The Bioscientist Journal Vol. 13 (1): 98 – 112, May 2025
Journal of the Faculty of Biosciences, Nnamdi Azikiwe University, Awka, Nigeria
Available online at *http://www.bioscientistjournal.com*
DOI 10.54117/the_bioscientist.v13i1.186



OPEN ACCESS

Full Length Research Article

PROXIMATE ANALYSIS, FTIR, AND GC-MS CHARACTERIZATION OF ETHANOL LEAF EXTRACT OF *Artocarpus heterophyllus* (JACK FRUIT)

Nwako C. A.[1*], Ene A. C.[2], Nwaogu L. A.[2], Nzebude C. P.[2]

[1]Department of Biochemistry, Federal University of Technology, Owerri.

*Corresponding author: **chinwenwako@gmail.com**

Article History: *Received: 8th October 2025 Accepted: 11th November 2025*

Abstract

Medicinal plants are rich in phytochemicals—bioactive secondary metabolites—that are central to traditional medicinal practices. Despite the existence of approximately 350,659 medicinal plant species globally, only about 2% have been scientifically investigated for their phytochemical profiles and bioactivities. This study assessed the proximate composition, (Fourier Transform Infrared Spectroscopy (FTIR), and Gas Chromatography-Mass Spectrometry (GC-MS) characteristics of *A. heterophyllus* leaves. Proximate analysis revealed a high carbohydrate content (49.138%), followed by moisture (12.525%), fat and oil (10.418%), ash (10.094%), and fibre (8.988%). FTIR analysis identified multiple functional groups, including alkenes, alcohols, sulfonates, nitro compounds, aromatics, isothiocyanates, carboxylic acids, and alkanes, suggesting diverse chemical functionalities. GC-MS profiling detected 48 compounds, with the most abundant being Succinic acid, 4-chloro-3-methylphenyl 2-methoxyphenyl ester (19.02%), and 9-Octadecenoic acid, 2,3-dihydroxypropyl ester (16.85%), among others. Literature comparison indicated that many of these compounds possess pharmacological activities such as antibacterial, antioxidant, antifungal, anti-inflammatory, anticancer, cytotoxic, antidiabetic, and hypolipidemic effects. These findings support the traditional medicinal use of *Artocarpus heterophyllus* leaves and highlight their potential for pharmaceutical development.

Keywords: *Artocarpus heterophyllus*, Proximate analysis, GC-MS, FTIR.

Introduction

Plants are rich in bioactive components, such as tannins, alkaloids, and flavonoids, which have significant effects on human physiology. These phytochemicals, naturally present in plants, offer health advantages beyond basic nutritional value (Georgia *et al.*, 2024). For ages, natural products have been integral to various traditional medicine systems worldwide, addressing a multitude of health issues. They remain invaluable in inspiring and guiding the creation of innovative and more effective pharmaceuticals for modern ailments (Ajinwo *et al.*, 2024). Traditional medicine systems continue to be popular due to factors such as limited availability of conventional medicines, increasing populations, the high expenses of modern treatments, and the undesirable side effects of many synthetic drugs (Nishath *et al*., 2025). Consuming a diet abundant in plant-based foods and phytochemicals is associated with a reduced risk of chronic diseases in humans (Sundarraj and Ranganathan, 2017). Medicinal plants are plentiful in phytochemicals, also known as active secondary metabolites, which play a crucial role in traditional therapies. However, a mere 2% of the approximately 350,659 known medicinal plant species globally have undergone scientific scrutiny to identify their phytochemical components and potential bioactivities (Nishath *et al*., 2025).

Jackfruit, a tropical evergreen plant belonging to the Moraceae family, originates from the Western Ghats of southern India, Sri Lanka, and the rainforests of Malaysia, Indonesia, and the Philippines. Now widely grown throughout the tropics, jackfruit trees yield the world's largest fruits, which can reach up to 55 kilograms in weight, 90 centimetres in length, and 50 centimetres in diameter (Uwanta *et al.*, 2024). The leaves of *A. heterophyllus* Lam. exhibit an oval to oblong form, characterized by a subtly glossy and leathery surface. These simple leaves, arranged alternately, feature pinnate venation and maintain their verdant hue year-round. Ranging in size from 4 to 25 cm in length and 2 to 12 cm in width, their morphology is subject to variations influenced by both environmental factors and the tree's developmental progress (Muhammad *et al.*, 2025).

The phytochemical constituents of the leaves of Jackfruit can be determined with High-Performance Liquid Chromatography (HPLC) which is often being used. However, HPLC, can be laborious and expensive. Therefore, there is an increasing demand for faster, simpler, and more affordable methods for detecting phytochemicals. Gas Chromatography-Mass Spectrometry (GCMS) can be used independently or with Fourier Transform Infrared Spectroscopy (FTIR) to provide qualitative and quantitative analysis of plant-based phytochemicals as Muthulakshmi and Anusya (2017) explained. FTIR is a powerful tool for identifying and characterizing chemical compounds or functional groups in complex plant extract mixtures (Dike *et al.*, 2023). On the other hand, by conducting a proximate analysis of plants, valuable insights can be gained into their nutritional composition through the quantification of essential nutrients present in the plant matter (Teneva *et al.*, 2025).Therefore, the aim of this

research work was to characterize the phytochemical and nutritional constituents of the ethanol leaf extract of *A. heterophyllus* using GCMS, FTIR and proximate analysis.

Materials and Methods

Plant Collection and Identification

The leaves of *A. heterophyllus* were collected from Obagwa Oforola in Owerri West Local Government of Imo State. The leaves were identified by a plant taxonomist, Mr Iwueze Francis of The Department of Forestry and Wildlife Technology, School of Agriclture And Agricultural Technology Federal University of Technology Owerri with voucher number: FUTO/FWT/ERB/2025/143

Preparation of *A. heterophyllus* Ethanol Leaf Extract

The leaves of *A. heterophyllus* were washed with clean tap water and dried at room temperature for 4 weeks. After drying, the leaves were pulverised into fine powder using a mechanical grinder and stored in an air-tight container for further analysis. Five hundred grams (500g) of the powder was extracted with 1 L of ethanol using the maceration method for 72 hours as described by Abubakar and Haque (2020). The mixture was then filtered using whatman filter paper (No. 4.). The ethanol extract was concentrated using a rotary evaporator at 40ºc and was evaporated to dryness using a waterbath at 60ºC. The extract was refrigerated at 4ºC till use.

GC–MS Analyses of *A. heterophyllus* Ethanol Leaf Extract

To identify bioactive compounds, the extract underwent GC-MS analysis using Agilent Technologies gas chromatography equipment, according to the method of Dike *et al*. (2023). The analysis was conducted using a GC-7890A model coupled with an MS-5975C detector, which featured an HP-5MS capillary column (30 M length, 250 µM internal diameter, 0.25 µM film thickness). Electron ionization at 70 eV was used for spectral detection. Helium gas, with a purity, was used as the carrier at a flow rate of 1 mL/min. The temperature of the oven began at 50 °C, increased to 150 °C at 3 °C/min, and was maintained for 10 minutes. Afterward, it was raised to 300 °C at a rate of 10 °C/min. A 1 µL aliquot of a 1% extract solution, dissolved in a suitable solvent, was introduced via splitless injection. The percentage of each compound in the extract was based on peak areas from the chromatogram (Dike *et al*., 2023).

Identification of chemical constituents of *A. heterophyllus* Leaf

Bioactive compounds within the extract were pinpointed through gas chromatography, a technique that scrutinized their retention times using an HP-5MS column. Subsequently, the mass spectra derived from this process were juxtaposed against authoritative spectral databases, Replib and Mainlib, integral to the GC-MS system, enabling definitive compound identification (Dike et al., 2023).

FTIR Spectroscopy of *A. heterophyllus* Leaf Extract

Fourier Transform Infrared analysis was performed utilizing a Buck Scientific M530 instrument, which includes a deuterated triglycine sulfate detector and a potassium bromide beam splitter. The Gram A1 software was used for acquiring and processing spectral data. Samples were prepared by mixing 1.0 g of the extract with 0.5 mL of nujol, followed by application onto a salt pellet. Infrared spectra were then recorded between 4,000 and 600 cm^{-1}. Spectral data were obtained

through the co-addition of 32 scans at a 4 cm^{-1} resolution, with transmittance values representing the resultant spectra (Dike et al., 2023).

Proximate Analyses of *A. heterophyllus* Leaf Extract

A proximate analysis of *A. heterophyllus* Leaf Extract was conducted to determine the presence of moisture, protein, fat, ash, and crude fibre using the methods as described by AOAC (2005) while the carbohydrate contents were calculated as the difference of the sum of the values of the other nutrients from 100.

Results

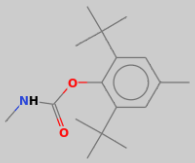
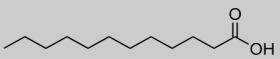
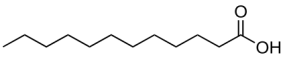
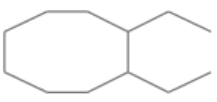
GCMS Characterization of Ethanol Leaf Extract of *A. heterophyllus*

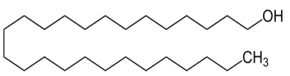
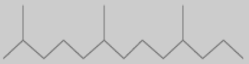
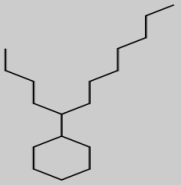
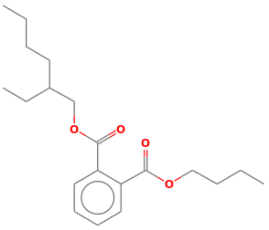
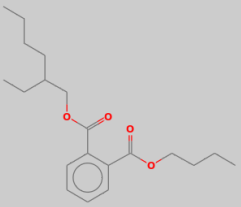
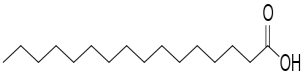
The GC-MS analyses of the ethanol leaves extract of *A. heterophyllus* (Table 1) revealed a total of 48 bioactive compounds majorly hydrocarbons, it showed the following compounds were most abundant:

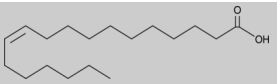
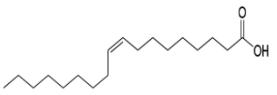
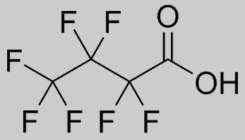
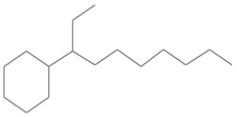
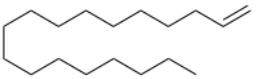
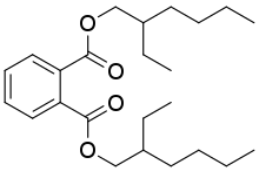
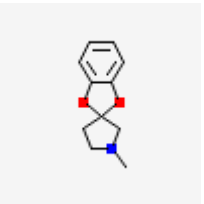
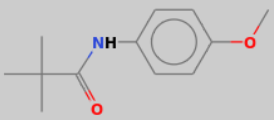
- Succinic acid, 4-chloro-3-methylphenyl 2-methoxyphenyl ester -(19.02%)
- 9-Octadecenoic acid (Z)-, 2,3-dihydroxypropyl ester -(16.85%)
- 2,6-Lutidine, 3,5-dichloro-4-cyclohexylthio- (11.52%)
- Pyrrolidine, 1-methyl-3,2'-spiro-benzo-1,3-dio xolane - (7.46%)

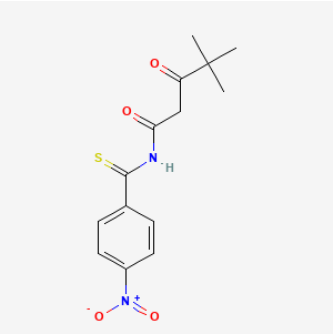
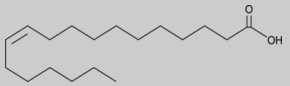
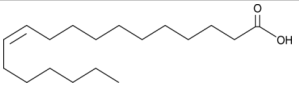
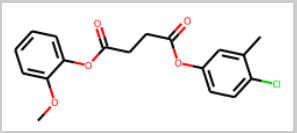
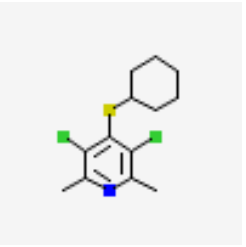
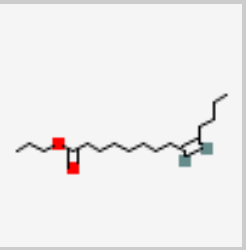
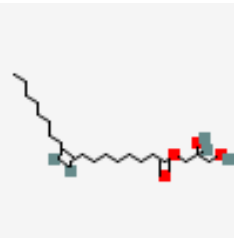
being the most abundant while Octadecane, 1-(ethenyloxy)- (0.16%), Tritetracontane (0.20), 9-Eicosene, (E)- (0.21%) were the least abundant compounds.

Table 1: GC-MS characterisation of ethanol leaf extract of *A. heterophyllus*

PK	RT (minutes)	Compound	Area Pct	Structure
1	6.8623	Cyclooctane, 1,2-diethyl-	0.54	
2	7.0011	Tetradecane	0.89	
3	8.4896	Phenol, 2,6-bis(1,1-dimethylethyl)-	0.65	
4	8.6109	Hexadecane	0.51	
5	9.5595	Dodecanoic acid	1.78	
6	9.7361	Dodecanoic acid	0.23	
7	10.0255	1-Tridecene	0.65	
8	10.1266	Cyclooctane, 1,2-diethyl-	0.34	
9	10.1893	Hexadecane	1.93	

10	10.8875	1-Hexacosanol	0.23	
11	10.9921	Tetradecane, 1-fluoro-	0.65	
12	11.7127	Heptadecane	0.86	
13	11.8457	2,6,10-Trimethyltridecane	0.84	
14	11.919	Tetracosane	0.38	
15	12.5291	Tetradecanoic acid	2.54	
16	13.0218	9-Eicosene, (E)-	1.21	
17	13.1685	Hexadecane	1.65	
18	13.3326	Hexadecane, 1-chloro-	0.65	
19	13.9125	Dodecane, 5-cyclohexyl-	0.28	
20	14.5649	Nonadecane	0.23	
21	14.7123	1,2-Benzenedicarboxylic acid, butyl 2-ethylhexyl ester	0.78	
22	15.316	n-Hexadecanoic acid	4.65	
23	15.7725	5-Eicosene, (E)-	1.27	
24	15.8975	Nonadecane	0.36	
25	17.4737	9-Octadecenoic acid	5.34	
26	17.6435	2- Chloropropionic acid, hexadecyl ester	1.17	

27	17.8409	cis-Vaccenic acid	0.51	
28	17.8732	Oleic Acid	0.44	
29	17.9526	Heptadecyl heptafluorobutyrate	0.54	
30	18.2928	1-Docosene	2.29	
31	18.4016	Tritetracontane	0.58	
32	18.5206	9-Eicosene, (E)-	0.21	
33	19.0821	Octadecane, 1-(ethenyloxy)-	0.16	
34	19.1959	Decane, 3-cyclohexyl-	0.42	
35	19.5793	Carbonic acid, eicosyl vinyl ester	0.22	
36	20.6082	1-Octadecene	0.98	
37	20.707	Tritetracontane	0.20	
38	21.7858	Bis(2-ethylhexyl) phthalate	0.70	
39	24.8635	Squalene	1.08	
40	31.3241	Pyrrolidine, 1-methyl-3,2'-spiro-benzo-1,3-dioxolane-	7.46	
41	32.097	Propanamide, N-(3-methoxyphenyl)-2,2-dimethyl-	0.69	

42	32.2001	pentanamide, 4,4-dimethyl-N-(4-nitrophenyl)-3-oxo-	1.02	
43	32.3524	cis-Vaccenic acid	2.62	
44	32.556	cis-Vaccenic acid	2.69	
45	32.9484	Succinic acid, 4-chloro-3-methylphenyl 2-methoxyphenyl ester	19.02	
46	32.9781	2,6-Lutidine, 3,5-dichloro-4-cyclohexylthio-	11.52	
47	36.6347	cis-9-Tetradecenoic acid, propyl ester	1.17	
48	37.2479	9-Octadecenoic acid (Z)-, 2,3-dihydroxypropyl ester	16.85	

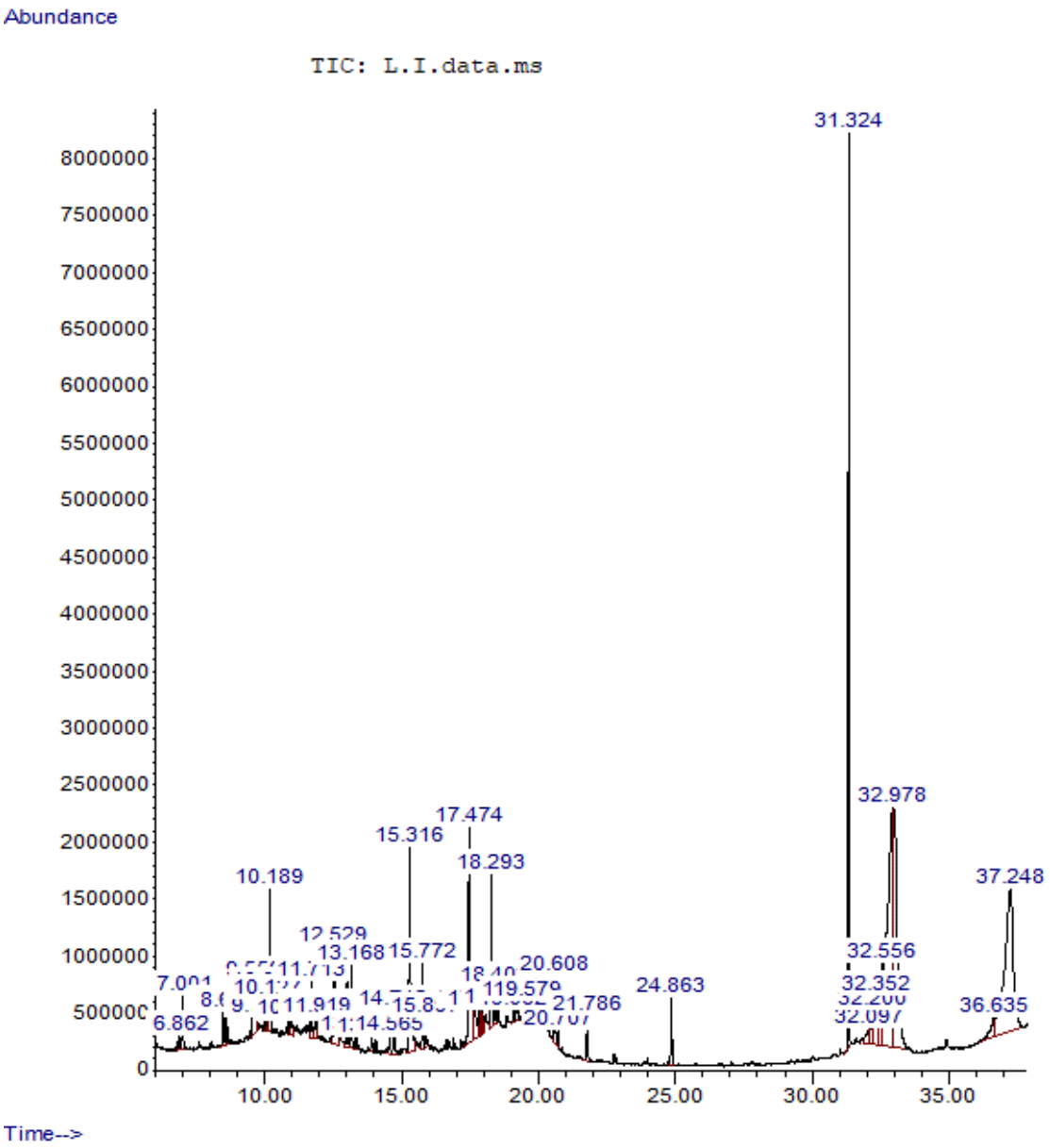


Figure 1: GCMS Chromatogram for Ethanol Leaves Extract of *A. heterophyllus*

FTIR characterization of ethanol leaf extract of *A. heterophyllus*

In Table 2, the ethanolic leaf extract exhibits functional groups such as C=C bending, C–O and S=O stretching, N–O and O–H stretching, and aromatic C–H, which are characteristic of alkenes, primary alcohols, sulfonates, nitro compounds, carboxylic acids, and aromatic hydrocarbons.

Table 2: FTIR characterization of ethanol leaf extract of *Artocarpus heterophyllus*

Wave number	Peak intensity	Peak shape	Bond	Compound
900.7966	Strong	Broad	C=C bending	Alkene
1047.5	Strong	Sharp	C-O stretching	Primary alcohol
1369.536	Strong	Sharp	S=o stretching	Sulfonate
1473.258	Weak	Broad	N-O stretching	Nitro compound
1664.323	Weak	Broad	C-H stretching	Aromatic compound
2020.284	Strong	Broad	N=C=S stretching	Isothiocyanate
2353.372	Strong	Sharp	O=C=O stretching	Carbon dioxide
2859.711	Strong	Sharp	C-H stretching	Alkane
3002.457	Strong	Sharp	C-H stretching	Alkene
3289.143	Medium	Broad	O-H stretching	Carboxylic acid
3772.403	Strong	Broad	O-H stretching	Free alcohol

Proximate Analyses Plant Parts of *A. heterophyllus*

The proximate composition **(Table 3)** showed carbohydrate (49.138%), ash (10.094 %), moderate moisture content (12.525%), Fibre content (8.988 %) protein (8.834 %) and lastly a fat and oil content of 10.418%.

Table 3: Proximate composition of ethanol leaf extract of *Artocarpus heterophyllus*

Parameter	Concentration (%)
Moisture	12.525
Ash	10.094
Fat & Oil	10.418
Fibre	8.988
Protein	8.837
Carbohydrate	49.138

Discussion

Medicinal plants are integral to promoting both individual and public health, largely due to the bioactive compounds they contain, which produce specific physiological effects in the human body (Dike *et al*., 2023). Gas chromatography is a versatile analytical technique widely utilized

across various fields, with particular effectiveness in the separation and analysis of complex mixtures such as essential oils, hydrocarbons, and solvents (Al-Rubaye *et al*., 2017). When coupled with mass spectrometry (GC-MS), this technique has greatly enhanced the analysis and structural elucidation of phytochemicals due to its high sensitivity, capable of detecting compounds at nanogram levels. GC-MS is instrumental in identifying bioactive constituents in medicinal plants and in determining the composition and presence of specific phytochemicals. Through comprehensive interpretation of GC-MS spectral data and retention times, researchers can reliably identify key components and assess their relative concentrations based on peak intensities (Dike *et al*., 2023).

This study evaluated the nutritional and medicinal potential of *Artocarpus heterophyllus* through proximate analysis and the identification of phytochemical constituents. Gas chromatography–mass spectrometry (GC-MS) analysis revealed a total of 48 compounds, as detailed in **Table 1,** with their respective relative abundances expressed as percentage peak areas, this is in contrast to the study carried out by Pani *et al* (2003), which identified 24 bioactive compound in the leaves of *A. heterophyllus*. The present study reveals a broader chemical diversity, particularly in esterified compounds and nitrogen-containing heterocycles such as pyrrolidine and lutidine derivatives. These compounds are absent in Yani *et al*. (2023)'s extract, suggesting that geographical location, solvent polarity and extraction method may significantly influence phytochemical yield.

The GC-MS profile of *A. heterophyllus* revealed a rich diversity of bioactive compounds. The predominance of esters and nitrogen-containing heterocycles distinguishes it from other medicinal plants. According to (Okoye *et al*., 2023), *Sida acuta* primarily contains fatty acids and terpenoids such as phytol and hexadecanoic acid, while *Hellenia speciosa* features squalene and linoleic acid but lacks the heterocyclic complexity observed in *A. heterophyllus* (Ramya *et al*., 2021).

Several of these compounds detected have been reported to exhibit a wide range of pharmacological activities, including antibacterial, antioxidant, anti-apoptotic, antifungal, cytotoxic, anti-inflammatory, antitumor, anticancer, immunostimulatory, chemopreventive, lipoxygenase-inhibitory, pesticidal, antidiabetic, and hypolipidemic properties. The presence of pyrrolidine and lutidine derivatives suggests potential neuroprotective and antimicrobial activities (Kumar *et al*., 2020). Fatty acids such as oleic and palmitic acid are known for their anti-inflammatory and antioxidant effects. Squalene, a triterpene, further enhances the extract's therapeutic profile due to its free radical scavenging properties. (Banakar and Jayaraj, 2018). However, certain constituents such as 2-Chloropropionic acid, hexadecyl ester; Pentanamide, 4,4-dimethyl-*N*-(4-nitrophenyl)-3-oxo-; Succinic acid, 4-chloro-3-methylphenyl 2-methoxyphenyl ester; 2,6-Lutidine, 3,5-dichloro-4-cyclohexylthio-; and *cis*-9-Tetradecenoic acid, propyl ester have limited or no documented pharmacological activities to date. The high abundance of succinic acid esters and 9-octadecenoic acid esters in the ethanol extract may confer enhanced antimicrobial and anti-inflammatory properties, as esters are known to improve membrane permeability and

bioavailability (Kumar et al., 2020). In contrast, Yani et al.'s profile, dominated by phytol and linoleic acid, aligns more closely with antioxidant and lipid metabolism modulation.

The FTIR characterization of the leaf extract, as presented in Table 2, revealed several absorption peaks across different spectral regions. In the single bond region (2500–4000 cm^{-1}), a broad absorption band observed between 3650 and 3250 cm^{-1} is indicative of hydrogen bonding. Peaks appearing between 3000 and 3200 cm^{-1} correspond to aromatic C–H stretching vibrations, while peaks below 3000 cm^{-1} are associated with C–H stretching in aliphatic single bonds. Specifically, absorptions in the range of 3000 to 2850 cm^{-1} suggest the presence of hydrogen atoms bonded to sp^3-hybridized carbon atoms. A distinct aldehyde peak was also identified between 2700 and 2800 cm^{-1}.

In the triple bond region (2000–2500 cm^{-1}), the absence of any detectable peaks suggests that C≡C bonds are not present. The double bond region (1500–2000 cm^{-1}) exhibited several peaks, including a weak absorption at 1662 cm^{-1}, which is characteristic of aromatic compounds. The spectral features rule out the presence of carboxylic acids (due to the absence of O–H stretches), aldehydes (no absorptions between 2830–2700 cm^{-1}), amides (absence of N–H and inappropriate carbonyl position), anhydrides (no second carbonyl band), and acyl chlorides (carbonyl frequency too low). Thus, the compound is more likely to be a ketone or an ester. In the fingerprint region (600–1500 cm^{-1}), a strong absorption near 900 cm^{-1} was observed, suggesting the presence of an alkene functional group.

The proximate analyses of the plant were conducted to quantify the percentages of moisture, ash, fat and oil, fibre, protein, and carbohydrate. As shown in Table 3. The high carbohydrate content (49.14%) proves A. *heterophyllus* as a potential energy source, surpassing values reported for *Moringa oleifera* (38–42%) and *Carica papaya* (40%) (Akinmoladun *et al*., 2022; Kumar *et al*., 2020). The fat and oil content (10.42%) are notably higher than in *Vernonia amygdalina* (7.2%) and *Moringa oleifera* (6.5%), indicating a richer lipid profile that complements the GC-MS findings of fatty acids (Okoye *et al*., 2023). Protein (8.84%) and fibre (8.99%) levels are comparable to *Hibiscus sabdariffa* and *Artocarpus altilis*, supporting potential dietary and gastrointestinal benefits (Ramya *et al*., 2021). Ash content (10.09%) reflects mineral richness, suggesting the presence of essential micronutrients such as calcium, magnesium, and potassium.

Consuming foods with high moisture content offer various health benefits, including aiding in thermoregulation, supporting immune function, lubricating joints, facilitating nutrient transport to cells, and enhancing sleep and mood. Additionally, such foods are typically low in calories and rich in essential vitamins, minerals, antioxidants, and dietary fibre, which contribute to overall health (Brianna, 2023). However, a high moisture content also increases the perishability of foods, making them more prone to microbial spoilage during storage (Gqaza *et al*., 2013). The ash content reflects the presence of inorganic minerals, suggesting that the plant may be a valuable source of essential minerals (Valdez-Solana *et al*., 2015; Ojwang *et al*., 2018). In the case of *A. heterophyllus*, the elevated ash content

indicates a significant mineral composition. Dietary fats play a key role in enhancing the palatability of food by absorbing and preserving flavours (Antia *et al*., 2006). Moreover, moderate fat intake is vital for a balanced diet, as fats provide essential fatty acids that the human body cannot synthesize, and aid in the absorption of fat-soluble vitamins such as A, D, and E (Afotey *et al*., 2024).

Carbohydrates generally contribute to the bulk of the human diet and serve a critical function as the primary energy source for cells, including those of the brain, muscles, and blood. They also support fat metabolism, conserve proteins from being used as an energy source, and act as a gentle laxative. The energy provided by plant-based carbohydrates is particularly important, as an adequate caloric intake is necessary for the optimal utilization of dietary proteins (Okiki *et al.*, 2015). Consequently, the high energy content of *A. heterophyllus* leaves may play a substantial role in meeting the body's daily caloric needs. Although crude fibre provides minimal direct nutritional value, sufficient intake is associated with several health benefits, including lowering serum cholesterol levels, enhancing the absorption of trace elements in the gastrointestinal tract, and reducing the risk of various health conditions such as coronary heart disease, diabetes, hypertension, constipation, as well as colon and breast cancers (Okiki *et al*., 2015). Fibre also promotes efficient digestion and contributes to colon health by aiding in the elimination of carcinogenic substances from the large intestine, thereby helping to prevent colon cancer (Afotey *et al*., 2024)

Conclusion

The results of the present study indicate that *A. heterophyllus* contains a wide array of bioactive compounds with various biological activities. The traditional use of *A. heterophyllus* leaves in the treatment of numerous ailments is substantiated by the presence of these diverse phytochemical constituents. Comparative analysis confirms its superior phytochemical and nutritional diversity relative to other medicinal plants, reinforcing its ethnomedicinal value. Therefore, *A. heterophyllus* may be regarded as a promising candidate for the development of phytopharmaceutical products.

References

Abubakar, A.R., and Haque, M. (2020). Preparation of Medicinal Plants: Basic Extraction and Fractionation Procedures for Experimental Purpose. *Journal of Pharmacy & Bioallied Sciences*, 12(1), 1-10. https://doi.org/10.4103/jpbs.JPBS_175_19

Adewole, E., Ojo, A., Omoaghe, A. O., Enye, L. A., and Jamshed, I. (2018). In Vitro Enzymatic Assays of *Azadirachta indica* Extract and Identification of Bioactive Compounds using Gas Chromatography-Mass Spectrophotometer. *Der Pharma Chemica, 10 (2)*, 105-109.

Afotey, B., Yuorkuu, E., Akinie, S., Eshun, F., and Sufyan, M. (2024). Determination of health and nutritional benefits of jackfruits (*Artocarpus heterophyllus*). *Journal of the Ghana Institution of Engineering*, *24*(1), 33-40. https://doi.org/10.56049/jghie.v24i1.149.

Ajinwo, J., Rosa, O., Worika, P., and Nengi, P. (2024). Evaluation of the Antimicrobial and Antioxidant Activity of the Pulp of *Artocarpus heterophyllus* Lam (Moraceae). *Medical Discoveries*, *3*(4), 1148.

Akinmoladun, F. O., Akinrinlola, B. L., and Farombi, E. O. (2022). Nutritional and phytochemical evaluation of *Moringa oleifera* leaf extract. *Journal of Medicinal Plants Research*, 16(3), 45–52. https://doi.org/10.5897/JMPR2022.7123

Al-Rubaye, A. F., Hameed, I. H., and Kadhim, M. J. (2017). A review: uses of gas chromatography-mass spectrometry (GC-MS) technique for analysis of bioactive natural compounds of some plants. *International Journal of Toxicological and Pharmacological Research*, *9*(1), 81-85.

Antia, B. S., Akpan, E. J., Okon, P. A., and Umoren, I. U. (2006). Nutritive and antinutritive evaluation of sweet potatoes (*Moringa oleifera*) leaves. *Pakistan Journal of Nutrition*, *5*(2), 166–168.

AOAC. (2005). Official Methods of Analysis. 18th edition, Washington D.C. Association of Official Analytical Chemists. p. 106

Dike, C. S., Emejulu, A. A., Chukwudoruo, C. S., Akpaki, M. A., Nsofor, W. N., and Edom, C. V. (2023). GC-MS and FTIR analyses of bioactive compounds present in ethanol leaf extract of Sida acuta from Imo State, Nigeria. *GSC Biological and Pharmaceutical Sciences*, *25*(02), 394-404. https://doi.org/10.30574/gscbps.2023.25.2.0500.

Dike, C. S., Emejulu, A. A., Chukwudoruo, C. S., Akpaki, M. A., Nsofor, W. N., and Edom, C. V. (2023). GC-MS and FTIR analyses of bioactive compounds present in ethanol leaf extract of *Sida acuta* from Imo State, Nigeria. *GSC Biological and Pharmaceutical Sciences, 25*(2), 394–404. https://doi.org/10.30574/gscbps.2023.25.2.0500

Elliott, B. (2023). *19 water-rich foods that help you stay hydrated*. Healthline. https://www.healthline.com/nutrition/19-hydrating-foods

Georgia, C. A., Ismail, B. O., Oluwabukola, T. A., Titilayo, O. A., Benjamin, T. T., Jamiu, T. A. and Ibunkun, T. S. (2024). Phytochemical and Antioxidant Analysis of *Artocarpus heterophyllus* Peel Extracts. *ASFI Research Journal*, *1*(1): e14762. https://doi.org/10.7004/asfirj-c2pw-xx13.

Gqaza, M. B., Njume, C., Goduka, I. N., and Grace, G. (2013). The proximate composition of *S. nigrum* plant leaves consumed in the Eastern Cape Province of South Africa. In *Proceedings of the 2nd International Conference on Nutrition and Food Sciences* (IPCBEE, Vol. 53, pp. 101–106). https://doi.org/10.7763/IPCBEE.2013.V53.20

Josekumar, V. S. (2018) Phytochemical evaluation, GC-MS analysis and antimicrobial activity of the leaves petiole of Artocarpus heterophyllus Lam. Asian Journal of Pharmacy and Pharmacology. https://doi.org/10.31024/AJPP.2018.4.3.7

Jegadeeswari, P., Nishanthini, A., Muthukumarasamya, S. and Mohan, V. (2012). GC-MS analysis of bioactive components of *Aristolochia krysagathra* (Aristolochiaceae). *Journal of Current Chemical and Pharmaceutical Sciences*, *2*. 226 – 232.

Muhammad, A. W. M. B., Ramli, M. S., Azmi, A. F. M. N., Dasiman, R., Zainon, F., Zainal, N. H., and Siva, R. (2025). Phytochemical screening of indian jujube (*Ziziphus mauritiana*) and jackfruit (*Artocarpus heterophyllus* Lam.) leaves extracted by ultrasound-assisted extraction (UAE). *Journal of Sustainability Science and Management*, *20*(1), 139 – 152. https://doi.org/10.46754/jssm.2025.01.008.

Nishath, T. K., Mathavi, P., Ambikapathy, V., Prakash, P., and Panneerselvam, A. (2025). GC-MS and FTIR analysis of phytochemical profiling of some medicinal plants. *Indian Journal of Natural Sciences, 16*(89), 92992–93002.

Okiki, P. A., Osibote, I. A., Balogun, O., Oyinloye, B. E., Idris, O., Adelegan, O., Asoso, S. O., and Olagbemide, P. T. (2015). Evaluation of proximate, minerals, vitamins and phytochemical composition of *Moringa oleifera* Lam. cultivated in Ado Ekiti, Nigeria. *Advances in Biological Research*, *9*(6), 436–443. https://doi.org/10.5829/idosi.abr.2015.9.6.96112

Okoye, T. C., Akah, P. A., Omeje, E. O., Okoye, F. B. C., and Nworu, C. S. (2023). GC-MS analysis and biological activities of *Sida acuta* leaf extract. *African Journal of Traditional, Complementary and Alternative Medicines*, 20(1), 45–53. https://doi.org/10.4314/ajtcam.v20i1.6

Ramya, R., Priyadharshini, S., and Ranjitha Kumari, B. D. (2021). GC-MS profiling of bioactive compounds from ethanol leaf extract of *Hellenia speciosa* and their antioxidant potential. *Biocatalysis and Agricultural Biotechnology*, 33, 101982. https://doi.org/10.1016/j.bcab.2021.101982

Samadd, M. A., Hossain, M. R., Taher, M. A., Hasan, M. M., Haque, S., Rafid, M. I., Hossia, S., Islam, A., and Khan, M. (2024). Multifaceted chemico-pharmacological insights into *Cynometra ramiflora* L.: unveiling its GC-MS, cytotoxic, thrombolytic, anti-inflammatory, antioxidant, anti-diarrheal, hypoglycemic, and analgesic potentials. *Natural Product Communications*, *19*(5), 1934578X241257377. https://doi.org/10.1177/1934578X241257377.

Sundarraj, A.A. and Ranganathan, T.V. (2017). Phytochemical screening and spectroscopy analysis of jackfruit (*Artocarpus integer* Thumb.) peel. *International Research Journal of Pharmacy*, *8*(9), 151 – 159.

Teneva, O., Petkova, Z., Dobreva, A., Dzhurmanski, A., and Antova, G. (2025). Evaluation of the Proximate Composition of *Amsonia tabernaemontana* Walt. Seeds and Glyceride Oil. *Molecules*, *30*(2), 408. https://doi.org/10.3390/molecules30020408.

Uwanta, E. J., Udo, I. E., Willie, I. N., and Akpakpan, A. E. (2024). Phytochemical screening, proximate and vitamin composition of Jack fruit (*Artocarpus Heterophyllus*) pulp and seed. *World Journal of Advanced Research and Reviews*, *22*(1), 1500–1506. https://doi.org/10.30574/wjarr.2024.22.1.1027.

Valdez-Solana, M. A., Mejía-García, V. Y., Téllez-Valencia, A., García-Arenas, G., Salas-Pacheco, J., Alba-Romero, J. J., and Sierra-Campos, E. (2015). Nutritional content and elemental and phytochemical analyses of *Moringa oleifera* grown in Mexico. *Journal of Chemistry*, *2015*, Article 860381. http://dx.doi.org/10.1155/2015/860381