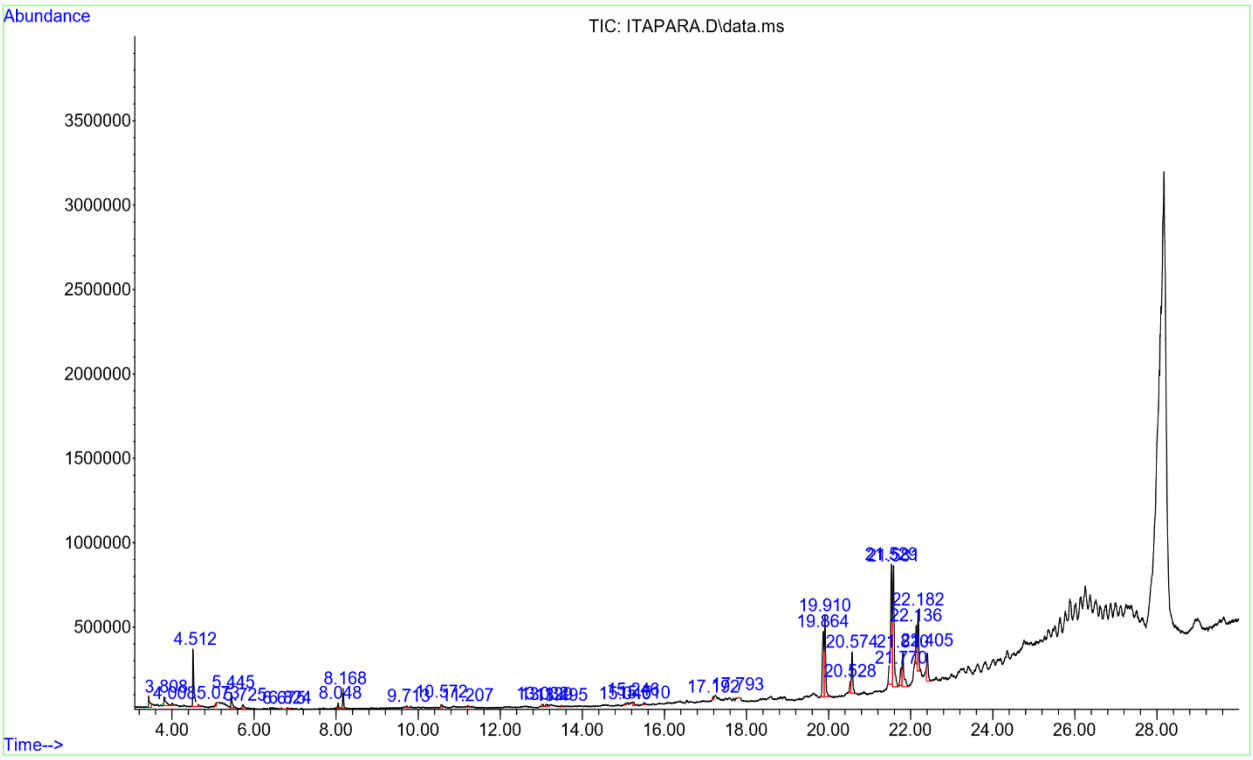

Figure 3: GC-MS chromatogram of ethanol extract of the root of *R. beninensis*

The majority-present compounds in *R. beninensis* are (19.47%) 9-Octadecenoic acid (Z)-, methyl ester, (19.24%) Hexadecanoic acid, methyl ester, (15.17%) 11-Octadecenoic acid, methyl ester, (7.65%) Methyl stearate, (6.21%) (E)-9-Octadecenoic acid ethyl ester, (6.72%) Silane, triethylfluoro, (5.8%) Hexadecanoic acid, ethyl ester, (3.82%) Octadecanoic acid, ethyl ester, (3.51%) (R) (-)-14-Methyl-8-hexadecyn-1-ol, (1.87%) Cyclotetrasiloxane, octamethyl.

The extracts of *K. ivorensis* stood out from the three plants studied because it contains as many phytochemicals as that of *F. paniculata*, but more than that of the *R. beninensis*. Its concentration of all the phytochemicals was also the highest except for saponin and steroids.

The GC-MS analysis of the ethanol extracts of the barks of *K. ivorensis*, *F. paniculata*, and *R. beninensis* roots to profile for the presence of bioactive compounds revealed their active principles with their retention time (RT), chemical formula, quality, and area. The comparison of the mass spectra of the constituents to those in the NIST library showed that the plant extracts identified 33, 37, and 33 different bioactive compounds from *K. ivorensis*, *F. paniculata*, and *R. beninensis* respectively. The most abundant compounds identified by GC-MS screening in the *K. ivorensis* extracts are linoleic acid ethyl ester (30.76%), (E)-9-octadecanoic acid ethyl ester (17.72%) and hexadecanoic acid ethyl ester (17.29%). In *F. paniculata* extracts, ethyl oleate (23.46%), hexadecanoic acid ethyl ester (14.55%) and octadecenoic acid ethyl ester (26%) were the major compounds while *R. beninensis* extracts have hexadecanoic methyl ester (19.24%) and 9-octadecenoic acid (19.47%). The most abundant secondary metabolites that are common to the three extracts as shown by the GC-MS analysis are hexadecanoic acid ethyl ester and octadecenoic acid ethyl ester. Hexadecanoic acid has been shown to have anti-inflammatory, antibacterial, and antifungal properties and has been used in the production of soap, cosmetics, and industrial mold release agents.[5] Hexadecenoic acid is also used as a flavouring compound in foods such as condiments, spices, and as a lubricant, antioxidant, hypocholesterolemic, nematicide, pesticide, and 5-alpha reductase inhibitor.[22,23] It has been documented that octadecanoic can be used as an emulsifier for food with no bioactivity.[24] Studies have shown that ethyl oleate piperidine-an alkaloid and p-mentha-1,5,8-triene have antimicrobial effects.[5,25] Although this current study determined the secondary metabolites components of the extracts of the three plants, it did not investigate the bioactivity of the extracts. Nevertheless, it provided preliminary information that could guide the basis for screening the extracts of the plants for bioactivity.

Conclusion

Phytochemical screening of the extracts of *K. ivorensis*, *F. paniculata* and *R. beninensis* showed the presence of steroids, flavonoids, saponins, and terpenoids. Significant quantities of tannins, phenols and reducing sugar were found in the extracts of *K. ivorensis* and *F. paniculata*. The GC-MS profiling of the extracts yielded compounds such as octadecanoic, hexadecanoic acid, ethyl oleate and p-mentha-1, 5, 8-triene acid in significant quantities. The extracts of the 3 plants contain secondary metabolites that could be sources of bioactive agents for therapeutic purposes. The information derived from the characterization of plant extracts for their phytochemical composition could be used to screen them for bioactivity.

Conflict of Interest

The authors declare no conflict of interest.

Author's Declaration

The authors hereby declare that the work presented in this article are original and that any liability for claims relating to the content of this article will be borne by them.

Acknowledgments

The authors are grateful to the technical staff in the Department of Pharmaceutical Microbiology and Biotechnology, Faculty of Pharmacy, University of Lagos for their support during this work and Dr Nodza George of the Department of Botany, University of Lagos, who authenticated the plant sample.

References

1. Gul R, Jan SU, Faridullah S, Sherani S, Jahan N. Preliminary Phytochemical Screening, Quantitative Analysis of Alkaloids, and Antioxidant Activity of Crude Plant Extracts from *Ephedra intermedia* Indigenous to Balochistan. Sci. W J. 2017;5873648. doi: 10.1155/2017/5873648.
2. Oyewale OB, Khadijat AM. Antibacterial, free radical scavenging and anticancer properties of essential oil from *Khaya ivorensis* A. Juss stem bark, Int. J. Dev. Res. 2020; 10(01): 33341-33346.
3. Seukep JA, Ngadjui B, Kuete V. Antibacterial Activities of *Fagara* and *Tragia benthamii* against Multi-Drug Resistant Gram-Negative Bacteria. SpringerPlus. 2015;4:567 https://doi.org/10.1186/s40064-015-1375-y.
4. Laws M, Shaaban A, Rahman KM. Antibiotic resistance breakers: current approaches and future directions. FEMS Microbiol. Rev. 2019; 43(5):490-516. doi: 10.1093/femsre/fuz014.
5. Saragih SS, Serepina G. Phytochemical Analysis of Bioactive Compounds in Ethanolic Extract of *Sterculia quadrifida R.Br.* AIP Conf. Proc. 2021; 2353, 030098. https://doi.org/10.1063/5.0053057.
6. Sorrenti V, Burò I, Consoli V, Vanella L. Recent Advances in Health Benefits of Bioactive Compounds from Food Wastes and By-Products: Biochemical Aspects. Int. J. Mol. Sci. 2023; 24(3):2019. doi: 10.3390/ijms24032019.
7. Tsana R, Mafo M, Ottou M, Sidjui LS, Nnanga N. Antimicrobial and Antioxidant Activities of Ethanolic Stem Bark and Root Extracts of *Khaya ivorensis* A Chev . (Meliaceae). J. Pharmacogn. Phytochem. 2019; *8*(4):1393–1397.
8. Abdelazem RE, Hefnawy HT, El-Shorbagy GA.Chemical Composition and Phytochemical Screening of Citrus sinensis (Orange) Peels.Zagazig J. Agric. Res. 2021; 48(3): 793–804.
9. Dey P, Kundu A, Kumar A, Gupta M, Lee BM, Bhakta T, Dash S, Kim HS. Analysis of alkaloids (indole alkaloids, isoquinoline alkaloids, tropane alkaloids).Recent Adv. Nat. Prod. Anal. 2020:505–67. doi: 10.1016/B978-0-12-816455-6.00015-9.
10. Hossain MA, AL-Raqmi KA, AL-Mijizy ZH, Weli AM, Al-Riyami Q. Study of total phenol, flavonoids contents and phytochemical screening of various leaves crude extracts of locally grown *Thymus vulgaris.* Asian Pac J Trop Biomed. 2013; 3(9):705-10. doi: 10.1016/S2221-1691(13)60142-2.
11. Chandra S, Khan S, Avula B, Lata H, Yang MH, Elsohly MA, Khan IA. Assessment of total phenolic and flavonoid content, antioxidant properties, and yield of aeroponically and conventionally grown leafy vegetables and fruit crops: a comparative study. Evid Based Complement Alternat Med. 2014; 2014:253875. doi: 10.1155/2014/253875.
12. Deshavath NN, Mukherjee G, Goud VV, Veeranki VD, Sastri CV. Pitfalls in the 3, 5-dinitrosalicylic acid (DNS) assay for the reducing sugars: Interference of furfural and 5-hydroxymethylfurfural. Int. J. Biol. Macromol. 2020;156: 180-185.doi: 10.1016/j.ijbiomac.2020.04.045.
13. Pérez M, Dominguez-López I, Lamuela-Raventós RM. The Chemistry Behind the Folin-Ciocalteu Method for the Estimation of (Poly) Phenol Content in Food: Total Phenolic Intake in a Mediterranean Dietary Pattern. J Agric Food Chem. 2023;71(46):17543-17553. doi: 10.1021/acs.jafc.3c04022.
14. Eden WT, Wahyuono S, Cahyono E, Astuti P. Phytochemical, Antioxidant, and Cytotoxic Activity of Water Hyacinth (*Eichhornia crassipes*) Ethanol Extract. Trop J Nat Prod Res. 2023; 7(4):3606-3612 http://www.doi.org/10.26538/tjnpr/v7i8.5.
15. Ezeobiora CE, Igbokwe NH, Amin DH, Okpalanwa CF, Mota'a SC, Mendie UE (2023). Antibacterial Potential of Endophytic Fungi from *Xylopia aethiopica* and Metabolites Profiling of *Penicillium* sp. XAFac2 and *Aspergillus* sp. XAFac4 by GC-MS. Trop J Nat Prod Res. 7(7):3538-3545. http://www.doi.org/10.26538/tjnpr/v7i7.37.
16. Tungmunnithum D, Thongboonyou A, Pholboon A, Yangsabai A. Flavonoids and Other Phenolic Compounds from Medicinal Plants for Pharmaceutical and Medical Aspects: An Overview. Medicines (Basel). 2018;5(3):93. doi: 10.3390/medicines5030093.
17. Akoro SM, Ogundare OC, Ajibade SO, Awofeso DO. Phytochemical Investigation of *Aristolochias ringens* (Vahl.) n-hexane root extract using GC-MS and FTIR. Trop. J.Phyto.Pharm. Sci. 2025;4(3):111 – 122. https://www.tjpps.org/index.php/home/article/view/157
18. Ezeonu S, Ejikeme CM. Qualitative and Quantitative Determination of Phytochemical Contents of Indigenous Nigerian Softwoods. New J. Sci. 2016; 9. https://doi.org/http://dx.doi.org/10.1155/2016/5601327
19. Aires A, Marrinhas E, Carvalho R, Dias C, Saavedra MJ. Phytochemical Composition and Antibacterial Activity of Hydroalcoholic Extracts of *Pterospartum tridentatum* and *Mentha pulegium* against *Staphylococcus aureus* Isolates. Biomed Res. Int. 2016; https://doi.org/10.1155/2016/5201879
20. Uraku AJ, Uraku OH, Azi OS, Ebenyi LN, Nwankwo VUO, Koroma BM. Studies on Medicinal Chemistry Potentials of *Hannoa undulata* Essential Oil. NJP. 2022; *56*(2). https://doi.org/10.51412/psnnjp.2022.34.
21. Cao S, Liu M, Han Y, Li S, Zhu X, Li D, Shi Y, Liu B. Effects of Saponins on Lipid Metabolism: The Gut-Liver Axis Plays a Key Role. Nutrients. 2024;16(10):1514. doi: 10.3390/nu16101514.
22. Muzahid AA, Sharmin S, Hossain MS, Ahamed KU, Ahmed N, Yeasmin MS, Ahmed NU, Saha BK, Rana GMM, Maitra B, Bhuiyan MNH. Analysis of bioactive compounds present in different crude extracts of *Benincasa hispida* and *Cucurbita moschata* seeds by gas chromatography-mass spectrometry. Heliyon. 2022; 9(1):e12702. doi: 10.1016/j.heliyon.2022.e12702.
23. Mensah-Agyei GO, Ayeni KI, Ezeamagu CO. GC-MS analysis of bioactive compounds and evaluation of the antimicrobial activity of the extracts of *Daedalea elegans*: A Nigerian mushroom. Afr. J. Microbiol. Res. 2020; 14(6): 204-210.
24. Adegoke AS, Jerry OV, Ademola OG. GC-MS Analysis of Phytochemical Constituents in Methanol Extract of Wood Bark from *Durio zibethinus* Murr. Int. J. Med. Plants Nat. Prod. 2019; *5*(3): 1–11. https://doi.org/10.20431/2454-7999.0503001.
25. Foudah AI, Alqarni MH, Alam A, Salkini MA, Ross SA, Yusufoglu HS. Phytochemical Screening, In Vitro and In Silico Studies of Volatile Compounds from *Petroselinum crispum* (Mill) Leaves Grown in Saudi Arabia. Molecules. 2022; 27(3):934. doi: 10.3390/molecules27030934