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Phytochemical Profiling of Aqueous, Methanol and Hexane Leaf Extracts of *Jatropha curcas* using Chromatographic and Spectral Fingerprintings

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Abstract

Jatropha curcas leaves have been reported to possess various applications to industries, humans and animals with their attendant side effects. There's a need for thorough phytochemical analysis and screening of plants like *Jatropha curcas* to ensure safe and informed use. In this study, phytochemical profilings of aqueous, methanol and hexane leaf extracts of *Jatropha curcas* using chromatographic and spectral finger-printings were investigated. The quantitative phytochemical analysis was performed using gas chromatography flame ionization detection (GC - FID) and Fourier transformed infra-red spectroscopy (FT-IR) to identify bioactive compounds and their functional groups, respectively. The quantities of bioactive compounds obtained in the aqueous, methanol and hexane leaf extracts of *J. curcas* using GC-FID were 20, 20 and 22, respectively. The FTIR analysis of *Jatropha curcas* revealed the presence of functional groups such as hydroxyl group-alcohol and phenol, amines (primary and secondary), aliphatic compounds (alkane, alkene, alkyne), carbonyl groups (ester, carboxylic acid, aldehyde, α, β - unsaturated ketone), carbodiimide, isothiocyanate, azide, thiol, halo compounds, sulphones and aromatic compounds. The results obtained revealed that the aqueous, methanol and hexane leaf extracts of *Jatropha curcas* are promising sources of valuable bioactive compounds and phytochemicals that could be utilized, potentially through chemical modifications, for pharmaceutical applications.

Keywords: Bioactive compounds, Gas chromatography, Infra-red spectroscopy, *Jatropha curcas*, Phytochemical analysis

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1. Introduction

Jatropha curcas L., a promising species that offers significant potentials due to its versatile and multi-purpose product range. It belongs to the genus *Jatropha*, family Euphorbiaceae and commonly known as physic nut, purging nut or pig nut (Sharma *et al*., 2016), Botuje in Southwest Nigeria. It originates from Mexico and Central America, but has spread all over the world especially Africa, and Asia and is mostly used for hedges (Pinto *et al*., 2018; Jumare *et al*., 2023). *Jatropha curcas* has garnered widespread interest in tropical and sub-tropical regions due to its remarkable adaptability. The plant's key attributes include exceptional hardiness, easy propagation, drought resistance, high oil content, rapid growth, and versatility across diverse agro-climatic conditions, making it an attractive crop with multiple potential applications (Sarabia *et al.*, 2022).

For the bulk of the rural population in Nigeria and other parts of Africa, medicinal plants are the main source of medicines for treating a variety of ailments in primary healthcare (Ekundayo and Ekekwe, 2013). According to the World Health Organisation (WHO, 2011) approximately 70 - 95 % of the population in developing countries rely on medicinal plants as their primary source of healthcare. The majority of plants grown in rural residential areas contain these biologically active substances, which have been demonstrated over many generations to be effective treatments for particular ailments (Eldahshan and Abdel-Daim, 2015; Okoye *et al*., 2016a; 2016b; Okoye *et al*., 2020a; 2020b; 2020c; Okeke *et al*., 2025).

Jatropha curcas contains various fats compounds such as saturated, unsaturated, and polysaturated fatty acids which have segment of oil mainly palmitic acid, steric and unsaturated fatty acids (Dilla *et al*., 2016). Various bioactive compounds tannins, phytosterol, glycosides, phenolic compound, flavonoids, sapogenins and steroidal exhibit extensive range of medicinal potential of plant (Sharma and Peet, 2016). Phytochemicals also contain different compounds

such as total, sugars, amino acids, protein, and phenolic compound such as terpenoids, and alkaloids (Bendigeri *et al*., 2023). It provides definite physiological actions to human bodies because plants have bioactive phytochemicals constituents used for the medicinal purpose (Rahu *et al*., 2021).

Mayel *et al*. (2021) reported that the FT-IR analysis of J. tanjorensis leaves revealed the presence of phytochemicals like alkanes, alkenes, alkyls, alkyl halides, alkynes, saturated aliphatic esters, primary amines, aromatics, nitro compounds, aromatic amines, aliphatic amines. From the GC-MS analyses, the aqueous extract had the highest number (51 phytochemicals) of phytochemicals, followed by 95% ethanolic extract (up to 31 phytochemicals), and lastly 95% ethanolic extract (up to 26 phytochemicals). Also, despite the fact that a sizeable section of the world's population largely relies on medicinal plants as their primary source of healthcare, there hasn't been enough research to identify and assess the bioactive chemicals contained in various medicinal plants especially *Jatropha curcas* using chromatographic and spectral finger-printings. It is vital to keep discovering these phytochemicals in order to support and validate their purported therapeutic effects. Therefore, this study was designed to investigate the phytochemical profilings of aqueous, methanol and hexane leaf extracts of *Jatropha curcas* using chromatographic and spectral finger-printings.

2. Materials and Methods

2.1 Collection and Identification of Plant Materials

Fresh leaves from *Jatropha curcas* (JC) were collected from a local garden in Anambra State. They were taxonomically identified and authenticated by an expert Botanist from the Department of Botany, Nnamdi Azikiwe University, Awka.

2.2 Preparation of Plant Extracts

Fresh leaves from *Jatropha curcas* was washed with clean water and then air-dried for 14 days at room temperature. The leaves were ground into coarse powder using an industrial blender. Twenty (20 g) of the powdered leaves of the test plants were weighed and placed into a 500 ml conical flask containing 100 ml distilled water, 300 ml n-hexane and 300 ml methanol, mixed and macerated for 72 h. The aqueous, n-hexane, and methanol extracts were double filtered using a muslin cloth and then through a filter paper (Whatman no. 1). The filtrates were concentrated to dryness in a water bath at 45 °C. The extracts were stored in a desiccator until needed (Iheukwumere *et al*., 2012a; 2012b; Mundi *et al*., 2013; 2014; Okoye *et al*., 2014).

2.3 Quantitative Phytochemical Analysis and determination of the functional groups of the plant phytochemicals using Gas Chromatography Flame Ionization Detection (GC-FID) and Fourier Transform infra-red (FT-IR) spectroscopy

2.3.1 Extraction of the phytochemicals

In this study, 0.2 g of aqueous, methanolic and N-hexane extracts of *Jatropha curcas* was weighed and transferred to test tubes and 15 ml of ethanol and 10 ml of 50 % (m/v) potassium hydroxide was added. The test tubes were allowed to react in a water bath at 60 ^{0}C for 3 h. After the reaction time, the reaction products in the test tubes were transferred into separator funnels. The tubes were washed successfully with 20 ml of ethanol, 10 ml of cold water, 10 ml of hot water and 3 ml of hexane, which were all transferred to the funnels. These extracts were combined and washed three times with 10 ml of 10 % V/V ethanol aqueous solution, and the ethanol solvent was evaporated. The samples were solubilized in 1000 µl of pyridine, of which 200 µl was transferred to vials for analysis (Buss and Butler, 2010; Kelly and Nelson, 2014).

2.3.2 Quantification of the plant phytochemicals using Gas Chromatography with flame Ionization Detector

GC-FID spectral analysis was performed to detect and quantify bioactive compounds in the extracts. The GC-MS model used for mass spectral identification was an Agilent 6890 Gas Chromatograph equipped with a flame ionization detector. A RESTEK 15-metre MXT-1 column (15 m x 250 µm x 0.15 µm) was employed. The injector temperature was set at 280 °C with a splitless injection of 2 µl of sample and a linear velocity of 30 cm s $^{-1}$. Helium 5.0 pa.s served as the carrier gas, with a flow rate of 40 ml min^{-1}. The oven initially operated at 200°C and was subsequently heated to 330 °C at a rate of 3 °C min^{-1}, maintaining this temperature for 5 minutes. The detector was maintained at 320 °C. The presence of phytochemicals was determined by the ratio of the area of the internal standard to the area of the identified phytochemicals. The concentrations of various phytochemicals were expressed in µg/g (Buss and Butler, 2010; Kelly and Nelson, 2014). Results were presented in graph form and analyzed based on peak identification and reference tables as described by Okafor *et al*. (2023), Dokubo and Uba (2023), Uba and Obiefuna (2023), Ubani *et al*. (2024), Uba *et al*. (2024) and Ele *et al*. (2025).

2.3.3 Determination of the functional groups of plant phytochemicals using Fourier Transform Infra-red (FTIR) Spectroscopy

This was carried out to determine the functional groups of the phytochemicals present in the plant extracts. Buck Scientific M530 USA FTIR was used for the analysis. This instrument was equipped with a detector of deuterated triglycine sulphate and a beam splitter of potassium bromide. The software of the Gram A1 was used to obtain the spectra and to manipulate them. Approximately 1.0g of samples and 0.5 ml of nujol were added, mixed properly, and placed on a salt pellet. During measurement, FTIR spectra were obtained at frequency regions of 4,000 – 600 cm-^{1} and co-added at 32 scans and 4 cm^{-1} resolution. FTIR spectra were displayed as transmittance values (Van der Weerd *et al*., 2004). The results in the form of graphs were analyzed, and the functional groups were identified by the peaks and the reference tables adopted from DNano (2025).

3. Results

Figure 1 showed the GC-FID chromatogram of the phytochemical compounds of the aqueous extract of *Jatropha curcas* leaf. The Y-axis, or the area of the peak (pA), represented the amount of a specific compound present, while the X-axis, or the retention time (Ret time), represented the time it took the compounds to move through the GC column and reach the detector. Table 1 showed the GC-FID

chromatographic data for the aqueous extract of *Jatropha curcas* leaf. The identified phytochemicals include flavonoid (93.0%), polyphenols (0.8%), phytoestrogen (6.2%), and benzoic acid derivative (0.2%). Flavonoids were the most predominant group of plant phytochemicals identified. The analysis revealed the presence of twenty (20) bioactive compounds, and they include kaempferol (0.3%), catechin (46.7%), quercetin (32.7%), luteolin (0.7%), resveratrol (0.6%), artemetin (1.5%), naringin (0.2%), retusin (0.1%), myricetin (0.2%), ellagic acid (0.2%), vanillic acid (0.2%), isorhamnetin (7.9%), naringenin (0.1%), apigenin (0.6%), myricetin (0.1%), epicatechin (1.5%), genistein (6.2%), tangeretin (0.1%), hesperidin (0.1%), and silymarin (0.1%) in different amounts (ppm) and retention times (min). Catechin (46.7%) was the most common phytochemical compound identified in aqueous extract of *Jatropha curcas* leaf.

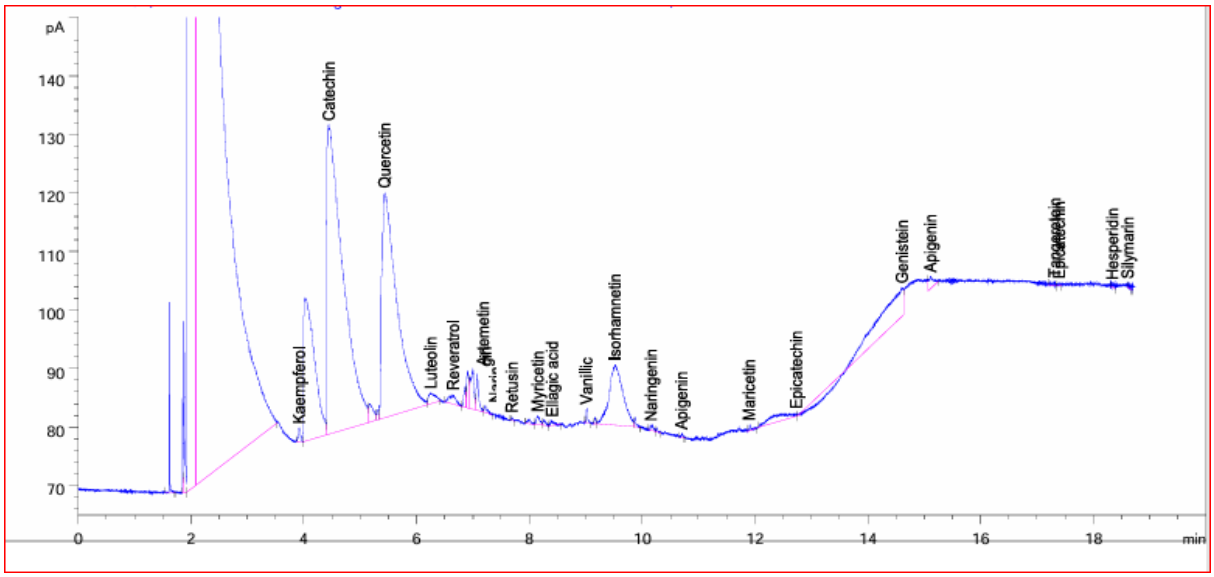

Figure 1: The GC-FID chromatogram of the phytochemical compounds of aqueous extract of *Jatropha curcas* leaves

Table 1: The GC-FID chromatographic data of the aqueous extract of *Jatropha curcas* leaf

S/No.	Ret Time (min)	Group of plant phytochemical	Peak name	Area (pA*s)	Amount (ppm)	Amount/Area
1.	3.925	Flavonoid	Kaempferol	6.66480	9.29131e-1(0.3)	1.39409e-1
2.	4.447	Flavonoid	Catechin	1031.88184	145.04649(46.7)	1.40565e-1
3.	5.439	Flavonoid	Quercetin	722.85400	101.59566(32.7)	1.40548e-1
4.	6.254	Flavonoid	Luteolin	15.20751	2.12932(0.7)	1.40017e-1
5.	6.646	Polyphenol	Resveratrol	13.46197	1.88077(0.6)	1.39710e-1
6.	7.004	Flavonoid	Artemetin	33.50598	4.70328(1.5)	1.40371e-1
7.	7.219	Flavonoid	Naringin	4.36695	5.94946e-1(0.2)	1.36238e-1
8.	7.695	Flavonoid	Retusin	1.11425	1.47466e-1(0.1)	1.32346e-1
9.	8.149	Flavonoid	Myricetin	6.22715	8.65738e-1(0.3)	1.39026e-1
10.	8.401	Polyphenol	Ellagic acid	3.44543	4.75209e-1(0.2)	1.37925e-1
11.	9.016	Benzoic acid derivative	Vanillic acid	3.89771	5.38730e-1(0.2)	1.38217e-1
12.	9.515	Flavonoid	Isorhamnetin	174.46471	24.52340(7.9)	1.40564e-1
13.	10.156	Flavonoid	Naringenin	3.09193	4.25483e-1(0.1)	1.37611e-1
14.	10.695	Flavonoid	Apigenin	1.39242	1.74171e-1(0.1)	1.25085e-1
15.	11.907	Flavonoid	Myricetin	2.37106	3.23393e-1(0.1)	1.36392e-1
16.	12.738	Flavonoid	Epicatechin	30.40840	4.26534(1.4)	1.40268e-1
17.	14.607	Phytoestrogen	Genistein	137.45218	19.25054(6.2)	1.40053e-1
18.	15.115	Flavonoid	Apigenin	12.05351	1.68398(0.5)	1.39709e-1
19.	17.312	Flavonoid	Tangeretin	1.61300	2.16625e-1(0.1)	1.34300e-1
20.	17.398	Flavonoid	Epicatechin	1.19933	1.58277e-1(0.1)	1.31972e-1
21.	18.351	Flavonoid	Hesperidin	1.31555	1.77680e-1(0.1)	1.35061e-1
22.	18.617	Flavonoid	Silymarin	1.55022	2.03440e-1(0.1)	1.31233e-1
	Totals			2209.53987	310.30907	

Ret time = Retention time; pA*s = peak areas; ppm = parts-per-million.

Figure 2 showed the GC-FID chromatogram of the methanol extract *Jatropha curcas* leaf. The Y-axis or the area of the peak (pA) represented the amount of a specific compound present, while the X-axis or the retention time (Ret time) represents the time it took the compounds to move through the GC column and reach the detector. Table 2 showed the GC-FID chromatographic data for the methanolic extract of *Jatropha curcas*. The GCFID analysis showed the plant phytochemicals identified and their various amounts. The identified phytochemicals include flavonoid (74.5%), polyphenols

(5.3%), alkaloid (0.1%), phytoestrogen (14.5%), and benzoic acid derivative (6.2%). Flavonoids were the most predominant (74.5%) plant phytochemical class identified. In addition, it confirmed the presence of twenty (20) bioactive compounds, and they include kaempferol (15.1%), catechin (40.4%), quercetin (1.0%), hesperidin (5.0%), luteolin (2.4%), resveratrol (2.6%), artemetin (0.9%), naringin (0.9%), retusin (0.7%), myricetin (0.4%), ellagic acid (2.7%), vanillic acid (6.2%), isorhamnetin (0.8%), naringenin (0.04%), myricetin (0.1%), epicatechin (5.4%), daidzein (6.1%), genistein (8.4%), apigenin (1.4%), and lunamarin (0.1%) at different amounts (ppm) and retention times (min). Catechin (40.4%) was the most common phytochemical compound identified in *Jatropha curcas* leaf methanolic extract.

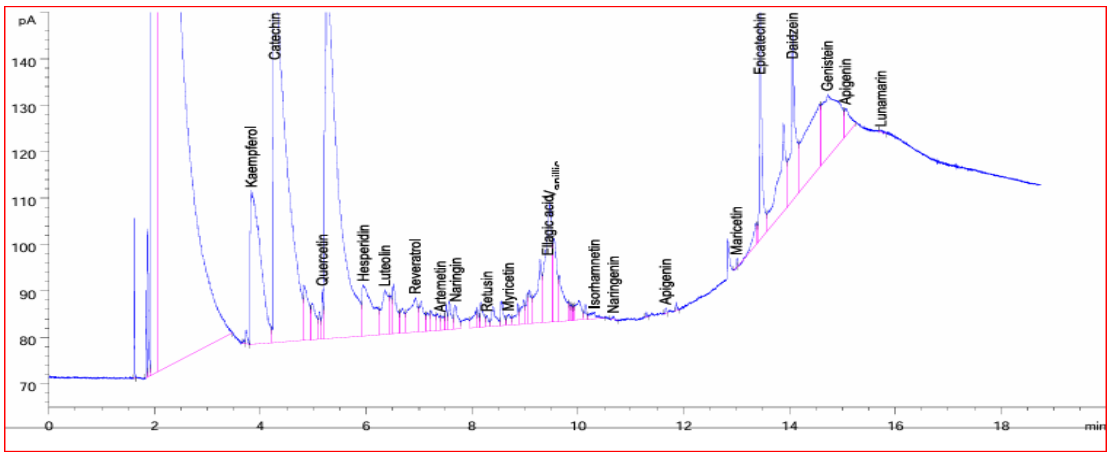

Figure 2: The GC-FID chromatogram of the phytochemical compounds of methanol extract of *Jatropha curcas* leaves

Table 2: The GC-FID chromatographic data of methanol extract of *Jatropha curcas* leaf

S/No.	Ret Time (min)	Class of plant phytochemical	Peak name	Amount (ppm) %	Area (pA*s)	Amount/ Area
1.	3.836	Flavonoid	Kaempferol	71.96816(15.1)	440.63547	1.40634e-1
2.	4.267	Flavonoid	Catechin	192.05970(40.4)	1366.32178	1.40567e-1
3.	5.176	Flavonoid	Quercetin	4.76011(1.0)	19.69657	1.40131e-1
4.	5.951	Flavonoid	Hesperidin	23.89529(5.0)	155.78708	1.40546e-1
5.	6.358	Flavonoid	Luteolin	11.17590(2.4)	79.55717	1.40476e-1
6.	6.936	Polyphenol	Resveratrol	12.44473(2.6)	81.52502	1.40383e-1
7.	7.405	Flavonoid	Artemetin	4.15235(0.9)	15.36688	1.40064e-1
8.	7.687	Flavonoid	Naringin	4.18040(0.9)	29.87473	1.39931e-1
9.	8.287	Flavonoid	Retusin	3.18391(0.7)	8.48381	1.39549e-1
10.	8.700	Flavonoid	Myricetin	1.65318(0.4)	11.82533	1.39800e-1
11.	9.283	Polyphenol	Ellagic acid	12.79011(2.7)	91.03340	1.40499e-1
12.	9.467	Benzoic acid derivative	Vanillic acid	29.67375(6.2)	211.10522	1.40564e-1
13.	10.309	Flavonoid	Isorhamnetin	3.72042(0.8)	12.30047	1.39866e-1
14.	10.680	Flavonoid	Naringenin	1.86069e-1(0.04)	1.38894	1.33965e-1
15.	11.661	Flavonoid	Apigenin	2.36330e-1(0.1)	1.83412	1.28852e-1
16.	13.007	Flavonoid	Myricetin	3.48945e-1(0.1)	2.55276	1.36693e-1
17.	13.444	Flavonoid	Epicatechin	25.65547(5.4)	182.52982	1.40555e-1
18.	14.061	Phytoestrogen	Daidzein	28.82462(6.1)	205.02066	1.40594e-1
19.	14.723	Phytoestrogen	Genistein	39.85385(8.4)	284.40250	1.40132e-1
20.	15.064	Flavonoid	Apigenin	6.05232(1.3)	43.12519	1.40343e-1
21.	15.730	Alkaloid	Lunamarin	2.28162e-1(0.1)	1.69993	1.34219e-1
Totals				476.04376	3246.06683	

Ret time = Retention time; pA*s = peak areas; ppm = parts-per-million.

Figure 3 showed the GC-FID Chromatogram of the N-hexane extract of *Jatropha curcas* leaf. The Y-axis or the area of the peak (pA) represents the amount of a specific compound present, while the X-axis or the retention time (Ret time) represents the time taken for the compounds to move through the GC column and reach the detector. Table 3 showed the GC-FID chromatographic data of the n-hexane extract of *Jatropha curcas* leaf. The GCFID analysis showed the presence of plant phytochemical classes such as flavonoids (91.0%), polyphenols (7.4%), alkaloid (0.5%), phytoestrogen (1.1%), and benzoic acid derivative (0.2%). Flavonoids (91.0%) were the most common plant phytochemical class identified. It also confirmed the presence of twenty-two (22) bioactive compounds, and they include kaempferol (30.8%), catechin (20.0%), quercetin (0.9%), hesperidin (5.2%), Luteolin (2.1%), resveratrol (6.5%), artemetin (2.3%), Myricetin

(0.6%), naringin (0.2%), Retusin (3.2%), ellagic acid (0.4%), vanillic acid (0.2%), isorhamnetin (1.4%), naringenin (0.4%), myricetin (19.0%), epicatechin (3.9%), daidzein (0.5%), genistein (0.6%), apigenin (0.5%), lunamarin (0.5%), gallocatechin (0.5%), and tangeretin (0.5%) at different amounts (ppm) and retention times (min). Kaempferol (30.8%) was the most predominant bioactive compound identified in the n-hexane extract of *Jatropha curcas*.

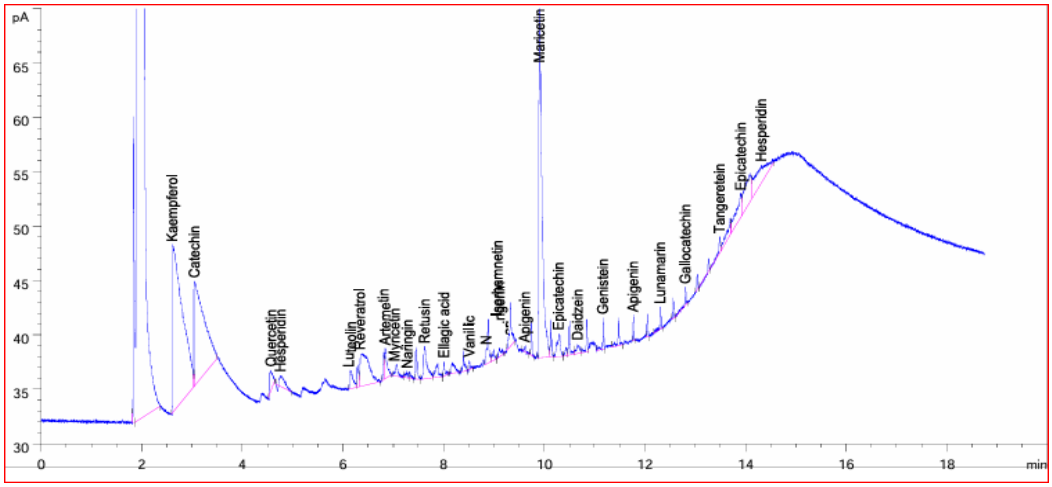

Figure 3: The GC-FID chromatogram of the N-hexane leaf extract of *Jatropha curcas*

Table 3: The GC-FID chromatographic data of the N-hexane extract of *Jatropha curcas* leaf

S/No.	Ret Time (min)	Class of plant Phytochemical	Peak name	Amount (ppm) %	Area (pA*s)	Amount/ Area
1.	2.617	Flavonoid	Kaempferol	29.60385(30.8)	210.53412	1.40613e-1
2.	3.055	Flavonoid	Catechin	19.18869(20.0)	129.44804	1.40510e-1
3.	4.567	Flavonoid	Quercetin	8.29861e-1 (0.9)	5.96399	1.39145e-1
4.	4.768	Flavonoid	Hesperidin	9.13843e-1(1.0)	6.57157	1.39060e-1
5.	6.160	Flavonoid	Luteolin	2.03277(2.1)	7.40762	1.39420e-1
6.	6.379	Polyphenol	Resveratrol	6.24677(6.5)	37.41651	1.40226e-1
7.	6.845	Flavonoid	Artemetin	2.21506(2.3)	8.70205	1.39630e-1
8.	7.069	Flavonoid	Myricetin	6.03474e-1 (0.6)	4.36262	1.38328e-1
9.	7.282	Flavonoid	Naringin	2.08754e-1(0.2)	1.61948	1.28901e-1
10.	7.630	Flavonoid	Retusin	3.04321(3.2)	14.59382	1.40005e-1
11.	8.010	Polyphenol	Ellagic acid	3.60166e-1(0.4)	2.62720	1.37091e-1
12.	8.517	Benzoic acid derivative	Vanillic acid	1.49303e-1 (0.2)	1.12811	1.32348e-1
13.	8.880	Flavonoid	Isorhamnetin	1.30445(1.4)	9.34233	1.39628e-1
14.	9.110	Flavonoid	Naringenin	3.89120e-1(0.4)	2.83327	1.37339e-1
15.	9.618	Flavonoid	Apigenin	1.23615e-1(0.1)	1.03318	1.19645e-1
16.	9.905	Flavonoid	Maricetin	18.28033(19.0)	130.06775	1.40545e-1
17.	10.295	Flavonoid	Epicatechin	1.29477(1.4)	9.28244	1.39486e-1
18.	10.659	Phytoestrogen	Daidzein	5.03851e-1(0.5)	3.65834	1.37726e-1
19.	11.168	Phytoestrogen	Genistein	6.10309e-1(0.6)	4.50330	1.35525e-1
20.	11.769	Flavonoid	Apigenin	3.95928e-1(0.4)	2.89167	1.36920e-1
21.	12.310	Alkaloid	Lunamarin	4.62194e-1(0.5)	3.36374	1.37405e-1
22.	12.804	Polyphenol	Gallocatechin	4.43159e-1(0.5)	3.22722	1.37319e-1
23.	13.483	Flavonoid	Tangeretin	4.44988e-1(0.5)	3.23720	1.37461e-1
24.	13.903	Flavonoid	Epicatechin	2.42301(2.5)	17.29846	1.40071e-1
25.	14.310	Flavonoid	Hesperidin	3.98308(4.2)	28.59438	1.39296e-1
Totals				96.05457	649.70843	

Ret time = Retention time; pA*s = peak areas; ppm = parts-per-million.

Figure 4 showed the FTIR spectrum profiles of *Jatropha curcas* leaf aqueous extract. The spectrum peak values ranged from 783.0996 to 3818.763 cm^{-1}. Table 4 showed the peak values and functional groups in *Jatropha curcas* leaf aqueous extract. The FTIR analysis showed characteristic peaks at 3692.367 cm^{-1}, 3474.121 cm^{-1}, 3248.309 cm^{-1} and 2794.685 cm^{-1} indicating the presence of free and Hydrogen-bonded hydroxyl (O-H stretching) alcohol and phenol; 3376.985 cm^{-1} indicating the presence of aliphatic primary amine (N-H stretching); 3000.157 cm^{-1} indicating the presence of aliphatic compound (alkene - C-H stretching); 2615.682 cm^{-1} indicating the presence of carboxylic acid (O-H stretching); 2134.644cm^{-1} and 2020.518 cm^{-1} indicating the presence of Carbodiimide (N=C=N stretching) and Isothiocyanate, respectively; 1618.268 cm^{-1} and 1386.091 cm^{-1} indicating the presence of α,β-unsaturated ketone (C=C stretching) and Aldehyde (C-H bending), respectively; 1171.657 cm^{-1} and 783.0996 cm^{-1} indicating the presence of Ester (C-O stretching) and Halo compound (Alkyl halide – C-Cl Stretching), respectively. However, the functional groups at peaks 3818.763 cm^{-1} and 2458.16 cm^{-1} are unknown.

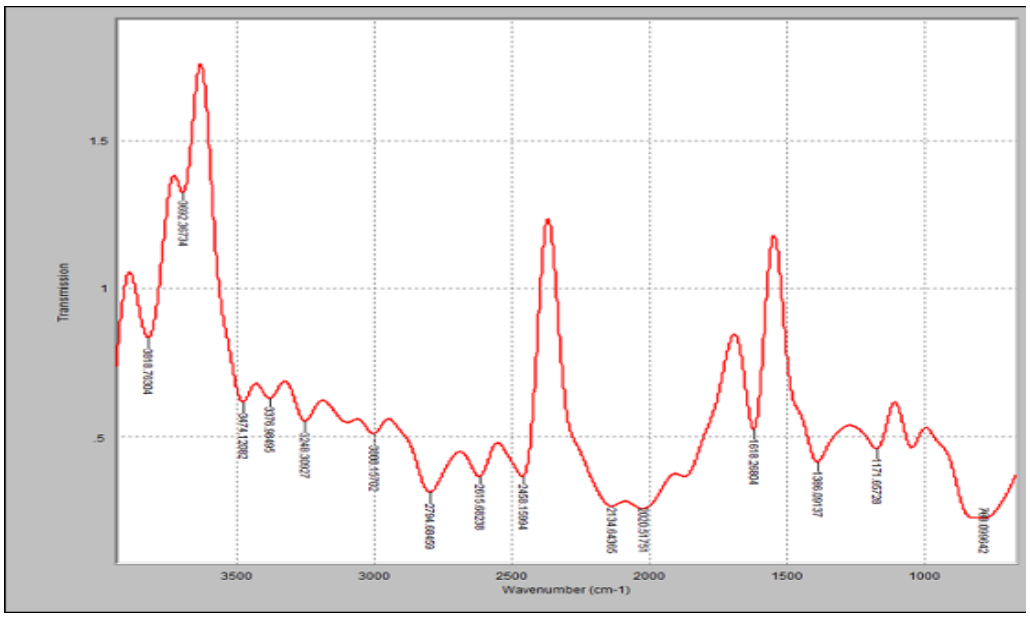

Figure 4: FT-IR spectrum of *Jatropha curcas* leaf aqueous extract

Table 4: FT-IR spectral peak values and functional groups in *Jatropha curcas* leaf aqueous extract

S/No	Wave number (Test samples) (cm^{-1})	Frequency range cm^{-1} (Reference number)	Chemical bond	Functional group	Peak details
1.	3818.763	Unknown	Unknown	Unknown	Unknown
2.	3692.367	(3584-3700)	O-H stretch (free)	Alcohol, phenol	Medium, sharp
3.	3474.121	(3200-3550)	O-H stretch (hydrogen bonded)	Alcohol	Strong, broad
4.	3376.985	(3300-3400)	N-H stretch	Aliphatic primary amine	Medium, sharp
5.	3248.309	(3200-3550)	O-H stretch (hydrogen bonded)	Alcohol	Strong, broad
6.	3000.157	(3000-3100)	C-H stretch	Alkene	Medium
7.	2794.685	(2700-3200)	O-H stretch	Alcohol	Weak, broad
8.	2615.682	(2500-3300)	O-H stretch	Carboxylic acid	Strong
9.	2458.16	Unknown	Unknown	Unknown	Unknown
10.	2134.644	(2120-2145)	N=C=N stretch	Carbodiimide	Strong
11.	2020.518	(1990-2140)	N=C=S stretch	Isothiocyanate	Strong
12.	1618.268	(1600-1650)	C = C stretch	α,β-unsaturated ketone	Strong
13.	1386.091	(1380-1390)	C–H bend	Aldehyde	Medium
14.	1171.657	(1163-1210)	C–O stretch	Ester	Strong, sharp
15.	783.0996	(700-800)	C-Cl stretch	Alkyl halide	Strong, sharp

Figure 5 showed the FTIR spectrum profiles of *Jatropha curcas* leaf methanol extract. The spectrum peak values ranged from 745.0246 to 3815.407 cm^{-1}. Table 5 showed the peak values and functional groups in *Jatropha curcas* leaf methanol extract. The FTIR analysis showed characteristic peaks at 3692.367 cm^{-1}, 3474.121 cm^{-1}, 3438.492 cm^{-1} and 2741. 87 cm^{-1} indicating the presence of hydroxyl (O-H stretching) alcohol; 3341.046 cm^{-1} indicating the presence of secondary amine (N-H stretching); 2919.306 cm^{-1}, 2208.298 cm^{-1} and 1618.899 cm^{-1} indicating the presence of aliphatic compounds such as alkane (C-H stretching), alkyne (C ≡C stretching) and conjugated alkene (C=C stretching), respectively; 2509.26 cm^{-1} 1432.508 indicating the presence of carboxylic acid (O-H stretching and O-H bending); 1991.11 cm^{-1}, 1820.864cm^{-1} and 1302.983 cm^{-1} indicating the presence of Isothiocyanate (N=C=S stretching), Aromatic compound (C-H bending) and Sulphone (S=O stretching), respectively; 844.9418 cm^{-1} and 745.0246 cm^{-1} indicating the presence of Halo compound (C-Cl stretching) and 1,2-disubstituted benzene (C-H bending), respectively. However, the functional groups at peaks 3815.407 cm^{-1}, 3684.352 cm^{-1} and 3551.156 cm^{-1} are unknown.

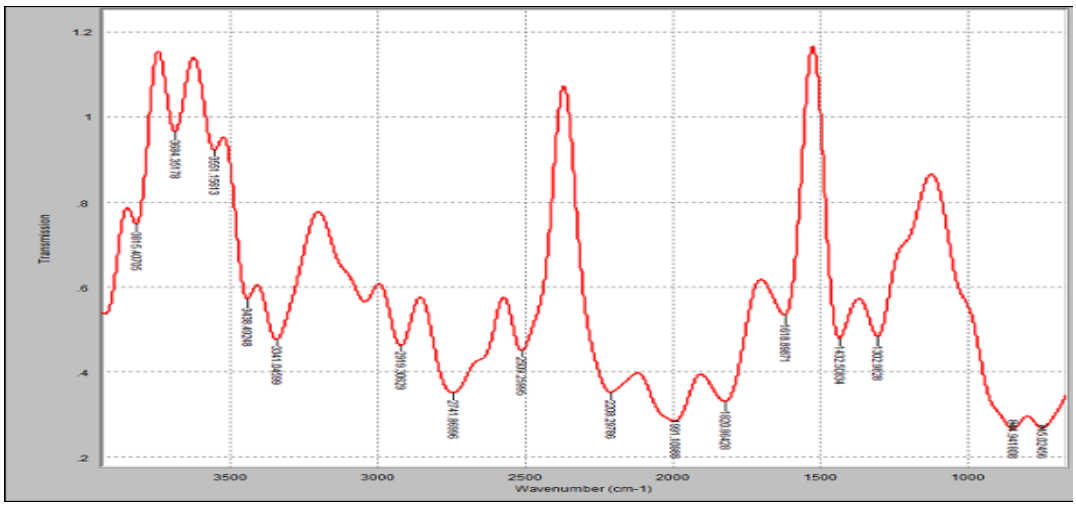

Figure 5: FT-IR spectrum of *Jatropha curcas* leaf methanol extract

Table 5: FT-IR spectral peak values and functional groups in *Jatropha curcas* leaf methanol extract

S/ No	Wave number (Test samples) (cm^{-1})	Frequency range (cm^{-1})(Reference number)	Chemical bond	Functional group	Peak details
1.	3815.407	Unknown	Unknown	Unknown	Unknown
2.	3684.352	Unknown	Unknown	Unknown	Unknown
3.	3551.156	Unknown	Unknown	Unknown	Unknown
4.	3438.492	(3200-3550)	O-H stretch	Alcohol	Strong, broad
5.	3341.046	(3310-3350)	N-H Stretch	Secondary amine	medium
6.	2919.306	(2840-3000)	C-H stretch	Alkane	Medium
7.	2741.87	(2700-3200)	O-H stretch	Alcohol	Weak, broad
8.	2509.26	(2500-3300)	O-H stretch	Carboxylic acid	Strong, broad
9.	2208.298	(2190-2260)	C ≡C stretch	Alkyne	Weak
10.	1991.11	(1990-2140)	N=C=S stretch	Isothiocyanate	Strong
11.	1820.864	(1650-2000)	C-H bend	Aromatic compound	Weak
12.	1618.899	(1600-1650)	C=C stretch	Conjugated alkene	Medium
13.	1432.508	(1395-1440)	O-H Bend	Carboxylic acid	Medium
14.	1302.983	(1300-1350)	S=O stretch	Sulfone	strong
15.	844.9418	(550-850)	C-Cl stretch	Halo compound	Strong
16.	745.0246	(735-775)	C-H Bend	1,2-disubstituted benzene	strong

Figure 6 showed the FTIR spectrum profiles of *Jatropha curcas* leaf n-hexane extract.

The spectrum peak values ranged from 809.8089 to 3351.693 cm^{-1}. Table 6 showed the peak values and functional groups in *Jatropha curcas* leaf n-hexane extract. The FTIR analysis showed characteristic peaks at 3351.693 $cm^{-1}$and 3236.918 cm^{-1}, indicating the presence of aliphatic primary amine (N-H stretching) and Hydrogen-bonded hydroxyl (O-H stretching) alcohol, respectively; 3034.318 cm^{-1}, 1988.379 cm^{-1} and 1270.395 cm^{-1} indicating the presence of aromatic compounds such as aromatic hydrocarbon (C-H stretching), aromatic compound (C-H bending) and aromatic amine (C-N stretching), respectively; 2914.94 cm^{-1} and 1610.693 cm^{-1} indicating the presence of aliphatic compounds such as alkane (C-H stretching) and conjugated alkene (C=C stretching), respectively; 2790.25 cm^{-1}, 2589.086 cm^{-1} and 2160.283 cm^{-1} indicating the presence of amine salt (N-H stretching), Thiol (S-H stretching) and Azide (N=N=N stretching), respectively; 2079.764cm^{-1}, 1385.129 cm^{-1} and 809.8089 cm^{-1} indicating the presence of Isothiocyanate (N=C=S stretching), Aldehyde (C-H bending) and 1,2,3,4-tetrasubstituted benzene (C-H bending), respectively. However, the functional group at peak 2465.59 cm^{-1} is unknown.

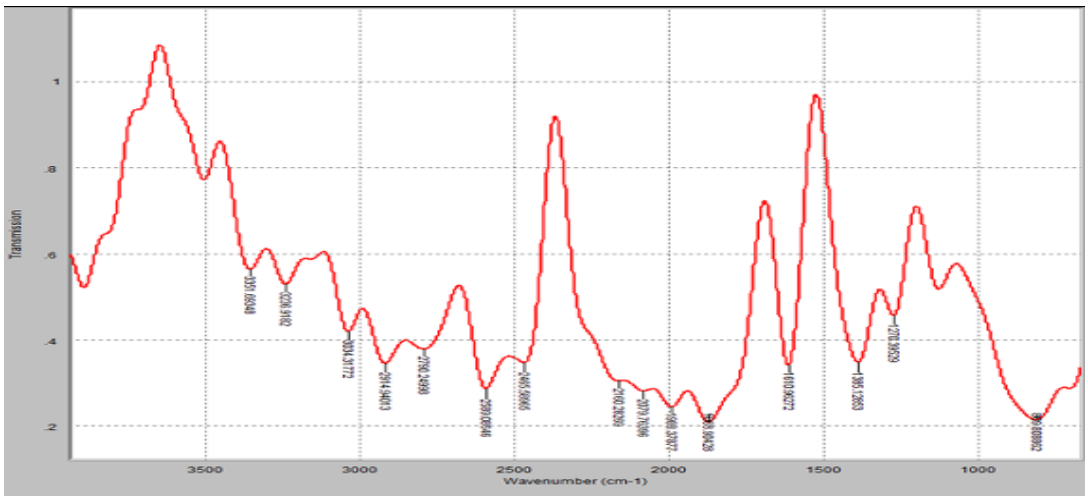

Figure 6: FT-IR spectrum of *Jatropha curcas* leaf N-hexane extract

Table 6: FT-IR spectral peak values and functional groups of phytochemicals in *Jatropha curcas* leaf N-hexane extract

S/No	Wave number (Test samples) (cm^{-1})	Frequency range (cm^{-1})(Reference number)	Chemical bond	Functional group	Peak details
1.	3351.693	(3300-3400)	N-H stretch	Aliphatic primary amine	Medium
2.	3236.918	(3200-3550)	O-H stretch(hydrogen bond)	Alcohol	Strong, broad
3.	3034.318	(3050-3100)	C-H stretch(aromatic)	Aromatic hydrocarbon	Medium to weak
4.	2914.94	(2840-3000)	C-H stretch	Alkane	Medium
5.	2790.25	(2800-3000)	N-H stretch	Amine salt	Strong, broad
6.	2589.086	(2550-2600)	S-H stretch	Thiol	Weak
7.	2465.59	Unknown	Unknown	Unknown	Unknown
8.	2160.283	(2120-2160)	N=N=N stretch	Azide	Strong
9.	2079.764	(1990-2140)	N=C=S stretch	Isothiocyanate	Strong, sharp
10.	1988.379	(1650-2000)	C-H bend	Aromatic compound	Weak
11.	1868.904	(1650-2000)	C-H bend	Aromatic compound	Weak
12.	1610.963	(1600-1650)	C=C stretch	Conjugated alkene	Medium
13.	1385.129	(1380-1390)	C-H bend	Aldehyde	Medium
14.	1270.395	(1266-1342)	C-N stretch	Aromatic amine	Strong
15.	809.8089	(790-830)	C-H bend	1,2,3,4-tetrasubstituted	Strong

4. Discussion

Plants have pharmacological activities attributed to the presence of secondary metabolites necessary for essential bioactivities. The presence of these secondary metabolites (phytochemicals) might be responsible for their use in traditional medicine and antimicrobial activity of plants extracts (Uba *et al*., 2016; Umeh *et al*., 2021; Faparusi and Adewale, 2021; Anameze *et al*., 2023; Ezeamama *et al*., 2025a; 2025b). In the present study, the quantities of bioactive compounds obtained in aqueous, methanol and hexane leaf extracts of *J. curcas* were 20, 20 and 22, respectively using Gas chromatography-Mass spectroscopy (GC-MS) detection technique. Thus, the hexane leaf extract of *Jatropha curcas* produced the highest number of bioactive compounds in this study. Hexane is a non polar solvent suitable for the extraction of lipophylic substances such as essential oils (Abedelmaksoud *et al*., 2025). The highest number of bioactive compounds in hexane extract might be due to the presence of lipophilic substances in *Jatropha curcas* which were well extracted by the hexane (Abedelmaksoud *et al*., 2025). Generally, the major phytochemical classes present in *J. curcas* extracts include flavonoids (74.5 – 93%), polyphenols (0.8 – 7.4%), phytoestrogen (1.1 – 14.5%), and benzoic acid derivative (0.2 - 6.2%). Most of the compounds detected in *Jatropha curcas* leaf extracts exhibit certain medicinal qualities including antibacterial, antioxidant (Guleria *et al*., 2025), anti-inflammatory and analgesic (Uche and Aprioku, 2010). Polyphenol was present in all extracts of both plants in varying degrees. Although the primary phytochemicals identified in the present study varied across the extracts due to differing polarities of the solvents used, flavonoids were the most predominant phytochemical compounds in the leaf extracts of both plants.

Also, the present study found that the FTIR analysis of the bioactive compounds in leaf extracts of *Jatropha curcas* revealed the presence of functional groups such as hydroxyl group-alcohol and phenol, amines (primary and secondary), aliphatic compounds (alkane, alkene, alkyne), carbonyl groups (ester, carboxylic acid, aldehyde, α,β-unsaturated ketone), carbodiimide, isothiocyanate, azide, thiol, halo compounds, sulphones and aromatic compounds. Similar findings were reported by Kichenamourty and Vellapandian (2022) who reported various functional groups of bioactive compounds identified in ethanol leaf extract of *J. curcas* using FT-IR

spectroscopy. Similar observations were reported by Enemchukwu *et al*. (2026a), (2026b), Uba and Okonkwo (2025), Uba *et al*. (2026) and Okonkwo *et al*. (2026) who documented different functional groups in the spectral profiling of leaf extracts.

5. Conclusion

In conclusion, plants contain secondary metabolites (phytochemicals) responsible for their pharmacological activities and traditional medicinal uses. In Jatropha curcas, hexane extract yielded the most bioactive compounds (22) vs. aqueous and methanol extracts (20 each), likely due to extraction of lipophilic substances. Major phytochemicals include flavonoids (74.5 - 93 %), polyphenols, phytoestrogen, and benzoic acid derivatives, exhibiting antibacterial, antioxidant, anti-inflammatory, and analgesic properties. FTIR analysis revealed functional groups like hydroxyl, amines, aliphatic compounds, carbonyl groups, and aromatics, aligning with other studies.

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