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PHYTOCHEMICAL CHARACTERIZATION AND IN VITRO BIOLOGICAL ACTIVITIES OF FRUIT PULP EXTRACTS OF GMELINA ASIATICA.

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ABSTRACT
Gmelina asiatica L. is a medicinal plant and traditionally used in Ayurveda for the management of various ailments; however, the phytochemical and biological potential of its fruit pulp not evaluated. The present study aimed to investigate the phytochemical composition, GC–MS profile, antioxidant, and antidiabetic activities of *G. asiatica* fruit pulp extracts. Preliminary phytochemical analysis showed the presence of various primary and secondary metabolites. GC–MS analysis of petroleum ether extract revealed 32 compounds, whereas in ethanol extract 41 compounds were identified including fatty acids, alkanes, sterols, triterpenoids, tocopherols, and other bioactive metabolites. The antioxidant potential was evaluated using DPPH and ABTS radical scavenging assays, where the ethanolic extract exhibited stronger activity with IC_{50} values of 64.99 ± 0.82 and 68.82 ± 0.76 µg/mL, respectively. The antidiabetic activity assessed through α-amylase inhibition and glucose uptake by yeast cells demonstrated higher activity in the ethanolic extract (IC_{50} values of 125.99 ± 1.16 and 142.26 ± 1.73 µg/mL, respectively) than the petroleum ether extract. The observed bioactivities may be attributed to the presence of phenolics, flavonoids, terpenoids, and other phytoconstituents identified during phytochemical and GC–MS analyses. Overall, the findings highlight *G. asiatica* fruit pulp as a promising source of natural antioxidant and antidiabetic compounds and provide scientific evidence supporting its potential therapeutic applications.

KEYWORDS: Antidiabetic activity; Antioxidant activity; Fruit pulp; GC–MS; *Gmelina asiatica*; Traditional Medicine.

INTRODUCTION
Plants serve as a main source of food and medicine that contain a diverse group of bioactive compounds with broad healing potential. Around 80% of the world population depends on plants for most of their health problems. (Latif and Nawaz, 2026). Many of the medicines developed from nature in tradition have not fulfilled the scientific requirements to be referred to as modern medicine (Merlin et al., 2009). Some of the compounds contain a wide variety of pharmacological properties that are either impossible or difficult to produce in the laboratory (Azhagmurugan and Rajan, 2014). Plants can synthesize a wide range of organic compounds called secondary metabolites, which do not directly involve the development and growth of the plant. Still, they play a vital role in protecting plants from various adverse conditions (Khare, 2007; Schultz, 2019). These compounds have various bioactivities such as anticancerous, antimicrobial, antidiabetic, and anti-inflammatory properties (Saxena et al., 2013).
Gmelina asiatica. Linn. (*Gmelina parviflora* Roxb.) is member of Lamiaceae family. It is a thorny, bushy and deciduous shrub, commonly referred to as “Asiatic bush beech” in English, “Kirushivani” in Kannada, “Vikarini” in Sanskrit and is native to India, China, and other south Asian countries (Dasanayake et al. 1983; Kiruba et al., 2015; Santhosha and Alluri, 2022). The plant is branched, deciduous, large-sized shrub or rarely grows into a small tree. It has many irregular, small and hairy branches, often much shortened and spinous at the ends; leaves are simple, small, opposite; ovate to elliptical in shape, entire/lobed margin, obtuse apex, with a sub-sessile petiole. Flowers are large and yellow with racemose inflorescence. Fruits are fleshy drupes and yellow to golden in colour (Kannan et al., 2012).
This plant has been widely used in Ayurveda and Indian folk medicine to treat gonorrhoea, rheumatism, catarrh, jaundice, diabetes, syphilis, jaundice, dandruff, skin infections, and as a blood purifier (Satyanarayana et al., 2007). Its therapeutic potential is attributed to the presence of bioactive constituents, particularly, triterpenoids, flavonoids, and phenolic compounds (Ksirri et al., 2024). It also exhibits antioxidant, anti-inflammatory, antidiabetic, anti-ulcer, analgesic, anticancer, anti-anxiety, antibacterial and wound healing properties (Jeeva et

al., 2019; Shanmugalingam et al., 2022)
Although phytochemical investigations of the aerial parts and roots of *G. asiatica* have been reported, the fruit pulp has not yet been investigated. Therefore, this study aimed to evaluate the phytochemical composition and biological activities of *G. asiatica* fruit pulp.

MATERIALS AND METHODS

Collection

Fruits of *G. asiatica* was collected at Savarna Gange Campus, Bengaluru North University, Mangasandra, Kolar, India and identified using the flora of Madras presidency (Gamble, 1928). The specimen was deposited in the Department of Botany, Bengaluru North University, Kolar.

Preparation and Extraction

Fruits were washed thoroughly in running tap water, pulp was separated and shade dried for 15-18 days in room temperature. The dried pulp was powdered, and extracted using Soxhlet apparatus using petroleum ether and ethanol solvents for 6-9 hours. Then the extracts stored in small glass bottles at 4^0C until further use (Banni and Jayaraj, 2023a).

Preliminary Phytochemical Analysis

Preliminary qualitative phytochemical screening of the extracts was performed following the standard methods described by Khandelwal (2007), with slight modifications. The extracts were evaluated for the presence of carbohydrates, proteins, tannins, saponins, alkaloids, phenolics, terpenoids, flavonoids, glycosides, and steroids.

GC-MS Analysis

The GC-MS analysis of pulp extracts of *G. asiatica* was conducted using the Shimadzu QP2010S model, supplied with an ELITE-5MS packed silica capillary column (30 m × 0.25 µm film thickness and 0.25 µm diameter). Extracts were prepared using various solvents. Using helium as the carrier gas at a continuous flow rate of 1.0 mL/min, with a column temperature and pressure of 80^0 °C and 65 kPa, respectively, the compounds were separated. The inlet temperature was set to 260^0 C; samples were introduced in splitless mode. The linear temperature was increased from 80 °C to 260 °C at a rate of 10 °C/min. The temperature was maintained at 280^0 C throughout the analysis. Compounds were identified according to their retention time. Data were compared with standard reference spectra from the Wiley 8 Library and NIST 11 Libraries (Ganesh and Mohan Kumar, 2017; Banni and Jayaraj, 2023a).

Antioxidant Assay

DPPH Radical Scavenging Assay

The DPPH radical scavenging antioxidant activity of the pulp extracts of *G asiatica* was determined using the methods described by Braca et al. (2002) and Banni and Jayaraj (2023b). 3.0 mL of methanolic DPPH solution (0.04 mM) was combined with 0.5 mL of the pulp extracts at varying concentrations, (100-500 µg/mL). The mixture was later incubated in darkness for 30 minutes. Thereafter, the absorbance was noted at 517nm on a UV-9000A UV/VIS spectrophotometer using methanol as the blank and ascorbic acid as the standard. The % was calculated using the following formula:

$$\text{DPPH radical scavenging activity (\%)} = \frac{Absorbance\ (standard) - Absorbance(sample)}{Absorbance\ (standard)} X100$$

ABTS Radical Scavenging Assay

The ABTS radical scavenging analysis of the fruit pulp extracts was evaluated using the method given by Re et al. (1999) and Banni and Jayaraj (2023b). The ABTS solution was made by mixing 7 mM of ABTS diammonium salt with 2.45 mM of potassium persulfate. The ABTS solution absorbance was set at 700 ± 0.025 (734nm). Varied concentrations of pulp extracts (100-500 µg/mL) were added to 1 mL of ABTS solution, and the mixture was incubated in the dark for 6 min. Using a UV-9000A UV/VIS spectrophotometer, the absorbance was measured at 734nm using BHA (Butylated hydroxyanisole) as the standard reference. The percentage was calculated using the following formula:

$$\text{ABTS scavenging activity (\%)} = \frac{Absorbance\ (standard) - Absorbance(sample)}{Absorbance\ (standard)} X\ 100$$

Antidiabetic Activity

α-Amylase Inhibition Assay

The *in vitro* α-amylase inhibition activity of pulp extracts was assessed in accordance with the methods explained by Keerthana et al. (2013) and Banni and Jayaraj (2024), with minor modifications. To prepare the mixture, 50 µL of pulp extracts at various concentrations (31.25-500 µg/mL) was mixed with 50 µL of α-amylase solution (0.5% in phosphate buffer, pH 6.9) and incubated for 15 min at room temperature. Thereafter, 100 µL of 1% starch (prepared in 20 mM phosphate-buffered saline) was introduced into the mixture and incubated for 15 min. To stop the enzymatic reaction, 250 µL of DNS solution (1% dinitro salicylic acid, 30% sodium potassium tartrate, and 20% v/v 2N sodium hydroxide) was added. The reaction mixture was incubated for 10 min in a water bath, followed by the addition of 2 mL of distilled water. The absorbance was recorded at 540 nm using a UV/VIS spectrophotometer (UV-9000A, California, US). The % was calculated using the following formula:

Percentage of inhibition (%) $= \frac{Absorbance\ (control) - Absorbance(sample)}{Absorbance\ (contr} X\ 100$

Glucose Uptake Capacity by Yeast Cells

The glucose uptake capacity of *G. asiatica* fruit pulp extracts by yeast cells was assessed according to the method described by Cirillo (1962), Harish et al. (2014) and Banni and Jayaraj (2024) with minor modifications. Commercial baker's yeast was washed thoroughly by centrifugation in distilled water at 3000×g for 5-7 min until a yeast supernatant was formed. Later, a yeast suspension (10% v/v) was prepared in distilled water to initiate the assay; 25 µL of various concentrations of pulp extracts (31.25-500 µg/mL) were mixed with 200 µL of glucose solution (1 mg/mL) and incubated at 37 °C for 10-15 min. To initiate the reaction, 25 µL of the yeast suspension was added, subsequently vortexed, and incubated for 60 min at 37 °C. The samples were then centrifuged at 2500×g for 5-6 min; DNS reagent (200 µL) was added to the resulting supernatant. The mixture was incubated in a boiling water bath for 5-6 min, cooled, and diluted to a volume of 2mL with distilled water. The absorbance was subsequently recorded at 540 nm using a UV/VIS spectrophotometer (UV-9000A, California, US). The percentage increase in glucose uptake was calculated using the following formula:

Glucose uptake capacity (%) $= \frac{Absorbance\ (control) - Absorbance(sample)}{Absorbance\ (control)} X\ 100$

RESULTS AND DISCUSSION

Preliminary Phytochemical Analysis

The qualitative preliminary phytochemical analysis of *G. asiatica* petroleum ether and ethanolic pulp extracts revealed the presence of compounds including proteins, reducing sugars, carbohydrates, glycosides, steroids, phenols, saponins, alkaloids, coumarin glycosides, flavonoids, tannins, and triterpenoids (Table 1). Similar results were earlier reported by Silvia and Satyanaraya (2014) in methanolic extract of *G. asiatica,* Florence and Regini (2016) in leaves of *G. asiatica*, Chothani and Patel (2012) in leaves of *Gmelina arborea* Roxb. These findings substantiate the traditional medicinal uses of *G. asiatica* and provide a scientific basis for treatment.

Table 1. Preliminary phytochemical analysis of petroleum ether and Ethanolic Fruit pulp extracts of *Gmelina asiatica* L.

Tests		Petroleum ether extract	Ethanol extract
Carbohydrates	Molisch's test	–	+
Reducing Sugars	Fehling's test	–	+
	Benedict's test	–	–
Hexose Sugar	Phloroglucinol test	–	–
	Iodine test	–	–
Proteins	Biuret's test	+	+
	Millon's test	–	–
Amino Acid	Ninhydrin's test	–	–
Protein containing Sulfur	Lead acetate test	+	+
Steroids	Salkowski's test	+	–
Glycosides	Anthrone test	+	+
Saponin's test		–	+
Coumarin's glycoside	NaOH test	+	–
Alkaloids	Dragendorff's test	+	+
	Wagner's test	–	+
	Mayer's test	+	–
Phenols	Ferric chloride test	+	+
Flavonoids	Shinodow's test	–	+
Tannins	Gelatin's test	+	+
Organic Acids	Sample + 5% $CaCl_2$	–	–
Triterpenoids	Sample + Dil. H_2So_4 +Chloroform	+	+

+ Present, - Absent

GC-MS Analysis

GC-MS is an analytical technique that employs the separation capabilities of Gas chromatography and the structural identification strength of mass spectrometry to identify compounds in a sample. Gas chromatography helps detect, separate, and provide partial characterization of organic compounds, while mass spectrometry provides precise structural data. This combined technique enables rapid and accurate identification of components in complex synthetic and natural mixtures (Kumaresan, 2016). Petroleum ether and ethanolic fruit pulp extracts exhibited the presence of bioactive compounds such as fatty acids, alkanes, sterols, triterpenoids, vitamins, volatile organic compounds, esters, and wax components.

Thirty-two compounds were detected in the petroleum ether extract. Among them, major and minor peaks were Hexacontane (22.99% and 34.24 min) and Dodecanoic acid (0.10% and 15.14 min), respectively (Table 2 and Fig

1a). Nonanal (0.13 % and 8.83 min), Tetradecanoic acid (0.13 % and 8.83 min), Tetradecanoic acid (0.25% and 17.44 min), n-Hexadecanoic acid (3.03% and 20.27 min), 9-Octadecanoic acid, (E)-(0.96 and 22.98 min), Nonacosanal (0.40% and 27.33 min), Dotriacontane (0.75% and 28.40 min), Bis(2-ethylhexyl) phthalate (0.86% and 28.84 min), Tetracontane (0.31% and 29.88 min), Heptacosanal (0.32% and 13.37 min), 1-Hexacosanol (1.45% and 30.97 min), Cyclohexane, [6-cyclopentyl-3-(3-cyclopentylpropyl)hexyl] (3.01% and 31.32 min), Tetracosane (6.23% and 31.37 min), Tetracosamethyl- cyclododecasiloxane (0.56% and 31.88 min), Heptatriacontane (2.72% and 32.74 min), Octacosanol (1.27% and 33.79 min), Nonyl octacosyl ether (4.28% and 35.46 min), Octacosyl acetate (0.89% and 35.58 min), γ-Tocopherol (0.47% and 36.03 min), Heptacosyl heptafluorobutyrate (1.54% and 36.44 min), Carbonic acid, decyl octadecyl ester (20.80% and 36.84 min), 1-Triacontanol (4.16% and 38.08 min), Stigmasterol (3.79% and 38.62 min), Tetrapentacontane (1.84% and 39.30 min), γ-Sitosterol (6.02% and 39.49 min), β-Amyrin (1.23% and 40.07 min), Stigmast-7-en-3-ol, (3β,5α)- (1.69% and 40.35 min), Lupeol (3.71% and 40.83 min), Glutinol (1.19% and 41.03 min), 13-Docosen-1-ol, (Z)- (1.86% and 41.65 min) and Tetracosyl benzoate (1.18% and 41.76 min) with their peak area and retention time, respectively.

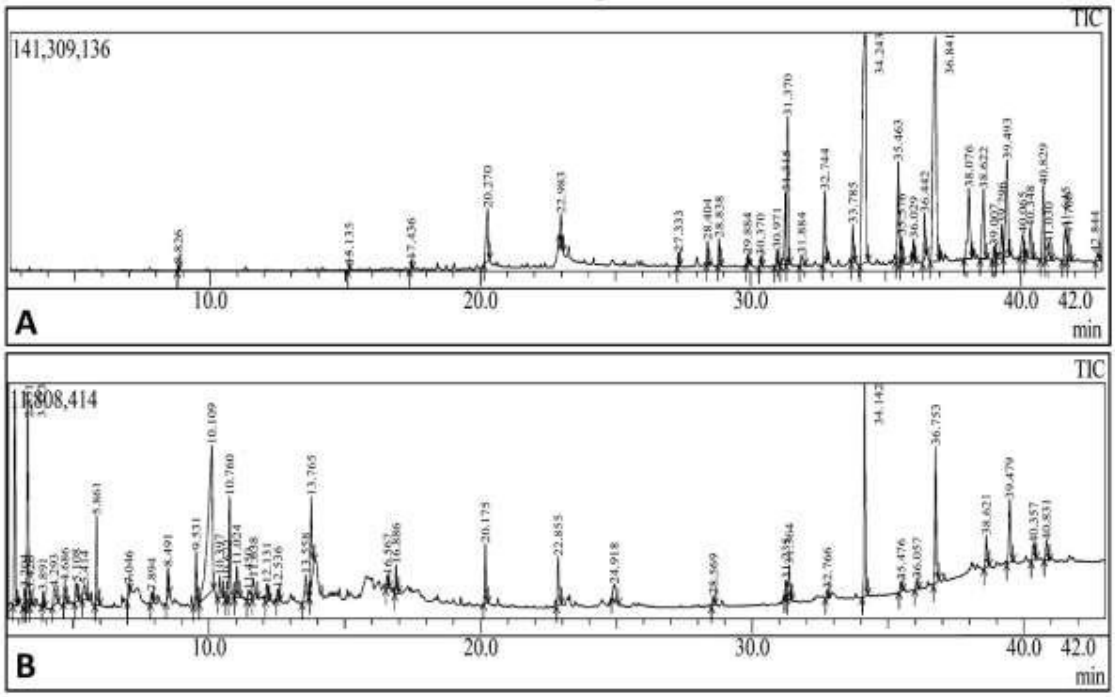
Table 2. GC-MS analysis of Petroleum ether Fruit pulp extract of *Gmelina asiatica* L.

Sl. No.	Retention Time	Area %	Molecular Weight (gm/mol)	Molecular Formula	Compound Name
1	8.83	0.13	142.24	$C_9H_{18}O$	Nonanal
2	15.14	0.10	200.32	$C_{12}H_{24}O_2$	Dodecanoic acid
3	17.44	0.25	228.37	$C_{14}H_{28}O_2$	Tetradecanoic acid
4	20.27	3.03	256.43	$C_{16}H_{32}O_2$	n-Hexadecanoic acid
5	22.98	0.96	282.46	$C_{18}H_{34}O_2$	9-Octadecenoic acid, €-
6	27.33	0.40	422.8	$C_{29}H_{58}O$	Nonacosanal
7	28.40	0.75	450.87	$C_{32}H_{66}$	Dotriacontane
8	28.84	0.86	390.56	$C_{24}H_{38}O_4$	Bis(2-ethylhexyl) phthalate
9	29.88	0.31	563.08	$C_{40}H_{82}$	Tetracontane
10	30.37	0.32	396.73	$C_{27}H_{56}O$	Heptacosanal
11	30.97	1.45	242.44	$C_{16}H_{34}O$	1-Hexacosanol
12	31.32	3.01	346.63	$C_{25}H_{46}$	Cyclohexane, [6-cyclopentyl-3-(3-cyclopentylpropyl) hexyl]
13	31.37	6.23	31.37	$C_{14}H_{30}$	Tetracosane
14	31.88	0.56	889.85	$C_{24}H_{72}O_{12}Si_{12}$	Tetracosamethyl-cyclododecasiloxane
15	32.74	2.72	521..02	$C_{37}H_{76}$	Heptatriacontane
16	33.79	1.27	410.76	$C_{28}H_{58}O$	Octacosanol
17	34.24	22.99	226.45	$C_{16}H_{34}$	Hexacontane
18	35.46	4.28	536.99	$C_{37}H_{76}O$	Nonyl octacosyl ether
19	35.58	0.89	452.8	$C_{30}H_{60}O_2$	Octacosyl acetate
20	36.03	0.47	414.7	$C_{28}H_{50}O_2$	γ-Tocopherol
21	36.44	1.54	592.7	$C_{31}H_{55}F_7O_2$	Heptacosyl heptafluorobutyrate
22	36.84	20.80	454.76	$C_{29}H_{58}O_3$	Carbonic acid, decyl octadecyl ester
23	38.08	4.16	438.81	$C_{30}H_{62}O$	1-Triacontanol
24	38.62	3.79	412.7	$C_{29}H_{48}O$	Stigmasterol
25	39.30	1.84	759.5	$C_{54}H_{110}$	Tetrapentacontane
26	39.49	6.02	414.72	$C_{29}H_{50}O$	γ-Sitosterol
27	40.07	1.23	426.72	$C_{30}H_{50}O$	β-Amyrin
28	40.35	1.69	414.7	$C_{29}H_{50}O$	Stigmast-7-en-3-ol, (3β,5α)-
29	40.83	3.71	426.7	$C_{30}H_{50}O$	Lupeol
30	41.03	1.19	426.72	$C_{30}H_{50}O$	Glutinol
31	41.65	1.86	324.58	$C_{22}H_{44}O$	13-Docosen-1-ol, (Z)-
32	41.76	1.18	458.76	$C_{31}H_{54}$	Tetracosyl benzoate

Forty-one compounds were detected in the ethanol extract (Table 3 and Figure 1b). with Benzoic acid (20.59 % and 10.11 min) and Dotriacontane (0.33 % and 32.77 min) were major and minor peaks, respectively. The extract also contains Ethane, 1,1-diethoxy- (8.84 % and 2.85 min), 2,2'-Bioxirane (0.70 % and 3.20 min), Propane, 2,2-diethoxy- (8.26 % and 3.32 min), 2-Propanone, 1-hydroxy- (0.62 % and 3.43 min), Formamide, N-methoxy- (0.46 % and 3.89 min), Glyceraldehyde (1.28 % and 4.29 min), 3-Furanmethanol (0.75 % and 4.69 min), Butanoic acid, 2,2-dimethyl-3-oxo-, methyl ester (1.00 % and 5.11 min), Dihydroxyacetone (1.31 % and 5.41 min), 1,2-Cyclopentanedione (3.05 % and 5.86 min), 2H-Pyran-2,6(3H)-dione (0.41 % and 7.05 min), 1-Ethylpentyl acetate (0.45 % and 7.89 min), Maltol (1.14 % and 8.49 min), 4H-pyran-4-one,2,3,hydro-3,5-dihydroxy 6-methyle (1.82 % and 9.53 min), Catechol (1.13% and 10.40 min), 3-Ethenylphenol (0.78 % and 10.67 min), 5-Hydroxymethylfurfural (4.39 % and 10.76 min), 1,2,3-Propanetriol, 1-acetate (1.51 % and 11.02 min), Malic acid (0.87 % and 11.45 min), Heptanoic acid,6 -oxo- (1.28 % and 11.64 min), Ethyl transe-3-methyl-2-oxiranecarboxylate (0.89 % and 12.13

min), 1,2:5,6-Dianhydrogalactitol (0,52 % and 12.54 min), Benzene ethanol, 4-hydroxy-(1.49 % and 13.56 min), 4-vinylbenzene-1,2-diol (3.88 % and 13.77 min), 1,4-Diacetyl-3-acetoxymethyl-2,5-methelene-1rhamnitol (0.55 % and 16.57 min), 2Propenoic acid3 (4-methoxypenyl)- (1.04 % and 16.89 min), n-Hexadecanoic acid (2.17 % and 20.18 min), 9-Octadecenoic acid, 1,2,3-Propanetriyl ester, (E,E,E)- (2.13 % and 22.86 min), DL-Xylitol, 1,3,4-triacetate 2,5-dibenzoate (1.40 % and 24.92 min), Hexadecanoic acid, 2-hydroxy-1-(hydroxymethyl) ethyl ester (0.42 % and 28.57 min), 9-Octadecenoic acid (Z)-, 2,3-dihydroxypropyl ester (0.73 % and 31.24 min), Heptatriacontane (7.47 % and 31.36 min), Tetrapentacontane (8.52 % and 34.14 min), Hexacontane (0.50 % and 35.48 min), γ-Tocopherol (0.43 % and 36.06 min Stigmasterol (1.55 % and 38.62 min), γ-Sitosterol (3.41 % and 39.48 min), Stigmast-7-en-3-ol,(3β,5α)-(0.89 % and 40.36 min), Lup-20(29)-en-3-ol, acetate, (3β)- (1.05 % and 40.83 min) with their peak area and retention time, respectively.

Figure 1. Chromatogram of GC-MS analysis of fruit pulp of *Gmelina asiatica* L. A: Petroleum ether extract **B:** Ethanol extract



Dotricontane, Heptatriacontane, Hexacontane, γ-Tocopherol, Stigmasterol, Tetrapentacontane, Stigmasterol, and Stigmast-7-en-3-ol, (3β,5α) were recorded in both petroleum ether and ethanol chromatograms. Similarly, Merlin et al. (2009) reported 22 compounds in chloroform extract and 9 compounds in ethanolic extract of *G. asiatica*, Azhagumurugan and Rajan (2014) reported 6 compounds in methanolic leaf extract of *G. asiatica*, Florence and Jeeva (2016) in leaf essential oil of *G. asiatica*.

Table 3: GC-MS analysis of Ethanolic Fruit pulp extract of *Gmelina asiatica* L.

Sl. No.	Retention Time	Area %	Molecular Weight (gm/mol)	Molecular Formula	Compound Name
1	2.85	8.84	118.17	$C_4H_{10}O_2$	Ethane, 1,1-diethoxy-
2	3.20	0.70	86.09	$C_4H_6O_2$	2,2'-Bioxirane
3	3.32	8.26	72.15	C_5H_{12}	Propane, 2,2-diethoxy-
4	3.43	0.62	74.08	$C_3H_6O_2$	2-Propanone, 1-hydroxy-
5	3.89	0.46	59.07	$C_2H_5NO_2$	Formamide, N-methoxy-
6	4.29	1.28	90.08	$C_3H_6O_3$	Glyceraldehyde
7	4.69	0.75	98.1	$C_5H_6O_2$	3-Furanmethanol
8	5.11	1.00	144.17	$C_7H_{12}O_3$	Butanoic acid, 2,2-dimethyl-3-oxo-, methyl ester
9	5.41	1.31	90.07	$C_3H_{6O}O_3$	Dihydroxyacetone
10	5.86	3.05	98.10	$C_5H_6O_2$	1,2-Cyclopentanedione
11	7.05	0.41	112.08	$C_5H_4O_3$	2H-Pyran-2,6(3H)-dione
12	7.89	0.45	158.24	$C_9H_{18}O_2$	1-Ethylpentyl acetate
13	8.49	1.14	126.11	$C_6H_6O_3$	Maltol
14	9.53	1.82	144.13	$C_6H_8O_4$	4H-Pyran-4-one, 2,3-dihydro-3,5-dihydroxy-6-methyl-
15	10.11	20.59	122.12	$C_7H_6O_2$	Benzoic acid
16	10.40	1.13	110.11	$C_6H_6O_2$	Catechol

17	10.67	0.78	108.14	C_7H_8O	3-Ethenylphenol
18	10.76	4.39	126.11	$C_6H_6O_3$	5-Hydroxymethylfurfural
19	11.02	1.51	134.13	$C_5H_{10}O_4$	1,2,3-Propanetriol, 1-acetate
20	11.45	0.87	134.09	$C_4H_60_5$	Malic Acid
21	11.64	1.28	144.17	$C_7H_{12}O_3$	Heptanoic acid, 6-oxo-
22	12.13	0.89	130.14	$C_6H_{10}O_3$	Ethyl trans-3-methyl-2-oxiranecarboxylate
23	12.54	0.52	146.14	$C_6H_{10}O$	1,2:5,6-Dianhydrogalactitol
24	13.56	1.49	138.16	$C_8H_{10}O_2$	Benzene ethanol, 4-hydroxy-
25	13.77	3.88	136.15	$C_8H_8O_2$	4-Vinylbenzene-1,2-diol
26	16.57	0.55	318.32	$C_{14}H_{22}O_8$	1,4-Diacetyl-3-acetoxymethyl-2,5-methylene-l-rhamnitol
27	16.89	1.04	178.18	$C_{10}H_{10}O_3$	2-Propenoic acid, 3-(4-methoxyphenyl)-
28	20.18	2.17	256.43	$C_{16}H_{32}O_2$	n-Hexadecanoic acid
29	22.86	2.13	885,43	$C_{57}H_{104}O_6$	9-Octadecenoic acid, 1,2,3-propanetriyl ester, (E, E, E)-
30	24.92	1.40	486.47	$C_5H_{12}O_5$	DL-Xylitol, 1,3,4-triacetate 2,5-dibenzoate
31	28.57	0.42	330.15	$C_{19}H_{38}O_4$	Hexadecanoic acid, 2-hydroxy-1-(hydroxymethyl)ethyl ester
32	31.24	0.73	356.55	$C_{21}H_{40}O_4$	9-Octadecenoic acid (Z)-, 2,3-dihydroxypropyl ester
33	31.36	7.47	528.02	$C_{37}H_{76}$	Heptatriacontane
34	32.77	0.33	450.87	$C_{32}H_{66}$	Dotriacontane
35	34.14	8.52	759.4	$C_{54}H_{110}$	Tetrapentacontane
36	35.48	0.50	843.61	$C_{60}H_{122}$	Hexacontane
37	36.06	0.43	416.68	$C_{28}H_{48}O_2$	γ-Tocopherol
38	38.62	1.55	412.7	$C_{29}H_{48}O$	Stigmasterol
39	39.48	3.41	414.7	$C_{29}H_{50}O$	γ-Sitosterol
40	40.36	0.89	414.71	$C_{29}H_{50}O$	Stigmast-7-en-3-ol, (3β,5α)-
41	40.83	1.05	468.75	$C_{32}H_{52}O_2$	Lup-20(29)-en-3-ol, acetate, (3β)-

Antioxidant Activity

Antioxidants obtained from plants play a crucial role in safeguarding the body against oxidative stress caused by free radicals and help control cellular damage that can lead to diseases such as cancer, diabetes, cardiovascular disorders, and neurodegenerative diseases (Halliwell and Gutteridge, 2015).

The antioxidant potential of *G. asiatica* pulp extracts was recorded using DPPH and ABTS radical scavenging assays. In both the DPPH and ABTS assays, ethanol extract revealed better radical scavenging activity (64.99±0.82 µg/mL and 68.82±0.76 µg/mL), followed by petroleum ether extract (73.06±0.95 µg/mL and 82.41±0.98 µg/mL), compared to the reference standard ascorbic acid (52.41±0.66 and 49.78±0.59), respectively (Table 4 and Figure 2a & 2b). Similar findings were reported by Shoeb et al. (2013)**,** the DPPH scavenging activity in *Gmelina arborea* leaf methanolic extract (19.20 µg/m) and n-butanol fraction (14.10 µg/mL). Audipudi et al. (2010) recorded antioxidant activity in methanol (IC_{50} = 15.4 µg/mL) and chloroform (IC_{50} = 18.6 µg/mL) extracts of *G. arborea*. Lawrence et al. (2016) also reported noteworthy antioxidant potential in the methanolic stem bark extract of *G. arborea* (124.39 µg/mL**).**

The higher antioxidant activity of the ethanol extract may be attributed to its higher contents of flavonoids and phenolics as they are potential free radical scavengers. These findings supported with the phytochemical screening and suggest that *G. asiatica* fruit pulp is a promising natural source of antioxidant compounds.

Table 4: *In vitro* antioxidant and antidiabetic activity of fruit pulp extracts of *Gmelina asiatica* L.

Extracts	**IC_{50} (µg/mL)**			
	Antioxidant Assay		**Antidiabetic Assay**	
	DPPH scavenging assay	**ABTS scavenging assay**	**α- amylase inhibition assay**	**glucose uptake capacity by yeast cell assay**
Petroleum ether extract	73.06±0.95	82.41±0.98	184.32±1.09	254.75±2.94
Ethanol extract	64.99±0.82	68.82±0.76	125.99±1.16	142.26±1.73
Standard	52.41±0.66	49.78±0.59	88.61±0.72	101.69±0.89

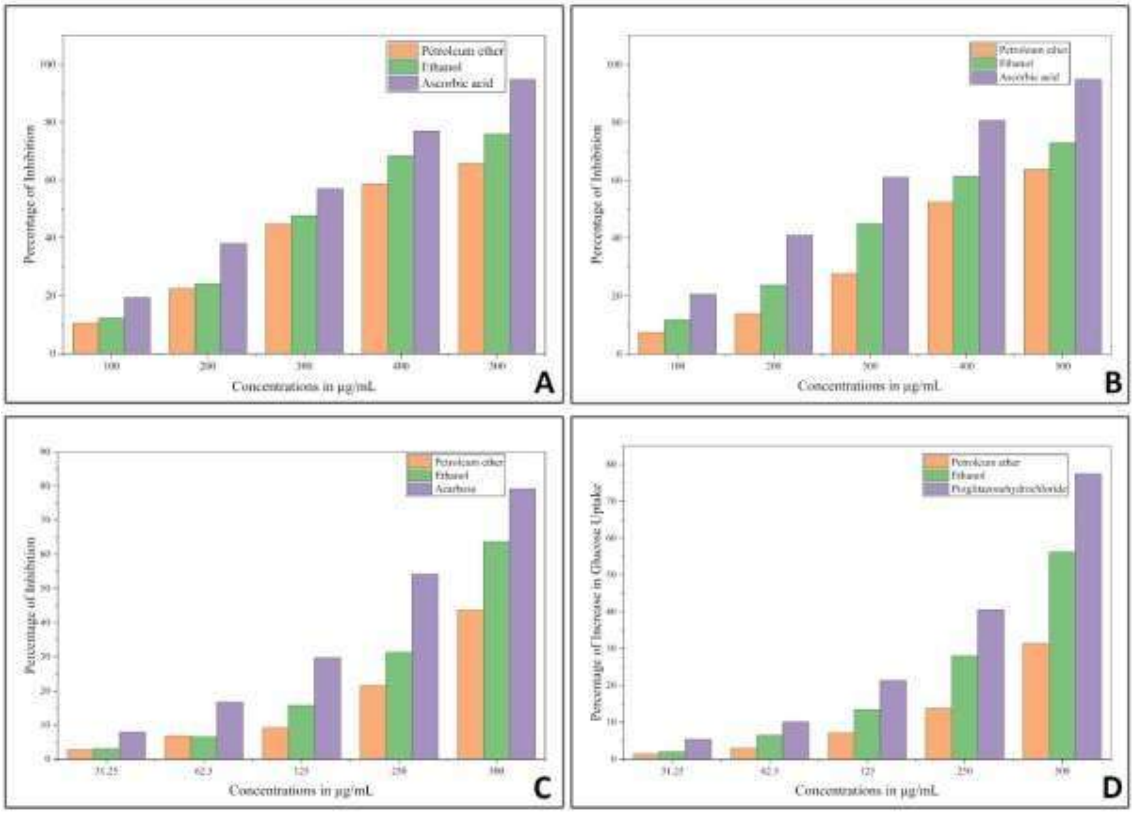
Each value represents the mean of three readings ± S.D., calculated based on the dry weight of the sample.

Antidiabetic Activity

Plants have been identified as a valuable source of various bioactive compounds that contribute to the regulation of diabetes mellitus. Many plants exhibit strong antidiabetic properties. These play a vital role in regulating blood glucose levels (Modak et al., 2007). In the present study, we evaluated the antidiabetic activity of *G. asiatica* petroleum ether and ethanolic pulp extracts using α-amylase inhibition and glucose uptake capacity by yeast cells assay. The antidiabetic activity was quantified based on the IC_{50} values.

The ethanolic extract exhibited a higher antidiabetic potential (125.99 ± 1.16 and 142.26 ± 1.73 µg/mL**)**) in both α-amylase inhibition and glucose uptake by yeast cells assays, compared to the petroleum ether extract (184.32 ± 1.09 and 254.75 ± 2.94 µg/mL) against standard acarbose **(**88.61 ± 0.72 and 101.69 ± 0.89 µg/mL), respectively (Table 4 and Figure 2c & 2d). Similarly, previous reports of Wadasinghe et al. (2023) in *G. arborea*, Mirshafie et al., (2015) in *Zhumeria majdae* Rech. f. and Wendelbo, Safamansouri et al. (2014) in *Phlomis bruguieri* Boiss.*, P. kurdica, P. rigida, P. Olivieri* and *P. caucasica* supported these results. The enhanced activity of the ethanolic extract may be attributed to its higher content of phenolics and flavonoids, suggesting that *G. asiatica* fruit pulp is a potential natural source of antidiabetic compounds.

Fig. 2. *In vitro* antioxidant and antidiabetic activity of fruit pulp extracts of *Gmelina asiatica* L. A- DPPH scavenging assay **B** ABTS scavenging assay **C** α-amylase inhibition assay **D** Glucose uptake by yest cells assay



CONCLUSION

The present study provides the first scientific evidence on the phytochemical composition and biological potential of *G. asiatica* fruit pulp. GC–MS analysis revealed the presence of diverse bioactive compounds, including fatty acids, sterols, triterpenoids, and other phytoconstituents. The ethanolic extract showed superior antioxidant and antidiabetic activities compared with the petroleum ether extract, which may be associated with the higher abundance of phenolic and flavonoid compounds. These findings suggest that G. asiatica fruit pulp represents a promising natural source of bioactive molecules with antioxidant and hypoglycemic potential. Further studies involving isolation, characterization, and *in vivo* evaluation of active compounds are required to validate its therapeutic applications.

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Author Contribution

Nandashree E: Writing– review & editing, Writing– original draft, Visualization, Validation, Supervision,

Software, Resources, Project administration, Investigation, Funding acquisition, Methodology, Formal analysis, Data curation, Conceptualization. **Mohammed Khalid:** Writing– review & editing, Writing– original draft, Funding acquisition, Data curation. **Dharshan K:** Writing– review & editing, Funding acquisition, Data curation. **Ayesha Tabassum:** Writing– review & editing, Funding acquisition, Data curation. **Rifath Tanzeem Y:** Writing– review & editing, Funding acquisition, Data curation. **Mahantesh Banni:** Writing– review & editing, Writing– original draft, Validation, Software, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization.

Declarations

Declaration of Competing Interest The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper

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