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Research Article

Phytochemical Quantification and GC-MS Profiling of the Methanolic Leaf Extract of *Artocarpus heterophyllus* Lam.

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ABSTRACT
Artocarpus heterophyllus Lam. (jackfruit) has a long history of ethnomedicinal use and contains diverse phytochemicals with potential pharmacological activities. However, the phytochemical composition of its leaves remains comparatively under-characterised. This study evaluated the qualitative and quantitative phytochemical composition and gas chromatography–mass spectrometry (GC-MS) profile of the methanolic leaf extract of *A. heterophyllus*. Fresh mature leaves were collected, authenticated, air-dried, pulverised, and extracted with 80% methanol. Qualitative phytochemical screening and spectrophotometric quantification were performed for alkaloids, saponins, tannins, flavonoids, and phenolics, while GC-MS analysis was used to identify bioactive constituents with reference to spectral library databases. The extraction of 600 g of leaf powder yielded 3.52 g of dried methanolic extract, corresponding to an extraction yield of 0.59%. The extract tested positive for alkaloids, saponins, tannins, flavonoids, and phenolics. Tannins were the most abundant phytochemical class (207.20 ± 4.19 mg/TAE/g), while alkaloids were the least abundant (26.25 ± 2.47 mg/g). Saponins, flavonoids, and phenolics recorded 59.75 ± 1.06 mg/g, 69.29 ± 3.09 mg/g, and 190.74 ± 2.55 mg/g, respectively. GC-MS analysis identified 27 compounds, with phytol (16.48%), 9,12,15-octadecatrienoic acid methyl ester (13.93%), pentadecanoic acid methyl ester (11.24%), and acetic acid chlorohexadecyl ester (6.25%) among the most abundant constituents. These findings provide a phytochemical and chemical profile of *A. heterophyllus* leaves and support further investigation of their potential pharmacological applications.

Keywords: *Artocarpus heterophyllus*; Bioactive compounds; GC-MS profiling; Jackfruit leaf; Methanolic extract; Phytochemical screening; Phytol; Tannins

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INTRODUCTION

Plants remain a major reservoir of bioactive secondary metabolites with proven and prospective therapeutic value, and interest in plant-based therapeutics has intensified as the burden of chronic non-communicable diseases, including diabetes mellitus, continues to rise globally (Ansari *et al*., 2024; Chahrour *et al*., 2025). Natural products are frequently perceived as safer and more affordable than synthetic agents, and their pharmacological actions are largely attributable to classes of phytochemicals such as polyphenols, flavonoids, tannins, alkaloids, and saponins, which exhibit antioxidant, enzyme-inhibitory, and cytoprotective activities relevant to metabolic disease management (Banerjee *et al*., 2022; Ashagrie *et al*., 2025). Mechanistically, specific bioactive compounds frequently identified in plant leaves such as phytol and various flavonoids are known to mitigate hyperglycemia through distinct molecular pathways. These include the inhibition of carbohydrate-hydrolyzing enzymes (α-amylase and α-glucosidase) to blunt postprandial glucose spikes, the activation of the PI3K/Akt insulin signaling cascade to promote cellular glucose uptake, and the modulation of peroxisome proliferator-activated receptors (PPARs) to improve systemic insulin sensitivity (Elmazar *et al*., 2013; Wang *et al*., 2017).

Artocarpus heterophyllus Lam. (jackfruit), a tropical tree species of the Moraceae family, has a long history of ethnomedicinal use for the management of microbial infections, wounds, inflammation, and diabetes (Ranasinghe *et al*., 2019; Gupta *et al*., 2023). Various parts of the plant, including the stem bark, seeds, and leaves, have been shown to contain flavonoids, sterols, alkaloids, tannins, and phenolic compounds linked to significant pharmacological activity (Kumar *et al*., 2022; Kaur *et al*., 2024). While the phytochemistry of jackfruit seeds and stem bark has received considerable research attention (Ajiboye *et al*., 2018; Dwitiyanti *et al*., 2019; Manurung *et al*., 2023), the leaves have not been as extensively characterised, despite reports that leaf extracts and leaf petioles contain pharmacologically relevant terpenoids (such as phytol), fatty acid derivatives, and phenolics (Durga *et al*., 2022; Kurian *et al*., 2018; Tambunan *et al*., 2023; Noor *et al*., 2024).

A precise understanding of the phytochemical composition of a plant part is a prerequisite for rationalising its ethnomedicinal use and for guiding subsequent pharmacological investigation. This study therefore aimed to determine the qualitative and quantitative phytochemical composition and the GC-MS constituent profile of the methanolic leaf extract of *A. heterophyllus*, to establish a chemical basis for the biological activities reported for this plant.

MATERIALS AND METHODS

Plant Collection and Authentication

Fresh, healthy, and mature leaves of *A. heterophyllus* were collected from Gudduley Farms, Kaduna, Nigeria. The plant material was transported in sterile containers to the Herbarium of the Department of Biological Sciences, Nigerian Defence Academy (NDA), Kaduna, for taxonomic identification, and a voucher specimen was deposited (voucher number NDA/BIOH/202637).

Extract Preparation

Leaves were rinsed with distilled water, air-dried, and pulverised. For the methanolic extract, 600 g of leaf powder was macerated in 1000 mL of 80% methanol for three days with intermittent agitation, filtered (Whatman No. 1), and the marc re-extracted twice with equal volumes of methanol to ensure exhaustive extraction. The pooled filtrates were frozen, lyophilised, and further concentrated by rotary evaporation at 40 °C to remove residual methanol. The dried extract was stored under refrigeration (2–8 °C) until analysis, and stock solutions were freshly prepared as required (Rynjah *et al*., 2017; Taye *et al*., 2020; Donkor *et al*., 2023).

Leaves were rinsed with distilled water, air-dried, and pulverised. For the methanolic extract, 600 g of leaf powder was macerated in 1000 mL of 80% methanol for three days with intermittent agitation, filtered through Whatman No. 1 filter paper, and the marc was re-extracted twice with equal volumes of 80% methanol to ensure exhaustive extraction. The pooled filtrates were frozen, lyophilised, and further concentrated by rotary evaporation at 40 °C to remove residual methanol. The dried extract was stored under refrigeration at 2–8 °C until analysis. Stock solutions were freshly prepared as required (Rynjah *et al*., 2017; Taye *et al*., 2020; Donkor *et al*., 2023***)***

RESULTS

Qualitative and Quantitative Phytochemical Composition

The methanolic leaf extract of *A. heterophyllus* tested positive for alkaloids, saponins, tannins, flavonoids, and phenolics, with tannins and phenolics giving the strongest qualitative reactions (Table 1). Quantitatively, tannins were the most abundant phytochemical class (207.20 ± 4.19 mg/g) and alkaloids the least abundant (26.25 ± 2.47 mg/g) (Table 2). Saponin and phenolic contents were 59.75 ± 1.06 mg/g and 190.74 ± 2.55 mg/g, respectively, while flavonoid content was 69.29 ± 3.09 mg/g.

GC-MS Profile

GC-MS analysis resolved 27 distinct compounds in the methanolic leaf extract of *A. heterophyllus*, spanning fatty acid esters, terpenoid alcohols, and long-chain hydrocarbons (Table 3). Phytol (16.48%), 9,12,15-octadecatrienoic acid methyl ester (13.93%), pentadecanoic acid, 14-methyl-, methyl ester (11.24%), and acetic acid, chloro-, hexadecyl ester (6.25%) were the most abundant constituents by relative peak area.

Table 1. Qualitative phytochemical screening of the methanolic leaf extract of *A. heterophyllus*

Phytochemical	Methanolic extract
Alkaloids	+
Saponins	+
Tannins	++
Flavonoids	+
Phenolics	++

Key: "+" = present; "++" = strongly present.

Table 2. Quantitative phytochemical composition of the methanolic leaf extract of *A. heterophyllus* (mg/g)

Phytochemical	Methanolic extract (mg/g)
Alkaloids	26.25 ± 2.47 mg/g
Saponins	59.75 ± 1.06 mg/g
Tannins	207.20 ± 4.19 TAE/g
Flavonoids	69.29 ± 3.09 QE/g
Phenolics	190.74 ± 2.55 GAE/g

Values are mean ± standard deviation of duplicate determinations.

QE = Quercetin equivalents; TAE = Tannic acid equivalents; GAE = Gallic acid equivalents. Values are expressed as mean ± standard deviation of duplicate determinations.

Table 3. GC-MS profile of bioactive compounds identified in the methanolic leaf extract of *A. heterophyllus*

S/N	Compound	Area (%	RT (min)	MW (g/mol)	Molecular formula
1	5-Octadecene, (E)-	5.33	6.62	252.5	$C_{18}H_{36}$
2	2-Piperidinone, N-[4-bromo-n-butyl]-	2.85	6.70	234.13	$C_9H_{16}BrNO$
3	13-Octadecenal, (Z)-	1.26	7.27	266.5	$C_{18}H_{34}O$
4	Carbonic acid, octadecyl vinyl ester	2.75	8.38	340.5	$C_{21}H_{40}O_3$
5	Acetic acid, chloro-, hexadecyl ester	6.25	8.94	318.9	$C_{18}H_{35}ClO_2$
6	1-Decanol, 2-hexyl-	1.72	9.01	242.44	$C_{16}H_{34}O$
7	1-Decanol, 2-hexyl- (isomer)	2.40	9.08	242.44	$C_{16}H_{34}O$
8	Oxalic acid, cyclobutyl octadecyl ester	2.42	9.48	396.6	$C_{24}H_{44}O_4$
9	Pentadecanoic acid, 14-methyl-, methyl ester	11.24	10.40	270.5	$C_{17}H_{34}O_2$
10	Phthalic acid, 2-cyclohexylethyl ethyl ester	5.56	10.82	304.4	$C_{18}H_{24}O_4$
11	Carbonic acid, but-3-en-1-yl dodecyl ester	5.02	11.04	284.4	$C_{17}H_{32}O_3$
12	Isobutyl tetradecyl carbonate	4.11	11.09	314.5	$C_{19}H_{38}O_3$
13	Bicyclo[3.1.1]heptane, 2,6,6-trimethyl-	5.36	12.14	168.23	$C_{10}H_{16}O_2$
14	9,12,15-Octadecatrienoic acid, methyl ester, (Z,Z,Z)-	13.93	12.22	292.5	$C_{19}H_{32}O_2$
15	Phytol	16.48	12.34	296.5	$C_{20}H_{40}O$
16	8-Oxabicyclo[5.1.0]octane	2.48	12.98	112.17	$C_7H_{12}O$
17	1-Docosene	0.45	13.23	308.6	$C_{22}H_{44}$
18	1-Dodecanol	0.72	17.86	186.33	$C12H_{26}O$
19	(Z)-2-((Hex-3-enyloxy)carbonyl)benzoic acid	0.90	17.88	248.27	$C_{14}H_{16}O_4$
20	9,17-Octadecadienal, (Z)-	2.51	27.61	264.4	$C_{18}H_{32}O$
21	Cyclohexane, 1,1′-(1,3-butadiene-1,4-diyl)bis-, (E,E)-	0.56	28.57	218.38	$C_{16}H_{26}$
22	Oleic acid	0.82	29.47	282.5	$C_{18}H_{34}O2$
23	9,12-Octadecadienoyl chloride, (Z,Z)-	0.56	30.15	298.9	$C_{18}H_{31}ClO$
24	1,3,12-Nonadecatriene	0.49	30.19	262.5	$C_{19}H_{34}$
25	9-Octadecenal	0.29	31.92	266.5	$C_{18}H_{34}O$
26	12-Methyl-E,E-2,13-octadecadien-1-ol	2.74	32.12	280.5	$C_{19}H_{36}O$
27	7-Pentadecyne	0.80	32.17	208.38	$C_{15}H_{28}$

RT = retention time; MW = molecular weight

DISCUSSION

The methanolic leaf extract of *Artocarpus heterophyllus* tested positive for alkaloids, saponins, tannins, flavonoids and phenolics, with tannins and phenolics giving the strongest qualitative reactions (Table 1). Quantitative analysis confirmed that tannins were the dominant class (207.20 ± 4.19 mg TAE/g), followed closely by phenolics (190.74 ± 2.55 mg GAE/g). Flavonoids (69.29 ± 3.09 mg QE/g), saponins (59.75 ± 1.06 mg/g) and alkaloids (26.25 ± 2.47 mg/g) were present in lower but still appreciable amounts (Table 2). These findings are consistent with earlier reports on jackfruit leaves. Amadi *et al.* (2018) also detected tannins, flavonoids, alkaloids and saponins in jackfruit leaf extracts, although they reported a relatively higher alkaloid content than tannin content. The higher tannin and phenolic levels observed in the present study may reflect differences in geographic origin, season of collection or extraction solvent, as methanol is known to be more efficient than water for extracting polar polyphenols (Noor *et al*., 2024; Chackrewarthy *et al*., 2010).

The extraction yield obtained in this work (0.59 % from 600 g of leaf powder) is relatively low but falls within the range commonly reported for methanolic extracts of jackfruit leaves. Durga *et al.* (2022) and Kurian *et al*. (2018) likewise recorded modest yields when methanol was used as the solvent, confirming that jackfruit leaves are not particularly rich in methanol-soluble matter under standard maceration conditions.

GC-MS analysis resolved 27 compounds, of which phytol (16.48 %), 9,12,15-octadecatrienoic acid methyl ester (13.93 %), pentadecanoic acid 14-methyl-methyl ester (11.24 %) and acetic acid chloro-hexadecyl ester (6.25 %) were the most abundant (Table 3). The predominance of phytol is in close agreement with previous GC-MS studies of jackfruit leaf and leaf-petiole extracts. Kurian *et al*. (2018) and Tambunan *et al.* (2023) both identified phytol as a major constituent, reporting relative abundances in the range of 12–18 %. The presence of linoleic-acid methyl ester (9,12,15-octadecatrienoic acid methyl ester) and other long-chain fatty-acid esters has also been documented in jackfruit leaves (Durga *et al*., 2022; Noor *et al.,* 2024). These lipophilic compounds, together with the high levels of tannins and phenolics quantified spectrophotometrically, indicate that the methanolic extract contains both hydrophilic polyphenols and lipophilic terpenoids/fatty-acid derivatives—a dual profile that is characteristic of *A. heterophyllus* leaves.

The high tannin content (207.20 mg TAE/g) is particularly noteworthy. Comparable or slightly lower tannin levels have been reported for jackfruit leaf extracts prepared with ethanol or aqueous-ethanol mixtures (Amadi *et al*., 2018; Noor *et al*., 2024). Tannins are known inhibitors of α-amylase and α-glucosidase (Barrett *et al.,* 2013; Zhu *et al*., 2020), while phytol has been shown to improve glucose tolerance via PI3K/Akt and PPAR pathways (Wang *et al*., 2017; Elmazar *et al*., 2013; Islam *et al*., 2018). The co-occurrence of these two classes of compounds therefore provides a plausible chemical basis for the antidiabetic and antioxidant activities traditionally attributed to jackfruit leaves.

The methanolic leaf extract of *A. heterophyllus* is rich in tannins and phenolics and contains phytol as its principal GC-MS constituent. The quantitative values and compound profile obtained in the present study are consistent with, and in several cases higher than, those reported in earlier phytochemical investigations of the same plant part, thereby strengthening the chemical foundation for further pharmacological evaluation of jackfruit leaves.

CONCLUSION

The methanolic leaf extract of *A. heterophyllus* contains a broad spectrum of pharmacologically relevant phytochemicals, with tannins and phenolics predominating in spectrophotometric assays and phytol, unsaturated fatty acid esters, and hydrocarbons predominating in the GC-MS profile. These findings provide a chemical basis for the reported ethnomedicinal and pharmacological uses of jackfruit leaves and support their further investigation as a source of bioactive compounds.

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