

# Phytochemical Profiling and GC-MS Analysis of *Conocarpus lancifolius* Fruits

Vaishali Mittal and Vartika Jain

Department of Botany, Government Meera Girls' College, Udaipur-313001, Rajasthan, India

## ABSTRACT

**Background and Objective:** Plants are repositories of several natural chemicals; the identification of which are important in the field of medicine, cosmetics, health and other industries. *Conocarpus lancifolius* Engl. (Family-Combretaceae) is an evergreen tree cultivated as an ornamental plant species. Since no comprehensive phytochemical analysis of its fruits was available, an attempt was made to evaluate the phytochemical composition and phyto-constituents present in its methanolic fruit extract. **Materials and Methods:** Both dry (mature) and green (immature) fruits (Dfr and Gfr, respectively) were collected from Udaipur city, Rajasthan, India. The aqueous and methanolic extracts underwent preliminary qualitative phytochemical screening, while the methanolic extract was subjected to Gas Chromatography-Mass Spectrometry (GC-MS) analysis for the first time. **Results:** The preliminary screening revealed the presence of carbohydrates, flavonoids, phenols, cardiac glycosides, terpenoids, coumarins, tannins, steroids, and phlobatannins, and the absence of amino acids and saponins. The GC-MS analysis demonstrated the presence of 80 and 65 biological compounds in Dfr and Gfr, respectively. The major compounds identified in Dfr and Gfr were, 1,2,3-benzenetriol (13.19, 26.13%), n-hexadecanoic acid (15.92, 11.12%),  $\beta$ -sitosterol (10.84, 9.57%), 10(E),12(Z)-Conjugated linoleic acid (9.51, 2.66%) and Lupeol (5.09, 5.57%), respectively. **Conclusion:** The preliminary phytochemical analysis and GC-MS profiling of *C. lancifolius* fruits from India have shown the presence of biologically significant phytochemicals for the first time and could stimulate future research to evaluate its complete pharmacological potential.

## KEYWORDS

Combretaceae, lanceleaf buttonwood, lupeol,  $\beta$ -sitosterol, pyrogallol, fatty acid, terpenoids

Copyright © 2026 Mittal and Jain. This is an open-access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution and reproduction in any medium, provided the original work is properly cited.

## INTRODUCTION

Metabolites are small molecules produced during metabolic processes and can be classified as primary or secondary. Primary metabolites, such as vitamins, amino acids, nucleotides, and organic acids, are essential for growth, reproduction, and normal physiological functions. In contrast, secondary metabolites, synthesized mainly during the stationary growth phase, are not directly involved in growth but play vital roles in plant defense and adaptation found abundantly in medicinal plants<sup>1</sup>. Moreover, the secondary metabolites, for example, alkaloids, flavonoids, tannins, phenolics, and saponins, exhibit diverse biological activities with significant therapeutic value<sup>2</sup>.





Fig. 1: *Conocarpus lancifolius* Engl

A qualitative and quantitative analysis of the phyto-constituents offers valuable insights for the discovery of new drugs. Gas Chromatography-Mass Spectrometry (GC-MS) is a reliable analytical method that has been widely used for the structural elucidation of a broad range of phyto-constituents, such as glycosides, flavonoids, phenolics, essential oils, alkaloids, saponins, steroids, and their derivatives, in addition to the analysis of volatile compounds<sup>3</sup>. Thus, the GC-MS profiling of a plant extract helps in the identification of pharmacologically valuable compounds.

*Conocarpus lancifolius* Engl. (Fig. 1) belonging to the family Combretaceae is an ornamental evergreen tree native to Somalia. It is commonly known as Lanceleaf Buttonwood and Damas tree and is notable for its resistance to heat and salt, as well as its tolerance to drought<sup>4</sup>. The plant is under the vulnerable category as per the IUCN Red Data List, and its decreasing population trend is a matter of concern<sup>5</sup>. Aerial parts, leaves, roots, and fruits of this plant have been explored for their phyto-pharmaceutical potential, and several pharmacological activities, including antioxidant, antimicrobial, anxiolytic, antidiabetic, cytotoxic, antiurease, cardio-protective, antiquorum-sensing, and acetylcholinesterase inhibition have been reported<sup>6-14</sup>. Besides, many secondary metabolites like phenolic compounds, flavonoids, alkaloids, fatty acids, steroids, terpenoids, coumarins, saponins, tannins, glycosides, anthraquinones etc. have been identified from leaves, roots, stems, and aerial parts of *C. lancifolius*.

Al-Taweel *et al.*<sup>6</sup> have isolated one novel compound 3,3',4' trimethoxy 4-O-cyclopentanone ellagic acid, and two known compounds, kaempferol 3-O-rutinoside and  $\beta$  sitosterol 3-O-glucoside, from the fruits of *C. lancifolius*. Whereas Afifi *et al.*<sup>7</sup> have reported several polyphenolic compounds from ethanolic fruit extract of *C. lancifolius*, such as 4-hydroxy benzoic acid, vanillic acid, caffeic acid, 1,2-dihydroxy benzene, catechin, benzoic acid, p-coumaric acid, t-ferulic acid, sinapic acid, vanillin, rutin hydrate, cinnamic acid, protocatechuic acid, quercetin, and tannins. However, phytochemical investigation of its fruits through GC-MS have still not been carried out. Hence, the present study was undertaken to investigate the bioactive compounds present in the methanolic extract of *Conocarpus lancifolius* fruits, contributing to a better understanding of its phytochemical composition.

## MATERIALS AND METHODS

**Plant collection and identification:** The dry (fully mature) and green (immature) fruits of *C. lancifolius* were collected during February-March, 2025 from Udaipur City, Rajasthan, India. The voucher specimen was prepared and authentication of the plant was carried out at Arid Zone Regional Centre, Botanical Survey of India (BSI), Jodhpur (No./BSI/AZRC/A.12012/Tech./2025-26(Pl. Id.)/445; dated 17.09.2025).

**Preparation of plant extracts:** Both dry and green fruits were washed under running tap water and air-dried in the shade at room temperature. After drying, both were powdered separately, coded as Dfr and Gfr, respectively, and stored at 4°C in a refrigerator. For preliminary qualitative phytochemical and GC-MS analyses, the following two types of extracts were prepared from the powdered plant materials.

**Aqueous extract:** Aqueous extracts were freshly prepared by soaking 400 mg of each Dfr and Gfr of *C. lancifolius* in 20 mL of distilled water separately, followed by boiling for 20 min. These were cooled and filtered through Whatman's No. 1 filter paper. The clear filtrates were utilized instantly for preliminary qualitative phytochemical screening.

**Methanolic extract:** One hundred gram of both Dfr and Gfr were soaked in 700 mL of methanol separately for eight days with periodic stirring and then filtered using Whatman's filter paper No. 1. The filtrates were evaporated in a boiling water bath at 40°C, and the concentrated extracts were stored in sterile glass petri dishes at 4°C in the refrigerator. The percent yields obtained for methanolic extracts of Dfr and Gfr were 1.88 and 10.34%, respectively. These extracts were used for qualitative phytochemical assessment as well as analyzed for the presence of various phytochemicals through GC-MS.

**Qualitative phytochemical screening:** Aqueous/ME or dry and green fruit powders of *C. lancifolius* were used for preliminary qualitative phytochemical screening of amino acids, carbohydrates, terpenoids, steroids, cardiac glycosides, phlobatannins, flavonoids, phenols, tannins, coumarins, and saponins as required. These tests were performed as per standard methodology<sup>15</sup>.

**Gas Chromatography-Mass Spectrometry (GC-MS) analysis:** To find out the chemical compounds present in the methanolic extracts of Dfr and Gfr of *C. lancifolius*, Gas Chromatography-Mass Spectrometry analysis was conducted on a Shimadzu GC-MS-QP2010 Ultra system with an AOC-20i+s autosampler. The system employed a Rxi-5 SIL MS column (30 m×0.25 mm i.d×0.25 mm film thickness) with helium as the carrier gas at a constant flow rate of 1.21 mL/min. In split mode, the injector operated with a 10:1 split ratio, 1 µL of injection volume, and 270°C injection temperature. The column oven temperature was initially established at 70°C for 2 min, subsequently increased at a rate of 10°C/min to 300°C, and held for 15 min. Ion source and interface temperatures were maintained at 220°C and 280°C, respectively. In scan mode, mass spectra were obtained with a solvent cut-off time of 3.50 min, a mass range of 40-600 m/z, and a scan rate of 3333 scans per second. Data were acquired in Total Ion Count (TIC) mode. Identifications of compounds were made by matching retention times and mass spectral patterns against the National Institute of Standards and Technology (NIST) and Wiley libraries. The relative abundance of each analyte was computed as the percentage of its peak area relative to the aggregate peak area of all detected components.

## RESULTS

**Qualitative phytochemical analysis:** A preliminary qualitative phytochemical analysis of both dry and green fruits of *C. lancifolius* has shown the presence of one primary metabolite that is carbohydrate and eight secondary metabolites, namely, flavonoid, phenol, cardiac glycoside, terpenoid, coumarin, steroid, tannin and phlobatanin. One primary metabolite amino acid and one secondary metabolite saponin were not detected in both Dfr and Gfr (Table 1).

**GC-MS analysis:** The methanolic extracts of dry and green fruits of *C. lancifolius*, analyzed through GC-MS, revealed 84 and 71 peaks in the chromatograms, corresponding to 80 and 65 compounds, respectively (Fig. 2 and 3). Among which, n-hexadecanoic acid (15.92%), pyrogallol (13.19%), β-sitosterol (10.84%), 10(E),12(Z)-Conjugated linoleic acid (9.51%), Oleic acid (5.36%) and Lupeol (5.09%) in Dfr (Table 2) whereas pyrogallol (26.13%), n-hexadecanoic acid (11.12%), β-sitosterol (9.57%) and Lupeol (5.57%) in Gfr (Table 3), were the most abundant compounds. Among the variety of secondary metabolites in *C. lancifolius*, terpenoids and fatty acid derivatives are predominant compounds present, followed by phenolic compounds, phytosterols, hydrocarbons, heterocyclic compounds, and other miscellaneous compounds (Table 4).

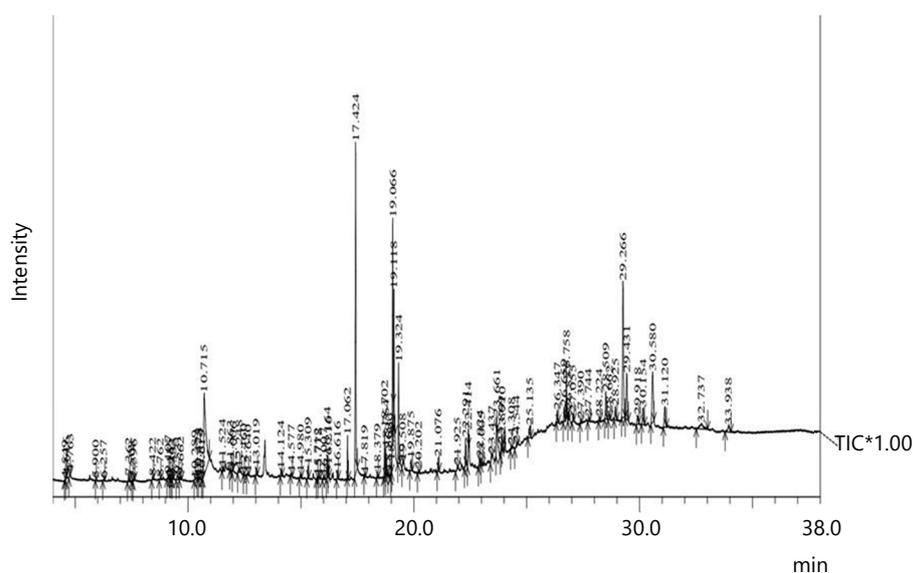


Fig. 2: GC-MS chromatogram of methanolic extract of *Conocarpus lancifolius* dry fruits

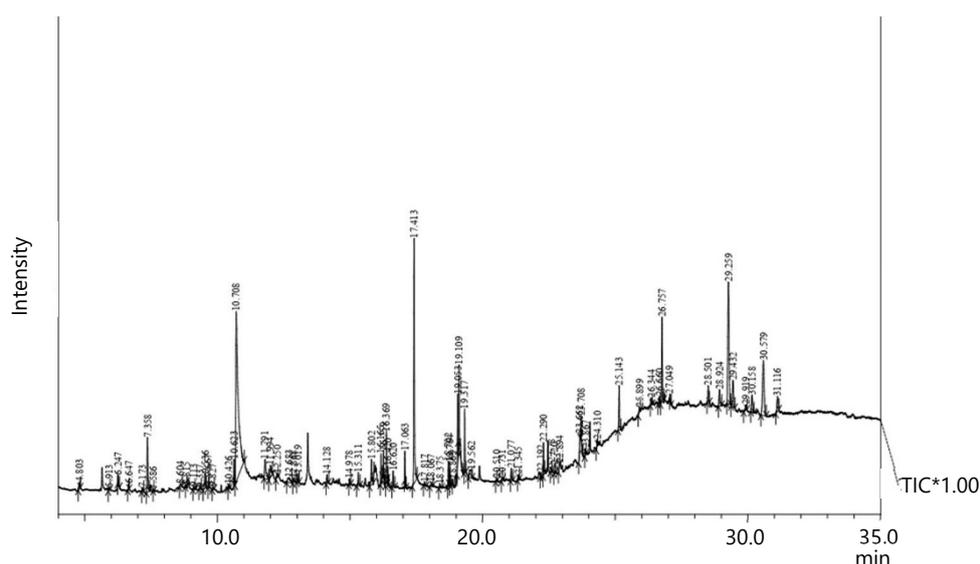


Fig. 3: GC-MS chromatogram of methanolic green fruit extract of *Conocarpus lancifolius*

The compounds which are unique to dry mature fruits of *C. lancifolius* are Diglycolic acid, ethyl 2-isopropoxyphenyl ester, Octanoic acid, Phenol, 8-Hydroxy-2-octanone, 2,4,6-Cycloheptatrien-1-one, Dehydromevalonic lactone, Dianhydromannitol, 3-Dimethylsilyloxytetradecane, Nonanoic acid, Acetic acid, 1,3,7-trimethylocta-2,6-dienyl ester, Dodecanal dimethyl acetal, 3-Methyl-2-(2-methyl-2-butenyl)-furan, 2-Isopropenyl-3-methylpyrazine, Guaia-6,9-diene, Longifolene, 6-Dimethyl(trimethylsilyl)silyloxytetradecane, D-Mannoheptulose,  $\gamma$ -Elemene,  $\alpha$ -Amorphene, Dodecanoic acid, Canophyllal, Orcinol, monoacetate, Decane, 2,3,8-trimethyl-, Isopropyl palmitate, 2-Methyl tetracosane, Heptadecanoic acid, Oleic Acid, Undec-10-ynoic acid, tetradecyl ester, Eicosanoic acid, 1H-1,3-Benzimidazol-7-amine, N-[(4-methoxyphenyl)methyl], Tyrosine, 9-Hexacosene, 1-Decyloxymethyl-3-methyl-1,3-dihydrobenzimidazol-2-ylideneamine, Ethyl 6,9,12,15-octadecatetraenoate, 9,12-Octadecadienoic acid (Z,Z)-, 2,3-dihydroxypropyl ester, Octadecanoic acid, 2,3-dihydroxypropyl ester, Benzoic acid, 2,4-dihydroxy-, 4-(1,1-dimethylpropyl)phenyl, Oleamide, 1,54-dibromotetrapentacontane, Dodecane, 1,1-dimethoxy-, Tetracosan-10-yl acetate, Campesterol, Stigmast-5-en-3-ol, oleat, Stigmasta-4,22-diene, Stigmastane-3,6-dione, (5- $\alpha$ ),  $\alpha$ -amyrin and Cyclopentanone, 2-(5-oxohexyl) as shown in Table 2. Besides, two peaks were obtained for four compounds, namely, 9-Octadecenamide, Phenol, 2-methyl-5-(1-methylethyl), Neophytadiene, and 10(E),12(Z)-Conjugated linoleic acid (Table 2).

Table 1: Qualitative phytochemical analysis of fruits of *Conocarpus lancifolius* Engl.

Phytochemical	Dry fruit (Dfr)	Green fruit (Gfr)
Carbohydrate	+	+
Amino acid	-	-
Flavonoid	+	+
Phenol	+	+
Cardiac glycoside	+	+
Terpenoid	+	+
Coumarin	+	+
Steroid	+	+
Saponin	-	-
Tannin	+	+
Phlobatanin	+	+

+: Present and -: Absent

Table 2: Phyto-compounds identified through GC-MS in methanolic extract of *Conocarpus lancifolius* dry fruits (Dfr)

Peak	R. Time	Area %	Name of the compound	Molecular formula	Molecular weight (g/mol)	Name of compound
1	4.549	0.05	Diglycolic acid, ethyl 2-isopropoxyphenyl ester	C <sub>15</sub> H <sub>20</sub> O <sub>6</sub>	296	Aromatic ester
2	4.616	0.06	Octanoic acid (Caprylic acid)	C <sub>8</sub> H <sub>16</sub> O <sub>2</sub>	144	Saturated fatty acid
3	4.763	0.15	Phenol	C <sub>6</sub> H <sub>5</sub> OH	94	Phenolic compound
4	5.900	0.01	4-hydroxy-2,5-dimethyl-3(2h)-furanone	C <sub>6</sub> H <sub>8</sub> O <sub>3</sub>	128	Heterocyclic compound
5	6.257	0.07	8-Hydroxy-2-octanone	C <sub>8</sub> H <sub>16</sub> O <sub>2</sub>	144	Aliphatic hydroxyl ketone
6	7.362	0.23	4H-Pyran-4-one, 2,3-dihydro-3,5-dihydroxy-6-methyl (Pyranone)	C <sub>6</sub> H <sub>8</sub> O <sub>4</sub>	144	Phenolic compound
7	7.508	0.02	2,4,6-Cycloheptatrien-1-one (Tropone)	C <sub>7</sub> H <sub>6</sub> O	106	Conjugated ketone
8	7.596	0.13	Dehydromevalonic lactone	C <sub>6</sub> H <sub>8</sub> O <sub>2</sub>	112	Cyclic α,β-unsaturated lactone
9	8.422	0.16	Dianhydromannitol	C <sub>6</sub> H <sub>10</sub> O <sub>4</sub>	146	Sugar alcohol derivative
10	8.762	0.06	3-Dimethylsilyloxytetradecane	C <sub>16</sub> H <sub>36</sub> OSi	272	Alkane derivative
11	9.107	0.18	Nonanoic acid	C <sub>9</sub> H <sub>18</sub> O <sub>2</sub>	158	Fatty Acid
12	9.185	0.03	Acetic acid, 1,3,7-trimethylocta-2,6-dienyl ester	C <sub>13</sub> H <sub>22</sub> O <sub>2</sub>	210	Monoterpene ester
13	9.262	0.02	Dodecanal dimethyl acetal	C <sub>14</sub> H <sub>30</sub> O <sub>2</sub>	230	Fatty acid
14	9.333	0.08	Phenol, 2-methyl-5-(1-methylethyl), (O-Thymol/Carvacrol)	C <sub>10</sub> H <sub>14</sub> O	150	Phenolic compound
15	9.531	0.37	3-Methyl-2-(2-methyl-2-butenyl)-furan (Rosefuran)	C <sub>10</sub> H <sub>14</sub> O	150	Terpenoid
16	9.662	0.16	Phenol, 2-methyl-5-(1-methylethyl), (O-Thymol/Carvacrol)	C <sub>10</sub> H <sub>14</sub> O	150	Phenolic compound
17	10.289	0.02	2-Isopropenyl-3-methylpyrazine	C <sub>8</sub> H <sub>10</sub> N <sub>2</sub>	134	Heterocyclic compound
18	10.423	0.05	Phenol, 2-methoxy-4-(2-propenyl), (1,3,4-Eugenol)	C <sub>10</sub> H <sub>12</sub> O <sub>2</sub>	64	Phenolic compound
19	10.478	0.07	n-Decanoic acid (Capric acid )	C <sub>10</sub> H <sub>20</sub> O <sub>2</sub>	172	Fatty Acid
20	10.619	0.04	4-tert-Butylcyclohexyl acetate	C <sub>12</sub> H <sub>22</sub> O <sub>2</sub>	198	Acid ester
21	10.715	13.19	1,2,3-benzenetriol (Pyrogallol)	C <sub>6</sub> H <sub>3</sub> (OH) <sub>3</sub>	126	Phenolic compound
21	11.524	0.13	Guaia-6,9-diene	C <sub>15</sub> H <sub>24</sub>	204	Sesquiterpene
23	11.863	0.07	Longifolene	C <sub>15</sub> H <sub>24</sub>	204	Sesquiterpene
24	12.006	0.07	6-Dimethyl(trimethylsilyl)silyloxytetradecane	C <sub>19</sub> H <sub>44</sub> OSi <sub>2</sub>	344	Organosilane
25	12.248	0.28	D-Mannoheptulose	C <sub>7</sub> H <sub>14</sub> O <sub>7</sub>	210	Monosaccharide
26	12.460	0.07	γ-Elemene	C <sub>15</sub> H <sub>24</sub>	204	Sesquiterpene
27	12.640	0.15	α-Amorphene	C <sub>15</sub> H <sub>24</sub>	204	Sesquiterpene
28	13.019	0.38	Dodecanoic acid (Lauric acid)	C <sub>12</sub> H <sub>24</sub> O <sub>2</sub>	200	Fatty Acid
29	14.124	0.37	Isocitronellol	C <sub>10</sub> H <sub>20</sub> O	156	Monoterpenoid
30	14.577	0.23	Caryophyllane, 4,8- beta-epoxy	C <sub>15</sub> H <sub>26</sub> O	222	Sesquiterpene
31	14.980	0.29	Canophyllal	C <sub>30</sub> H <sub>48</sub> O <sub>2</sub>	440	Pentacyclic triterpenoid
32	15.309	0.48	Tetradecanoic acid (Myristic acid)	C <sub>14</sub> H <sub>28</sub> O <sub>2</sub>	228	Fatty Acid
33	15.712	0.10	Orcinol, monoacetate	C <sub>7</sub> H <sub>8</sub> O <sub>2</sub>	124	Phenolic compounds
34	15.778	0.21	Decane, 2,3,8-trimethyl-	C <sub>13</sub> H <sub>28</sub>	184	Branched alkane

Table 2: Continue

Peak	R. Time	Area %	Name of the compound	Molecular formula	Molecular weight (g/mol)	Nature of compound
35	16.007	0.17	Isopropyl palmitate	C <sub>19</sub> H <sub>38</sub> O <sub>2</sub>	298	Fatty acid ester
36	16.164	0.67	Neophytadiene	C <sub>20</sub> H <sub>38</sub>	278	Diterpene
37	16.216	0.33	2L, 4d-dihydroyeicosane	C <sub>20</sub> H <sub>42</sub> O <sub>2</sub>	314	Fatty alcohol
38	16.616	0.40	Phytol (3,7,11,15-Tetramethyl-2-hexadecen-1-ol)	C <sub>20</sub> H <sub>42</sub> O	296	Diterpenoid
39	17.062	1.47	Hexadecanoic acid, methyl ester (Palmitic acid methyl ester)	C <sub>17</sub> H <sub>34</sub> O <sub>2</sub>	270	Fatty acid ester
40	17.424	15.92	n-Hexadecanoic acid (Palmitic acid)	C <sub>16</sub> H <sub>32</sub> O <sub>2</sub>	256	Fatty acid ester
40	17.819	0.09	2-Methyl tetracosane	C <sub>25</sub> H <sub>52</sub>	352	Alkane
42	18.379	0.25	Heptadecanoic acid (Margaric acid)	C <sub>17</sub> H <sub>34</sub> O <sub>2</sub>	270	Saturated fatty acid
43	18.702	1.78	9,12-Octadecadienoic acid (Z,Z)-, methyl ester (Methyl linoleate)	C <sub>19</sub> H <sub>34</sub> O <sub>2</sub>	294	Fatty acid ester
44	18.764	0.97	9-Octadecenoic acid, methyl ester, (E)-	C <sub>19</sub> H <sub>36</sub> O <sub>2</sub>	296	Fatty acid ester
45	18.869	0.05	Neophytadiene	C <sub>20</sub> H <sub>38</sub>	278	Terpenoid
46	18.999	0.44	Octadecanoic acid, methyl ester (Methyl stearate)	C <sub>19</sub> H <sub>38</sub> O <sub>2</sub>	298	Fatty acid ester
47	19.066	8.90	10(E),12(Z)-Conjugated linoleic acid	C <sub>18</sub> H <sub>32</sub> O <sub>2</sub>	280	Fatty acid
48	19.118	5.36	Oleic Acid	C <sub>18</sub> H <sub>34</sub> O <sub>2</sub>	282	Fatty acid
49	19.324	4.29	Octadecanoic acid (stearic acid)	C <sub>18</sub> H <sub>36</sub> O <sub>2</sub>	284	Fatty acid ester
50	19.508	0.15	9-Octadecenamide	C <sub>18</sub> H <sub>35</sub> NO	281	Fatty amide
51	19.875	0.61	10(E),12(Z)-Conjugated linoleic acid	C <sub>18</sub> H <sub>35</sub> NO	281	Fatty amide
52	20.202	0.13	Undec-10-ynoic acid, tetradecyl ester	C <sub>25</sub> H <sub>46</sub> O <sub>2</sub>	378	Fatty acid ester
53	21.076	0.57	Eicosanoic acid (Arachidic acid)	C <sub>20</sub> H <sub>40</sub> O <sub>2</sub>	312	Saturated fatty acid
54	21.925	0.09	1H-1,3-Benzimidazol-7-amine, N-[(4-methoxyphenyl)methyl	C <sub>16</sub> H <sub>17</sub> N <sub>3</sub> O	267	Heterocyclic compound
55	22.291	1.19	Hexadecanoic acid, 2-hydroxy-1-(hydroxymethyl)ethyl ester (Glycerol beta-palmitate)	C <sub>19</sub> H <sub>38</sub> O <sub>4</sub>	330	Fatty acid ester
56	22.414	0.81	Tyrosine	C <sub>9</sub> H <sub>11</sub> NO <sub>3</sub>	181	Amino acid
57	22.924	0.40	9-Hexacosene	C <sub>26</sub> H <sub>52</sub>	364	Hydrocarbon
58	23.005	0.23	1-Decyloxymethyl-3-methyl-1,3-dihydrobenzimidazol-2-ylideneamine	C <sub>19</sub> H <sub>31</sub> N <sub>3</sub> O	317	Heterocyclic compounds
59	23.437	0.18	Ethyl 6,9,12,15-octadecatetraenoate	C <sub>20</sub> H <sub>32</sub> O <sub>2</sub>	304	Fatty acid ethyl ester
60	23.661	0.94	9,12-Octadecadienoic acid (Z,Z)-, 2,3-dihydroxypropyl ester	C <sub>21</sub> H <sub>38</sub> O <sub>4</sub>	354	Fatty acid ester
61	23.869	0.17	Octadecanoic acid, 2,3-dihydroxypropyl ester	C <sub>21</sub> H <sub>42</sub> O <sub>4</sub>	358	Fatty acid ester
62	23.910	0.66	Benzoic acid, 2,4-dihydroxy-, 4-(1,1-dimethylpropyl)phenyl	C <sub>21</sub> H <sub>42</sub> O <sub>4</sub>	358	Aromatic ester
63	24.308	0.16	9-octadecenamide (Oleamide)	C <sub>18</sub> H <sub>35</sub> NO	281	Fatty amide
64	24.544	0.19	Squalene	C <sub>30</sub> H <sub>50</sub>	410	Triterpenoid
65	25.135	0.98	1,54-dibromotetrapentacontane	C <sub>54</sub> H <sub>100</sub> Br <sub>2</sub>	914	Hydrocarbon
66	26.347	0.56	γ-Tocopherol (Vitamin E)	C <sub>28</sub> H <sub>48</sub> O <sub>2</sub>	416	Phenolic compound
67	26.659	0.77	Cholesta-4,6-dien-3-ol, (3.beta.)	C <sub>27</sub> H <sub>44</sub> O	384	Cholesterol
68	26.758	1.20	1-Heptacosanol	C <sub>27</sub> H <sub>56</sub> O	396	Fatty alcohol
69	26.857	0.40	Stigmast-5-en-3-ol, oleat	C <sub>47</sub> H <sub>82</sub> O <sub>2</sub>	678	Phytosterol
70	27.055	0.49	α-Tocopherol (Vitamin E)	C <sub>29</sub> H <sub>50</sub> O <sub>2</sub>	430	Phenolic compound
71	27.390	0.17	Dodecane, 1,1-dimethoxy-	C <sub>14</sub> H <sub>30</sub> O <sub>2</sub>	230	Acetal
72	27.744	0.27	Tetracosan-10-yl acetate	C <sub>26</sub> H <sub>52</sub> O <sub>2</sub>	396	Fatty acid ester
73	28.224	0.22	Ergost-5-en-3-ol (3.beta.,24R)-(Campesterol)	C <sub>28</sub> H <sub>48</sub> O	400	Phytosterol
74	28.509	1.91	Stigmasterol	C <sub>29</sub> H <sub>48</sub> O	412	Phytosterol
75	28.662	0.35	Stigmasta-4,22-diene	C <sub>29</sub> H <sub>48</sub>	396	Phytosterol
76	28.925	0.99	1-Hexacosanol (Ceryl alcohol)	C <sub>26</sub> H <sub>54</sub> O	382	Primary fatty alcohol
77	29.266	10.84	Stigmast-5-en-3-ol, (3beta), (β-sitosterol)	C <sub>29</sub> H <sub>50</sub> O	414	Phytosterol
78	29.431	3.82	Stigmastanol	C <sub>29</sub> H <sub>52</sub> O	416	Phytosterol
79	29.918	0.70	α-amyrin	C <sub>30</sub> H <sub>50</sub> O	426	Triterpenoid

Table 2: Continue

Peak	R. Time	Area %	Name of the compound	Molecular formula	Molecular weight (g/mol)	Nature of compound
80	30.154	1.44	Lup-20(29)-en-3-one (Lupenone)	C <sub>30</sub> H <sub>48</sub> O	424	Triterpenoid
81	30.580	5.09	Lupeol	C <sub>30</sub> H <sub>50</sub> O	426	Triterpenoid
82	31.120	1.85	γ Sitostenone	C <sub>29</sub> H <sub>48</sub> O	412	Phytosterol
83	32.737	1.45	Cyclopentanone, 2-(5-oxohexyl)	C <sub>11</sub> H <sub>18</sub> O <sub>2</sub>	182	Fatty acid derivative
84	33.938	0.94	Stigmastane-3,6-dione, (5-α)	C <sub>29</sub> H <sub>48</sub> O <sub>2</sub>	428	Phytosterol

R. time: Retention time and NR: Not reported

Table 3: List of phyto-constituents present in green fruits of *C. lancifolius* analyzed through GC-MS

Peak	R. Time	Area %	Name of the compound	Molecular formula	Molecular weight (g/mol)	Name of compound
1	4.803	0.46	4H-Pyran-4-one, 2,3-dihydro-3,5-dihydroxy-6-methyl	C <sub>6</sub> H <sub>8</sub> O <sub>4</sub>	144	Phenolic
2	5.913	0.12	Furaneol	C <sub>6</sub> H <sub>8</sub> O <sub>3</sub>	128	Acetate ester
3	6.247	0.37	1,3,5-Triazine-2,4,6-triamine (Melamine)	C <sub>3</sub> H <sub>6</sub> N <sub>6</sub>	126	Heterocyclic compound
4	6.647	0.21	3,7-Dimethylocta-1,6-dien-3-ol (Linalool)	C <sub>10</sub> H <sub>18</sub> O	154	Monoterpene alcohol
5	7.173	0.19	Pentanoic acid (Valeric acid)	C <sub>18</sub> H <sub>16</sub> O <sub>2</sub>	144	Alkyl carboxylic acid
6	7.358	2.65	4H-Pyran-4-one, 2,3-dihydro-3,5-dihydroxy-6-methyl	C <sub>6</sub> H <sub>8</sub> O <sub>4</sub>	144	Phenolic compound
7	7.586	0.03	2-Cyclopenten-1-one, 2-hydroxy-3-methyl-(Corylon)	C <sub>6</sub> H <sub>8</sub> O <sub>2</sub>	112	Fatty acid derivatives
8	8.604	0.19	5-Hydroxymethylfurfural	C <sub>6</sub> H <sub>6</sub> O <sub>3</sub>	126	Heterocyclic furan derivative
9	8.815	0.07	Butanoic acid, 3-hydroxy-3-methyl	C <sub>5</sub> H <sub>10</sub> O <sub>3</sub>	118	Hydrocarboxylic acid
10	9.113	0.15	Decanoic acid (Capric acid)	C <sub>10</sub> H <sub>20</sub> O <sub>2</sub>	172	Fatty acid
11	9.337	0.05	Butanamide, 2-hydroxy-N,2,3,3-tetramethyl-	C <sub>8</sub> H <sub>17</sub> NO <sub>2</sub>	159	Branched hydroxyamide
12	9.536	0.79	Phenol, 2-methyl-5-(1-methylethyl)	C <sub>10</sub> H <sub>14</sub> O	150	Phenolic compound
13	9.667	0.25	Phenol, 2-methyl-5-(1-methylethyl)	C <sub>10</sub> H <sub>14</sub> O	150	Phenolic compound
14	9.827	0.13	3-Methylpiperidin-4-ol	C <sub>6</sub> H <sub>13</sub> NO	115	Heterocyclic alcohol
15	10.426	0.16	Phenol, 2-methoxy-4-(2-propenyl) (1,3,4-Eugenol)	C <sub>10</sub> H <sub>12</sub> O <sub>2</sub>	164	Phenolic compound
16	10.623	0.48	4-tert-Butylcyclohexyl acetate	C <sub>12</sub> H <sub>22</sub> O <sub>2</sub>	198	Carboxylic ester
17	10.708	26.13	1,2,3-benzenetriol (Pyrogallol)	C <sub>6</sub> H <sub>6</sub> O <sub>3</sub>	126	Phenolic compound
18	11.791	1.78	Silane, dimethyl(but-2-enyloxy) isobutoxy	C <sub>10</sub> H <sub>22</sub> OSi	202	Alkoxysilane derivative
19	11.994	0.97	2-Oxovaleric acid, tert-butyl dimethylsilyl ester	C <sub>11</sub> H <sub>22</sub> O <sub>3</sub> Si	230	Alpha keto acid
20	12.250	0.24	Anhydro-d-mannosan (Levogluconan)	C <sub>6</sub> H <sub>10</sub> O <sub>5</sub>	162	Carbohydrate derivative
21	12.683	0.72	10,12-Tricosadiynoic acid	C <sub>23</sub> H <sub>38</sub> O <sub>2</sub>	346	Fatty acid
22	12.868	0.21	2-[Di(tert-butyl) silyl oxy methyl] tetrahydro furane	C <sub>13</sub> H <sub>28</sub> O <sub>2</sub> Si	244	Silyl ether
23	13.019	0.32	Ethyl iso-allocholate	C <sub>26</sub> H <sub>44</sub> O <sub>5</sub>	436	Steroid derivative
24	14.128	0.36	Isocitronellol	C <sub>10</sub> H <sub>20</sub> O	156.27	Monoterpene
25	14.978	0.24	Caryophyllane, 4,8- beta-epoxy	C <sub>15</sub> H <sub>26</sub> O	222	Sesquiterpene
26	15.311	0.66	Tetradecanoic acid (Myristic acid)	C <sub>14</sub> H <sub>28</sub> O <sub>2</sub>	228	Fatty acid
27	15.802	1.40	1-Heptatriacotanol	C <sub>37</sub> H <sub>76</sub> O	537	Fatty alcohol
28	16.165	0.83	Neophytadiene	C <sub>20</sub> H <sub>38</sub>	278	Terpenoid
29	16.259	0.42	(E)-3-Methyl-5-((1R,4aR,8aR)-5,5,8a-trimethyl-2-methylenedecahydronaphthalen-1-yl)pent-2-en-1-ol (Copalol)	C <sub>20</sub> H <sub>34</sub> O	290	Diterpenoid
30	16.369	1.99	Copalol	C <sub>20</sub> H <sub>34</sub> O	290	Diterpenoid
31	16.420	0.29	5-isopropyl-6,6-dimethylhept-3-yne-2,5-diol	C <sub>12</sub> H <sub>22</sub> O <sub>2</sub>	198	Oxygenated monoterpoid
32	16.620	0.80	Phytol (3,7,11,15-Tetramethyl-2-hexadecen-1-ol)	C <sub>20</sub> H <sub>40</sub> O	296	Diterpenoid
33	17.063	0.82	Hexadecanoic acid, methyl ester	C <sub>17</sub> H <sub>34</sub> O <sub>2</sub>	270	Fatty acid ester
34	17.413	11.12	n-Hexadecanoic acid (Palmitic acid)	C <sub>16</sub> H <sub>32</sub> O <sub>2</sub>	256	Fatty acid ester
35	17.817	0.10	Nonadecane	C <sub>19</sub> H <sub>40</sub>	268	Alkane
36	18.067	0.18	7-Hexadecenoic acid, methyl ester, (Z)-	C <sub>17</sub> H <sub>32</sub> O <sub>2</sub>	268	Fatty acid ester
37	18.375	0.21	9-octadecenoic acid (z)	C <sub>19</sub> H <sub>36</sub> O <sub>2</sub>	296	Fatty acid ester
38	18.702	0.86	9,12-Octadecadienoic acid (Z, Z), methyl ester (Methyl linoleate)	C <sub>19</sub> H <sub>34</sub> O <sub>2</sub>	294	Fatty acid ester

Table 3: Continue

Peak	R. Time	Area %	Name of the compound	Molecular formula	Molecular weight (g/mol)	Name of compound
39	18.764	0.75	9-Octadecenoic acid, methyl ester, (E)	C <sub>19</sub> H <sub>36</sub> O <sub>2</sub>	296	Fatty acid ester
40	18.869	0.14	Phytol (3,7,11,15-Tetramethyl-2-hexadecen-1-ol)	C <sub>20</sub> H <sub>40</sub> O	296	Diterpenoid
41	19.053	2.66	10(E),12(Z)-Conjugated linoleic acid	C <sub>18</sub> H <sub>32</sub> O <sub>2</sub>	280	Fatty acid
42	19.109	2.85	cis-9-Hexadecenal	C <sub>16</sub> H <sub>30</sub> O	238	Unsaturated aldehyde
43	19.317	2.46	Octadecanoic acid	C <sub>18</sub> H <sub>36</sub> O <sub>2</sub>	284	Fatty acid ester
44	19.562	0.97	9(E),11(E)-Conjugated linoleic acid (ethyl linoleate)	C <sub>18</sub> H <sub>32</sub> O <sub>2</sub>	280	Fatty acid ethyl ester
45	20.510	0.07	Myristic acid glycidyl ester	C <sub>17</sub> H <sub>32</sub> O <sub>3</sub>	284	Fatty acid ester
46	20.731	0.10	7-Hexadecenal, (Z)-	C <sub>16</sub> H <sub>30</sub> O <sub>2</sub>	238	Unsaturated aldehyde
47	21.077	0.50	9-Octadecenoic acid (Z)-	C <sub>19</sub> H <sub>36</sub> O <sub>2</sub>	296	Fatty acid ester
48	21.345	0.14	Behenic alcohol	C <sub>22</sub> H <sub>46</sub> O	326	Fatty alcohol
49	22.192	0.13	Heneicosane	C <sub>21</sub> H <sub>44</sub>	296	Hydrocarbon
50	22.290	1.26	Hexadecanoic acid, 2-hydroxy-1-(hydroxymethyl)ethyl ester	C <sub>19</sub> H <sub>38</sub> O <sub>4</sub>	330	Fatty acid ester
51	22.578	0.22	Docosyl pentafluoro propionate	C <sub>25</sub> H <sub>45</sub> F <sub>5</sub> O <sub>2</sub>	472	Long-chain fluorinated ester
52	22.720	0.10	1-octanol, 3,7-dimethyl	C <sub>10</sub> H <sub>22</sub> O	158	Fatty acid ester
53	22.894	0.03	3-Methylbutylhexadecanoate	C <sub>21</sub> H <sub>42</sub> O <sub>2</sub>	326	Fatty acid ester
54	23.662	0.24	6,9- Octadecadienoic acid, methyl ester	C <sub>19</sub> H <sub>34</sub> O <sub>2</sub>	294	Fatty acid ester
55	23.708	0.16	2-Methylhexacosane	C <sub>27</sub> H <sub>56</sub>	380	Hydrocarbon
56	23.867	0.24	Octadecanoic acid, 2,3-dihydroxypropyl ester	C <sub>23</sub> H <sub>42</sub> O <sub>4</sub>	358	Fatty acid ester
57	24.310	0.27	13-Docosamide, (Z) (Erucamide)	C <sub>22</sub> H <sub>43</sub> NO	337	Fatty acid amide
58	25.143	1.95	1-Heptacosanol	C <sub>27</sub> H <sub>56</sub> O	396	Fatty alcohol
59	25.899	0.29	Heptacosyl heptafluorobutyrate	C <sub>31</sub> H <sub>55</sub> F <sub>7</sub> O <sub>2</sub>	592	Hydrocarbon
60	26.344	0.31	γ-Tocopherol	C <sub>28</sub> H <sub>48</sub> O <sub>2</sub>	416	Phenolic compound
61	26.660	0.30	Cholesta-4,6-dien-3-ol, (3-beta)	C <sub>27</sub> H <sub>44</sub> O	384	Cholesterol
62	26.757	4.43	1-Heptacosanol	C <sub>27</sub> H <sub>56</sub> O	396	Fatty alcohol
63	27.049	0.22	α-Tocopherol	C <sub>29</sub> H <sub>50</sub> O <sub>2</sub>	430	Phenolic compound
64	28.501	1.04	Stigmasta-5,23-dien-3-ol, (3-beta), (Stigmasterol)	C <sub>29</sub> H <sub>48</sub> O	412	Phytosterol
65	28.924	1.14	1-Hexacosanol (Ceryl alcohol)	C <sub>26</sub> H <sub>54</sub> O	382	Primary fatty alcohol
66	29.259	9.57	β-Sitosterol	C <sub>29</sub> H <sub>50</sub> O	414	Phytosterol
67	29.432	2.10	Stigmastanol	C <sub>29</sub> H <sub>52</sub> O	416	Phytosterol
68	29.919	0.37	β-Amyrin	C <sub>30</sub> H <sub>50</sub> O	426	Triterpenoid
69	30.158	1.31	Lup-20(29)-en-3-one (Lupenone)	C <sub>30</sub> H <sub>48</sub> O	424	Triterpenoid
70	30.579	5.57	Lupeol	C <sub>30</sub> H <sub>50</sub> O	426	Triterpenoid
71	31.116	1.15	Gamma-sitostenone	C <sub>29</sub> H <sub>48</sub> O	412	Phytosterol

R. time: Retention time and NR: Not reported

Table 4: Phytochemical composition in methanolic extract of dry (Dfr) and green fruits (Gfr) of *C. lancifolius*

Phytochemical group	Total % area in Dfr	Total % area in Gfr
Fatty acid derivatives	38.09	39.43
Terpenes, terpenoids and derivatives	19.04	16.90
Phenolic compounds and derivatives	9.52	11.26
Phytosterols	9.52	5.63
Hydrocarbons	5.95	8.45
Heterocyclic compounds	5.95	4.22
Amino acid	1.19	-
Miscellaneous compounds	10.71	14.08

The unique compounds which were observed in green fruits as not observed in dry fruits of *C. lancifolius* are β-Amyrin, Heptacosyl heptafluorobutyrate, Erucamide, 2-Methylhexacosane, Docosyl pentafluoro propionate, 1-octanol, 3,7-dimethyl, 3-Methylbutylhexadecanoate, 6,9- Octadecadienoic acid, methyl ester, 2-Methylhexacosane, Octadecanoic acid, 2,3-dihydroxypropyl ester, 9-Octadecenoic acid (Z)-, Behenic alcohol, Heneicosane, 9(E),11(E)-Conjugated linoleic acid, Myristic acid glycidyl ester, 7-Hexadecenal, (Z)-, cis-9-Hexadecenal, 7-Hexadecenoic acid, methyl ester, (Z)-, Nonadecane, Copalol,

5-isopropyl-6,6-dimethylhept-3-yne-2,5-diol, 1-Heptatriacotanol, Ethyl iso-allocholate, 2-[Di(tert-butyl)silyl oxy methyl] tetrahydro furan, Silane, dimethyl(but-2-enyloxy) isobutoxy, 2-Oxovaleric acid, tert-butyl dimethylsilyl ester, Levoglucosan, 3-Methylpiperidin-4-ol, Butanamide, 2-hydroxy-N,2,3,3-tetramethyl-, Butanoic acid, 3-hydroxy-3-methyl, 5-Hydroxymethylfurfural, Corylon, Pentanoic acid, Furaneol, Melamine and Linalool. Whereas the 4H-Pyran-4-one, 2,3-dihydro-3,5-dihydroxy-6-methyl, Phytol, Phenol, 2-methyl-5-(1-methylethyl), Copalol, 1-Heptacosanol and 9-Octadecenoic acid (Z)- gave double peaks (Table 3).

## DISCUSSION

Due to the ecological and therapeutic importance, research on secondary metabolites has become a key focus in fields such as organic chemistry, pharmacology, molecular biology, and bioinformatics<sup>16</sup>. GC-MS is a method that integrates the separation of phytochemicals using gas chromatography with their detection via mass spectrometry and is mostly utilized for identifying and characterizing volatile and semi-volatile components in intricate plant matrices. For phytochemical investigations, the methanolic extracts are mostly used because methanol is an effective solvent for dissolving a variety of polar and moderately non-polar compounds<sup>3</sup>. Hence, in the present investigation, methanol was utilized for the extraction of maximum phyto-constituents.

The constituents of the methanolic extract of *C. lancifolius* were classified into major phytochemical groups based on their structural classes as determined by GC-MS analysis (Table 4). Many of these compounds have recognized pharmaceutical significance, with previous studies reporting diverse biological activities, like antioxidant, antidiabetic, anticancer, analgesic, antimicrobial, and anti-inflammatory etc. (Table 2 and 3). Fatty acid derivatives constituted the predominant chemical class, accounting for 38.09% and 39.43% of the total composition in Dfr and Gfr, respectively (Table 4). This predominance primarily resulted from the high abundance of compounds such as palmitic acid, myristic acid, 10(E),12(Z)-conjugated linoleic acid, oleic acid, stearic acid, capric acid, lauric acid, as well as 9-octadecenoic acid methyl ester (E) in Dfr (Table 2) and hexadecanoic acid, 1-heptacosanol, stearic acid, ceryl alcohol, 9-octadecenoic acid methyl ester (E), and cis-9-hexadecenal in Gfr (Table 3).

Fatty acids represent one of the most fundamental classes of biomolecules, exhibiting diverse biological activities with notable therapeutic relevance. Terpenoids, the second most abundant class of biomolecules in the present study (Table 4), are multifunctional secondary metabolites structurally derived from isoprene (C<sub>5</sub>) units in plants. *C. lancifolius* fruits were also found to possess a considerable number of phenolic compounds which have a benzene ring with one or more hydroxyl groups and can occur in a variety of structures such as phenylpropanoids, flavonoids, tannins, melanins, lignins, etc. On the other hand, phytosterols are natural triterpenoids in plants having a tetracyclic structure with functional groups usually at C-3,4,7,12,17 positions. Hydrocarbons are organic compounds made up of carbon and hydrogen atoms and classified as aliphatic/alicyclic or aromatic compounds. Remarkably, all of these secondary metabolites have shown to possess various biological activities for example, antioxidant, antimicrobial, anti-inflammatory, anticancer, antiangiogenic, antidiabetic, hypolipidemic, neuroprotective, immunomodulatory, hepatoprotective etc.<sup>1,17,18</sup>. Thus, the rich phytochemical profile of *C. lancifolius* fruits could motivate pharmacologists for novel drug discovery.

Bonnet *et al.*<sup>19</sup> have shown that green (immature) fruits of *Musa acuminata* contained more polyphenol content. Similar results were also observed in this study, where green fruits of *C. lancifolius* showed more phenolic compounds (11.26%) than dry mature fruits (9.52%). Likewise, higher terpenoid and phytosterol contents were observed in mature fruits of *C. lancifolius* (28.56%) than in its green fruits (22.53%), as shown in Table 4. These results are similar to a study by Simchuer and Srihanam<sup>20</sup> where higher triterpenoids and sterol contents were observed in ripe fruits of *Ampelocissus martini* than in immature fruits. Moreover, high concentrations of  $\beta$ -sitosterol were also found in ripe fruits, comparable to the findings of the present study, where 10.84%  $\beta$ -sitosterol is found to be present in dry mature fruits and 9.57% is found in green fruits.

The compounds detected in the present study have also been reported in other plant parts of *C. lancifolius*. For example, Al-Shatti *et al.*<sup>21</sup> reported 4.90% pyrogallol, 5.61% heneicosane and 5.61% dianhydromannitol from leaves of *C. lancifolius*. Moni *et al.*<sup>22</sup> also reported various bioactive compounds from hot methanolic extract of the leaves of *C. lancifolius* through GC-MS, some of which are similar to the present study, such as phytol, hexadecanoic acid, campesterol and oleic acid. The essential oil obtained from leaves of *C. lancifolius* revealed presence of 85 compounds through GC-MS among which the common compounds in both leaves and fruits are Hexadecanoic acid, Heneicosane, Hexacosane, Squalene,  $\gamma$ -Sitosterol, Lupenone, Lupeol, Eicosanoic acid, Neophytadiene, Tetradecanoic acid and Dodecanoic acid with relative abundance % of 2.97, 0.29, 3.06, 1.09, 0.07, 0.61, 3.29, 0.08, 0.26, 0.48, 0.45, respectively as reported by Salim *et al.*<sup>14</sup>.

Interestingly, several phytochemicals detected in the current study have been previously reported in some other plant species of the Combretaceae family, though their relative abundance was variable for example, 4.17% 1-Heptacosanol, 0.5% Hexadecanal, 10.48%  $\gamma$ -Sitosterol were reported in the root of *Terminalia travancorensis*<sup>23</sup>. Recently, Sarvendra *et al.*<sup>24</sup> reported various similar phyto-compounds such as 2.66% Phytol, 5.88% Palmitic acid, 2.61% Neophytadiene, 0.12% Heptadecanoic acid, 2.62% Linoleic acid, 0.44% Behenic acid, 1.17% Heptacosane, and 2.31% Squalene from leaves of *Combretum indicum*. The difference in concentration of these phyto-constituents might be the result of variations at the generic level, edaphic, climatic, and geographical factors, as well as conditions of plant collection and extraction.

Besides, some of these compounds are allelopathic in nature, for example, hexacosane and hexadecanoic acid ethyl ester, which are also found in the leaves of an invasive alien plant species, *Lantana camara*<sup>4</sup>. This needs to be investigated in detail as *C. lancifolius* is also an exotic species for India, and questions related to its suitability for plantation in various Indian states are being raised. Therefore, the results of this study may stimulate the assessment of the dual biological roles, i.e., ecological impact and therapeutic potential of *C. lancifolius*.

## CONCLUSION

GC-MS analysis of the methanolic extract of *Conocarpus lancifolius* fruits unveiled a wide spectrum of bioactive phytochemicals, which have promising therapeutic potential. The major metabolites, particularly lupeol,  $\beta$ -sitosterol acetate, stigmastanol, pyrogallol, linoleic acid, and phytol, dominate the profile and also possess antioxidant, antimicrobial, anti-inflammatory, and lipid-lowering activities. This is the first GC-MS-based comparative study of mature and green (immature) fruits of *C. lancifolius* and lays the foundation for further bioassay-guided isolation, toxicity assessment, and pharmacological evaluation to find novel drugs.

## SIGNIFICANCE STATEMENT

This study provides the first comprehensive evaluation of phyto-constituents from the methanolic extracts of both mature and immature fruits of *Conocarpus lancifolius* through the GC-MS technique. These phytochemicals are reported to possess a wide range of pharmacological activities. Hence, the present investigation will pave the way for a detailed evaluation of the therapeutic potential of its fruits. Moreover, this study will encourage the researchers to further investigate the allelopathic nature of these compounds, since *C. lancifolius* is an exotic plant species for India and may become an Invasive Alien Plant Species in the future.

## ACKNOWLEDGMENTS

Authors are thankful to the Advanced Instrumentation Research Facility (AIRF), Jawahar Lal Nehru University, New Delhi, India, for providing the GC-MS facility. First author is also thankful to CSIR-UGC, New Delhi, for providing financial assistance in the form of Junior Research Fellowship.

## REFERENCES

- Palazon, J. and M.A. Alcalde, 2025. Secondary metabolites in plants. *Plants*, Vol. 14. 10.3390/plants14142146.
- Mohamed, A.A., A.A. Khalil and H.E.S. El-Beltagi, 2010. Antioxidant and antimicrobial properties of kaff maryam (*Anastatica hierochuntica*) and doum palm (*Hyphaene thebaica*). *Grasas Aceites*, 61: 67-75.
- Kumari, A. and V. Jain, 2025. Phytochemical composition and GC-MS analysis of *Hymenodictyon orixense* Mabb. leaves. *GSC Biol. Pharm. Sci.*, 32: 156-179.
- Kayesth, S. and K.K. Gupta, 2018. Impact of *Lantana camara* hexane extract on survival, growth and development of *Dysdercus koenigii* Fabricius (Heteroptera: Pyrrhocoridae). *Acta Ecol. Sinica*, 38: 187-192.
- Redha, A., R. Al-Hasan and M. Afzal, 2021. Synergistic and concentration-dependent toxicity of multiple heavy metals compared with single heavy metals in *Conocarpus lancifolius*. *Environ. Sci. Pollut. Res.*, 28: 23258-23272.
- Al-Taweel, A.M., S. Perveen, G.A. Fawzy, R. Mehmood, A. Khan and S.I. Khan, 2016. New ellagic acid derivative from the fruits of heat-tolerant plant *Conocarpus lancifolius* Engl. and their anti-inflammatory, cytotoxic, PPAR agonistic activities. *Pak. J. Pharm. Sci.*, 29: 1833-1837.
- Afifi, H.S., H.M. Al Marzooqi, M.J. Tabbaa and A.A. Arran, 2021. Phytochemicals of *Conocarpus* spp. as a natural and safe source of phenolic compounds and antioxidants. *Molecules*, Vol. 26. 10.3390/molecules26041069.
- Zaman, K., F. Rahim, M. Taha, M. Sajid and S. Hayat, 2021. Synthesis, *in vitro* antiurease, *in vivo* antinematodal activity of quinoline analogs and their *in-silico* study. *Bioorg. Chem.*, Vol. 115. 10.1016/j.bioorg.2021.105199.
- Abdel Bar, F.M., A.A. Salkini, Y. Amen and A.E. Sherif, 2023. Acetylcholinesterase inhibitors from *Conocarpus lancifolius* Engl. (Combretaceae). *Nat. Prod. Res.*, 37: 1668-1673.
- Saadullah, M., A. Farid, A. Ali, M. Rashad and F. Naseem *et al.*, 2022. Molecular modeling study of novel *Lancifolamide* bioactive molecule as an inhibitor of acetylcholinesterase (AChE), herpes simplex virus (HSV-1), and anti-proliferative proteins. *Molecules*, Vol. 27. 10.3390/molecules27175480.
- Khurm, M., Y. Guo, Q. Wu, X. Zhang and M.U. Ghori *et al.*, 2023. *Conocarpus lancifolius* (Combretaceae): Pharmacological effects, LC-ESI-MS/MS profiling and *in silico* attributes. *Metabolites*, Vol. 13. 10.3390/metabo13070794.
- Moglad, E., S. El-Shae, M. Allam and H.A. Algahtan, 2023. Antimicrobial and antiquorum-sensing activity of *Conocarpus lancifolius* Engl. (Combretaceae). *Emir. J. Food Agric.*, 35: 197-202.
- Prajapati, P., B.B. Maitreya and R.M. Rawal, 2024. Qualitative and quantitative phytochemical screening and chemical fingerprint analysis of *Conocarpus lancifolius* plant using HPTLC. *Vegetos*, 38: 1506-1514.
- Salim, A., A.A. Arasteh, R. Sahrish, D. Labash, A.A. El-Keblawy, H.A. Gad and N.S. Ashmawy, 2025. Comparative metabolic profiling and biological evaluation of essential oils from *Conocarpus* species: antidiabetic, antioxidant, and antimicrobial potential. *Plants*, Vol. 14. 10.3390/plants14030464.
- Kunwar, B., V. Jain and S.K. Verma, 2024. *In vitro* thrombolytic potential of a nutritive vegetable-*Momordica dioica* Roxb. ex Willd. *Asian J. Biol. Sci.*, 17: 228-234.
- Lal, N., N. Sahu, A.O. Shirale, P. Gurav and K. Rani *et al.*, 2023. Plant Secondary Metabolites and their Impact on Human Health. In: *Nano-Biofortification for Human and Environmental Health*, Rajput, V.D., H. El-Ramady, S.K. Upadhyay, T. Minkina, B. Ahmed and S. Mandzhieva, Springer International Publishing, Switzerland, ISBN: 978-3-031-35147-1, pp: 295-321.
- Russo, M., L. Spagnuolo, G. Cafeo and L. Dugo, 2025. Phenolic Compounds (Extraction, Quantification, Biological Activities). In: *Phytochemicals for Health*, Locatelli, M., M. Tomczyk, L. Dugo and M. Russo, Elsevier, Amsterdam, Netherlands, ISBN: 978-0-443-15366-2, pp: 397-420.
- Begum, I.F., R. Mohankumar, M. Jeevan and K. Ramani, 2016. GC-MS analysis of bio-active molecules derived from *Paracoccus pantotrophus* FMR19 and the antimicrobial activity against bacterial pathogens and MDROs. *Indian J. Microbiol.*, 56: 426-432.

19. Bonnet, C.B., O. Hubert, D. Mbeguie-A-Mbeguie, D. Pallet, A. Hiol, M. Reynes and P. Poucheret, 2013. Effect of physiological harvest stages on the composition of bioactive compounds in Cavendish bananas. *J. Zhejiang Univ.-Sci. B*, 14: 270-278.
20. Simchuer, W. and P. Srihanam, 2018. Phytosterol screening of skin and seed extracts of wild grape *Ampelocissus martinii* Planch. fruits. *Orient. J. Chem.*, 34: 875-880.
21. Al-Shatti, A.H., A. Redha, P. Suleman and R. Al-Hasan, 2014. The allelopathic potential of *Conocarpus lancifolius* (Engl.) leaves on dicot (*Vigna sinensis* L.), monocot (*Zea mays* L.) and soil-borne pathogenic fungi. *Am. J. Plant Sci.*, 05: 2889-2903.
22. Moni, S.S., M.F. Alam, M.H. Sultan, H.A. Makeen and H.A. Alhazmi *et al.*, 2021. Spectral analysis, *in vitro* cytotoxicity and antibacterial studies of bioactive principles from the leaves of *Conocarpus lancifolius*, a common tree of Jazan, Saudi Arabia. *Braz. J. Biol.*, Vol. 83. 10.1590/1519-6984.244479.
23. Lakshmi, M. and B.R. Nair, 2017. GC-MS analysis of the chloroform extract of bark of *Terminalia travancorensis* Wight & Arn. (Combretaceae). *Int. J. Pharm. Sci. Res.*, 8: 794-798.
24. Sarvendra, K., S. Chaubey, V.K. Shukla, A. Patel and S.C. Sati, 2025. Comprehensive GC-MS profiling of methanolic and chloroform extracts of *Combretum indicum* leaf for therapeutic potential use. *YMER*, 24: 26-35.