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PHYTOCHEMICAL SCREENING OF DHAMAN (*GREWIA TILIIFOLIA* VAHL) FRUIT IN SUB-TROPICAL REGION OF INDIA

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Abstract: The present study was conducted to determine the availability of bioactive phytomolecules in the Dhaman (*Grewia tiliifolia*) fruit collected from a sub-tropical region of India. Methanolic and ethanolic extracts were prepared from processed Dhaman fruits. The extracts were screened for phytomolecules using the Gas chromatography – mass spectrometry (GC-MS) method. Results found that the methanolic extract has alkaloids at 5%, esters at 21%, triterpenoids at 2%, fatty alcohol at 5%, acid chloride at 2%, hydrocarbons at 26%, and steroids at 2%. However, the ethanolic extract has alkaloids (2%), ester (27%), fatty alcohol (6%), hydrocarbons (9%), steroids (13%), amide (4%), and triglycerides (2%) in different amounts. From this study, it has been concluded that the Dhaman fruit is highly enriched in different phytomolecules. As a result, Dhaman fruit has a high potential for curing various human diseases and well-being.

Keywords: bio-active molecules, ethanolic extract, GC-MS, methanolic extract, phytomolecules.

Introduction

Ayurveda, an ancient system of medicine originating in India, recommends the utilization of various components of the *Grewia tiliifolia* plant for treating conditions such as irritation, burning sensations, fever, blood disorders, excessive menstrual flow, and diabetes [ZIA-UL-HAQ & al. 2013]. It is known to be effective in addressing gastric issues, hyperdipsia, rhinopathy, ulcers, skin diseases, haematemesis, and general debility. Traditional healing practices involve employing the leaves, bark decoction, and infusion of this medicinal plant to treat snakebites in livestock through wound drenching [OWUOR & KISANGAU, 2006]. The application of fresh leaf paste aids in burn treatment, while the powdered bark is utilized for its aphrodisiac properties [MRABTI & al. 2022]. Furthermore, the ripe fruits of *Grewia tiliifolia* are consumed for their nutritional value [AHMAD & al. 2013]. DIXIT & GEEVAN (2000) documented the historical use of *Grewia tiliifolia* as an agricultural tool and food source.

Grewia tiliifolia, commonly known as Dhamani or Dhaman, is a medium-sized tree reaching a height of approximately 20 meters, with a trunk length of 8 meters and a diameter of 65 cm. The plant bears small yellow flowers on thick axillary peduncles. It holds a significant place in the Ayurvedic system of medicine. *Grewia tiliifolia* is primarily found in various regions of India, including Punjab, Himachal Pradesh, Uttar Pradesh, Chennai, Andhra Pradesh, and Mumbai. It belongs to the Malvaceae family, which encompasses approximately 150

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species of small trees or shrubs distributed across subtropical and tropical regions, including tropical Africa, Arabia, the Himalayas, India, Pakistan, China, Bangladesh, Myanmar, Thailand, and Northern Australia [ULLAH & al. 2012]. India alone hosts around 40 different species, such as *G. asiatica*, *G. tenax*, *G. hirsuta*, *G. damine*, *G. lasiodiscus*, *G. optiva*, *G. biloba*, *G. bicolor*, and many others [KUMAR & al. 2022].

Grewia tiliifolia, known as Dhaman, exhibits various medicinal properties. The powdered wood of *G. tiliifolia* is used as an emetic to counteract opium poisoning. Additionally, the stem bark acts as a coagulant and shows cardiovascular effects [KUMAR & al. 2022]. Studies have demonstrated the analgesic and antipyretic properties of *G. tiliaefolia* bark [PAVIAYA & al. 2013]. The plant is often employed in the treatment of burning sensations, blood disorders, and as an aphrodisiac and tonic. Furthermore, the methanolic extract and a constituent called gulonic acid gamma-lactone obtained from *G. tiliifolia* have shown in vivo wound healing activity [AHAMED & al. 2009]. ADHIKARI & al. (2010) reported the use of flowers, fruits, bark, and leaves of *G. tiliifolia* for treating syphilis. Notably, *G. tiliifolia* exhibits cholinesterase inhibitory properties and demonstrates anti-amyloidogenic and neuroprotective effects in *in-vitro* and *in silico* conditions [MALAR & al. 2017]. *G. tiliifolia* is utilized in cases of inflammation and burning sensations [JUVEKAR & al. 2007]. It is employed for the treatment of skin diseases, inflammatory bowel diseases, diarrhea, and pruritus [BADAMI & al. 2002]. Previous researchers have isolated three triterpenoids, namely betulin, friedelin, and lupeol, from the stem bark of *G. tiliifolia* [BADAMI & al. 2002, 2004]. Moreover, the methanolic extract of *G. tiliifolia* stem bark demonstrates potent antioxidant and antibacterial properties [JUVEKAR & al. 2007]. The same extract has shown significant wound healing activity in various cutaneous wound models in rats [AHAMED & al. 2009].

In traditional Indian folk medicine, *Grewia asiatica* fruit, also known as Dhaman fruit, is used to alleviate blood disorders, as well as cardiac and respiratory diseases [POONAM & SINGH, 2009]. Research suggests that *G. asiatica* possesses anticancer [GUPTA & al. 2014], antioxidant [ZIA-UL-HAQ & al. 2013], radio-protective, hepatoprotective [SHARMA & SISODIA, 2009], and antihyperglycemic [KHATTAB & al. 2015] activities. *Grewia asiatica* fruit is rich in nutrients, including vitamins and minerals, and contains various bioactive compounds such as anthocyanins, tannins, phenolics, and flavonoids [ZIA-UL-HAQ & al. 2013].

Although the utilization of Dhaman trees in traditional medicine is well-established, there remains a paucity of studies focusing on the phytochemical screening of Dhaman fruit. Further investigations in this area may unveil specific curative properties associated with Dhaman fruits, offering new avenues for research. Consequently, these findings hold potential implications for promoting human well-being in the Post-COVID-19 era.

Materials and methods

Experimental site

The experiment was performed in Rehan Khas village, situated in the Kangra district in Himachal Pradesh. The experimental site lies between 32°9'49.02" North Latitude and 75°54'49.30" East Longitude (Figure 1).

Figure 1. Experimental site make by Google 3D Earth Pro software

Environmental conditions

The experiment was conducted under average temperatures of 22-37 °C in Rehan Khas village in District Kangra HP. In Himachal Pradesh, over 30 years of records, average air temperatures were 0.7 to 2.4 °C higher than in the 1980s, as against the global average of 0.5 °C; the Himachal Pradesh trend indicates an increase of 0.06 °C per year.

Plant material collection

Fresh fruits were collected from the Dhaman tree (Figure 2). The fruits of Dhaman were dried for 30 days in the shade at room temperature. Then grounded, the fruit and a powder were obtained. Powdered samples were kept in a refrigerator (4 °C) for further experiments.

Figure 2. Dhaman tree; the experimental plant from where fruit samples were collected

Plant ethics, guidelines, and source

We hereby confirm that our utilization of plants in this study adheres strictly to international, national, and/or institutional guidelines. Our research specifically excludes the involvement of genetically modified plants, as well as any genetic plant resources procured from local suppliers or collectors. This encompasses species obtained from protected areas, endangered species possessing medical significance, or quarantine organisms (e.g., harmful pests or plant pathogens). Consequently, we did not require legal authorization from the appropriate governing body or the need to adhere to standard protocols. Our sample collection occurred within the confines of Rehan Khas village, located in the Kangra district of Himachal Pradesh. The experimental site's geographical coordinates fall between 32°9'49.02" North Latitude and 75°54'49.30" East Longitude (Figure 1).

Preparation of fruit extract

The extraction of Dhaman tree fruit was conducted following the method proposed by FATOPE & al. (1993), with minor adjustments. Briefly, 20 g of fruit powder was percolated at room temperature using 400 mL of methanol for methanolic extraction, as well as for aqueous extraction. Another 20 g of powdered fruit was mixed with 400 mL of hot water, starting at an initial temperature of 98 °C. The mixture was then placed in conical flasks, tightly sealed, and subjected to agitation in a shaker at room temperature for 24 hours, operating at 100 rpm. After the 24-hour period, the extract was filtered using a muslin cloth, followed by further filtration using Whatman filter paper no. 1. The filtrates were subsequently concentrated using a water bath set at a temperature range of 35-40 °C. The resulting extracts were appropriately labelled and stored in a refrigerator at 4 °C. To prepare a stock solution, the extract was dissolved in DMSO to achieve a concentration of 0.5 g/mL.

Phyto-characterization of fruit extract

Salkowski test (Terpenoid test): a sample weighing 0.5 g was combined with 2 mL of chloroform, followed by the addition of 3 mL of concentrated sulfuric acid to form a distinct layer. The presence of terpenoids was indicated by the formation of a reddish-brown coloration at the interface.

Flavonoid test: to 0.5 mL of the extract filtrate, 5 mL of dilute ammonia was added, followed by the addition of 1 mL of concentrated sulfuric acid. The presence of flavonoids was indicated by the appearance of a yellow coloration in the solution, which faded over time.

Saponin test: 0.5 g of the extract was mixed vigorously with 5 mL of distilled water. After the formation of a stable and persistent froth, 3-4 drops of olive oil were added, and the mixture was vigorously shaken again. The formation of an emulsion indicated the presence of saponins.

Saponin glycosides test: 0.5 mL of the extract was treated with 80% H_2SO_4, resulting in a deep yellow coloration, confirming the presence of saponin glycosides.

Tannin test: a sample weighing 0.5 g was mixed with 10 mL of distilled water and boiled. The solution was then filtered, and a few drops of 0.1% ferric chloride were added. The presence of tannins was indicated by the formation of a brownish-green or blue-black color.

Phenolics test (Ferric chloride test): small amounts of the aqueous and alcoholic extracts were separately dissolved in 2 mL of distilled water, followed by the addition of a few drops of 10% aqueous ferric chloride solution. The presence of phenols was confirmed by the development of a blue or green color.

Carbohydrate test (Molisch's test): 0.5 g of the extract was mixed with 5 mL of distilled water, and the resulting solution was filtered. To the filtrate, 1 mL of α-Naphthol and

concentrated H_2SO_4 were added, leading to the formation of a purple color, indicating the presence of carbohydrates.

Chlorogenic acid test: 0.5 mL of the extract was treated with aqueous ammonia and exposed to the air. The resulting solution exhibited a green color, suggesting the presence of chlorogenic acid.

Coumarin test: 0.5 mL of both aqueous and alcoholic extract solutions were treated with 10% sodium chloride. The yellow coloration of the solution indicated the presence of coumarin.

Flavone test: two methods were employed to detect the presence of flavones. In the first method, 0.5 mL of the extract was treated with sodium hydroxide, and the appearance of a yellow coloration indicated the presence of flavones. In the second method, 0.5 mL of the extract was treated with sulfuric acid, resulting in a yellowish-orange coloration, also indicating the presence of flavones.

Anthocyanin test: two methods were utilized to determine the presence of anthocyanin. In the first method, 0.5 mL of the extract was treated with aqueous sodium hydroxide, and the formation of a blue or violet coloration confirmed the presence of anthocyanin. In the second method, 0.5 mL of the extract was treated with sulfuric acid, resulting in a yellowish-orange coloration, also indicating the presence of anthocyanin.

Phytochemical screening using GC-MS: the phytochemical analysis was conducted utilizing a Thermo Trace 1300GC gas chromatography system coupled with a Thermo TSQ 8000 Triple Quadrupole MS, following the procedure described by BHARDWAJ & al.(2019), with minor adjustments. Data processing was performed using XCalibur 2.2SP1 software with Foundation 2.0SP1. The analysis employed a BP 5MS column (30 m X 0.25 mm, 0.25 µm). The total program duration was 60 minutes, and the temperature program for the column oven was as follows: starting at 80 °C (maintained for 1.0 minute), followed by an increase to 236°C at a rate of 6 °C/min, with a 5-minute hold, and finally reaching 300 °C at a rate of 8 °C/min with a 20-minute hold. The carrier gas (Helium) flow rate was set at 1.10 mL/min, and the injection volume and injector temperature were 2.0 µL and 280 °C, respectively. The mass range analyzed was 50-650 m/z using electron ionization (EI) mode. Identification of phytocomponents was based on comparison of their mass spectral data with the NIST 2.0 database. The results were expressed as percentage areas.

Methodology limitations: due to limitations in logistical support and funding, certain essential parameters such as antioxidant analysis and in vitro studies to assess biological effects could not be conducted. However, despite these limitations, our study successfully revealed unique and significant findings regarding the percentage availability of various phytomolecules in Dhaman fruit, which was the main objective of this investigation.

Results and discussions

Phytochemical characterization of extracts of *Grewia tiliifolia* fruits

After extracting herbal plants using different solvents, the extract with the highest yield (aqueous extract of *Grewia tiliifolia*) was subjected to phytochemical characterization to identify various bioactive phytomolecules. The analysis revealed the presence of terpenoids, flavonoids, saponins, tannins, phenols, carbohydrates, coumarin, and anthocyanin in three of the extracts. However, chlorogenic acid and saponin glycoside were not detected. These findings are consistent with a study conducted by HARIDAS & al. (2017), which also reported the presence of terpenoids, flavonoids, and phenols in the tender leaves of *Grewia tiliifolia* Vahl.

It is worth noting that terpenoids, flavonoids, and phenols possess notable antioxidant activity, suggesting their potential as antioxidants.

Gas chromatography (GC-MS) analysis

The present study covers the GC-MS analysis of methanol and ethanol extracts of *Grewia tiliifolia* (Figure 3 and 4). Both extracts obtained using the soxhlet extraction showed the presence of 48 compounds in each. Most compounds found in these two extracts were of the ester class. In contrast, hydrocarbons, fatty alcohol, alkaloids, triglyceride, amide, steroids, triterpenoid, sesquiterpenoid, acid chloride, phenic acid derivatives, and fatty acid classes of secondary metabolites were also identified (Table 1 & 2, Figure 5). The maximum peak area was found in methanol extract for 9,12-octadecadienoic acid, methyl ester, trans-13-Octadecenoic acid, and methyl ester.Further, in ethanol extract, 2-methyl-Z, Z-3,13-octadecadienol was found at a maximum, followed by n-Hexadecanoic acid.

Grewia tiliifolia bark has long been employed in traditional medicine. Previous investigations [BADAMI & al. 2002, 2004] successfully isolated three triterpenoids, namely betulin, friedelin, and lupeol, from the stem bark of *G. tiliifolia*. These studies also assessed the in vitro cytotoxic properties of *G. tiliifolia* bark against various cell lines [BADAMI & al. 2003]. Phalsa, a member of the *Grewia* species, is another plant used in folk medicine. It contains essential mineral elements, carbohydrates, and various active metabolites such as flavonoids and alkaloids [PATIL & al. 2011; ULLAH & al. 2012]. Historically, plants have been a source of lead compounds for anticancer drugs like vincristine and taxol [GREENWELL & RAHMAN, 2015]. *G. villosa*, belonging to the *Grewia* genus, has been reported to possess anticancer activity, and compounds such as nitidanin, grewin, harman, and gulonic acid have been identified from different *Grewia* species [KHADEER AHAMED & al. 2010; WALIULLAH & al. 2011].

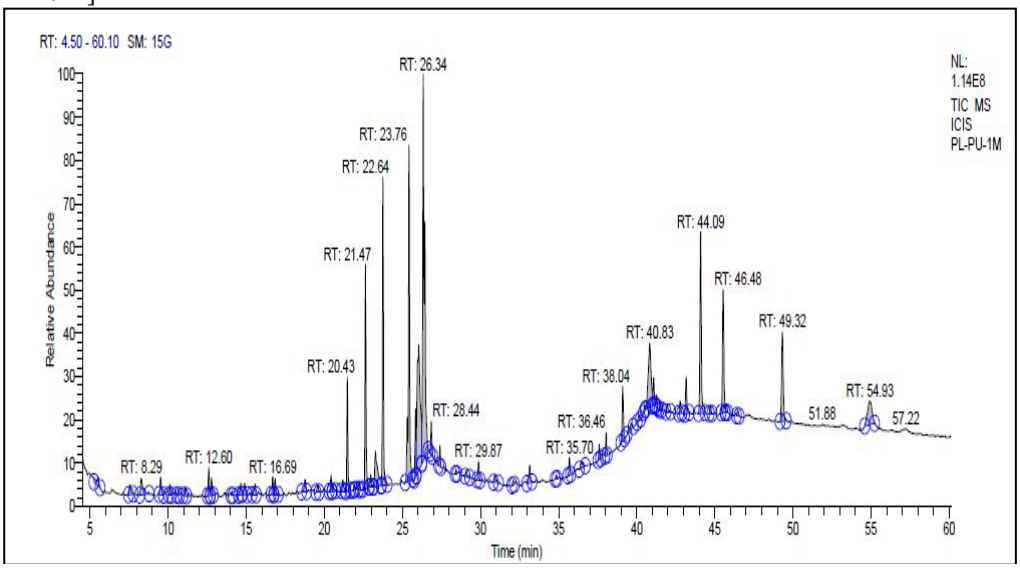

Figure 3. GC-MS Chromatogram of methanolic extract of *Grewia tiliifolia* fruit

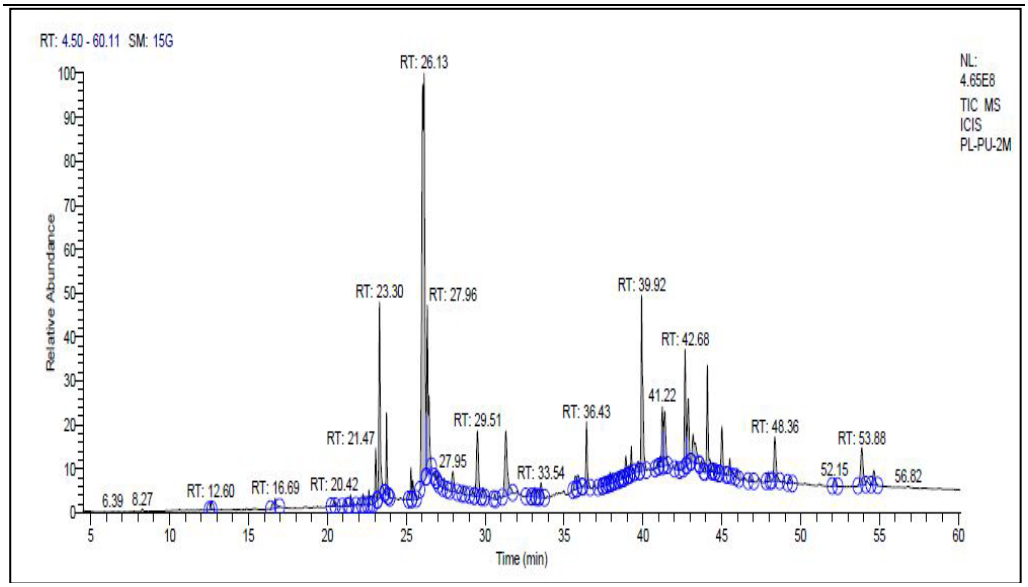

Figure 4. GC-MS Chromatogram of ethanolic extract of *Grewia tiliifolia* fruit

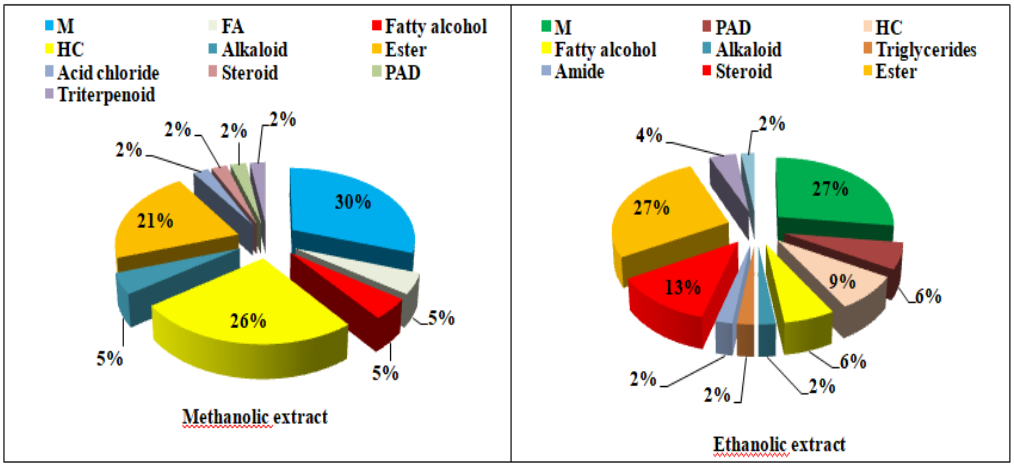

Figure 5. GC-MS Chromatogram of methanolic and ethanolic extract of *Grewia tiliifolia* fruit

Table 1. Compound identified in methanolic extract of *Grewia tiliifolia* fruit using GC-MS

S. No.	Compound name	Formula	M.W.	R.T.	% Area	CAS No.
1.	1,1,1,3,5,5,5-Heptamethyltrisiloxane	$C_7H_{22}O_2Si$	166.33	39.64	0.46	1873-88-7
2.	1,1,1,5,7,7,7-Heptamethyl-3,3-bis(trimethylsiloxy)tetrasiloxane	$C_{13}H_{40}O_5Si_6$	444.97	29.87	0.52	38147-00-1
3.	17-Octadecynoic acid	$C_{18}H_{32}O_2$	280.44	26.05	9.71	34450-18-5
4.	2-Hexyl-1-octanol	$C_{14}H_{30}O$	214.39	10.66	0.18	19780-79-1
5.	2-t-Butyl-1-methyl-3-phenyl-imidazolidin-4-one	$C_{14}H_{20}N_2O$	232.32	9.52	0.61	NA
6.	3,7,11,15-Tetramethyl-2-hexadecen-1-ol	$C_{20}H_{40}O$	296.53	21.19	0.34	102608-53-7
7.	3-Hexadecene,(Z)-	$C_{16}H_{32}$	224.42	12.60	0.73	34303-81-6
8.	4,2-Cresotic acid, 6-methoxy-, bimol. ester, methyl ester, 4,6-dimethoxyotoluate	$C_{29}H_{30}O_{10}$	538.54	29.09	0.22	19314-74-0
9.	4,4-Bis(dichlorofluoromethyl)-1,2-oxathietane-2,2-dioxide	$C_4H_2Cl_4F_2O_3S$	309.93	36.46	0.37	22721-88-6
10.	5-Octadecene,(E)-	$C_{18}H_{36}$	252.48	16.69	0.46	7206-21-5
11.	6,9,12-Octadecatrienoic acid, phenylmethyl ester,(Z,Z,Z)-	$C_{25}H_{36}O_2$	368.55	34.85	0.10	77509-03-6
12.	7,9-Ditertbutyl-1-oxaspiro(4,5)deca-6,9-diene-2,8-dione	$C_{17}H_{24}O_3$	276.37	22.26	0.18	82304-66-3
13.	9,12-Octadecadienoic acid, methyl ester	$C_{19}H_{34}O_2$	294.47	26.34	17.01	2462-85-3
14.	9,12-Octadecadienoyl chloride, (Z,Z)-	$C_{18}H_{31}ClO$	298.89	30.92	0.34	7459-33-8
15.	ç-Sitosterol	$C_{29}H_{50}O$	414.70	44.09	6.23	83-47-6
16.	Cyclopropaneoctanoic acid,2-[[2-[(2-ethylcyclopropyl)methyl]cyclopropyl]methyl], methyl ester	$C_{22}H_{38}O_2$	334.53	32.08	0.15	10152-71-3
17.	Cyclotrisiloxane, hexamethyl	$C_6H_{18}O_3Si_3$	222.46	40.16	0.22	541-05-9
18.	Decane, 2,3,5,8-tetramethyl-	$C_{14}H_{30}$	198.39	15.57	0.38	192823-15-7
19.	Decane, 2-methyl-	$C_{11}H_{24}$	156.31	20.56	0.23	6975-98-0
20.	Di-n-decylsulfone	$C_{20}H_{42}O_2S$	346.61	39.11	1.61	111530-37-1
21.	Dodecane, 2,6,11-trimethyl-	$C_{15}H_{32}$	212.41	14.11	0.13	31295-56-4
22.	Dodecane, 4,6-dimethyl-	$C_{14}H_{30}$	198.39	14.65	0.36	61141-72-8
23.	Eicosanoic acid, ethyl ester	$C_{22}H_{44}O_2$	340.58	26.85	0.79	18281-05-5
24.	Hexadecane, 2,6,11,15-tetramethyl-	$C_{20}H_{42}$	282.55	19.58	0.28	504-44-9
25.	Hexadecanoic acid, ethyl ester	$C_{18}H_{36}O_2$	284.48	2376.	7.95	628-97-7
26.	l-Proline, N-methoxycarbonyl-, isohexyl ester	$C_{13}H_{23}NO_4$	257.33	8.29	1.09	NA
27.	Methyl stearate	$C_{19}H_{38}O_2$	298.50	25.84	1.61	112-61-8
28.	n-Hexadecanoic acid	$C_{16}H_{32}O_2$	256.42	23.27	2.47	57-10-3
29.	Octadecane, 1-(ethenyloxy)-	$C_{20}H_{40}O$	296.53	20.43	0.42	930-02-9
30.	Octane, 2,4,6-trimethyl-	$C_{11}H_{24}$	156.31	12.78	0.51	62016-37-9
31.	Octasiloxane, 1,1,3,3,5,5,7,7,9,9,11,11,13,13,15,15-hexadecamethyl-	$C_{16}H_{50}O_7Si_8$	579.25	37.60	0.38	19095-24-0
32.	Pentanoic acid, 5-hydroxy-,2,4-ditbutylphenyl esters	$C_{19}H_{30}O_3$	306.44	14.90	0.43	166273-38-7

33.	Phthalic acid, cyclobutyl isobutyl ester	$C_{25}H_{38}O_4$	402.57	21.47	3.01	NA
34.	Silane, cyclohexyldimethoxymethyl-	$C_9H_{20}O_2Si$	188.34	7.55	0.39	17865-32-6
35.	Silane, diethyldecyloxypentadecyloxy-	$C_{29}H_{62}O_2Si$	470.88	45.53	4.27	NA
36.	Silicic acid, diethyl bis(trimethylsilyl) ester	$C_{10}H_{28}O_4Si_3$	296.58	41.09	0.79	3555-45-1
37.	Squalene	$C_{30}H_{50}$	410.72	38.04	0.55	111-02-4
38.	Tetracosamethylcyclododecasiloxane	$C_{24}H_{72}O_{12}Si_{12}$	889.84	22.98	0.30	18919-94-3
39.	Tetradecanoic acid, 10,13-dimethyl-, methyl ester	$C_{17}H_{34}O_2$	270.45	22.64	5.89	267650-23-7
40.	trans-13-Octadecenoic acid, methyl ester	$C_{19}H_{36}O_2$	296.49	25.43	10.61	NA
41.	Undecane, 2-methyl-	$C_{12}H_{26}$	170.33	18.77	0.51	7045-71-8
42.	Undecane, 3,7-dimethyl-	$C_{13}H_{28}$	184.36	11.12	0.27	17301-29-0
43.	Z-(13,14-Epoxy)tetradec-11-en-1-ol acetate	$C_{16}H_{28}O_3$	268.39	28.44	0.11	NA

Table 2. Compound identified in ethanolic extract of *Grewia tiliifolia* fruit using GC-MS

S. No.	Compound name	Formula	M.W.	R.T.	% Area	CAS No.
1.	1,1,1,3,5,5,5-Heptamethyltrisiloxane	$C_7H_{22}O_2Si_3$	222.50	42.11	0.35	1873-88-7
2.	1,1,1,5,7,7,7-Heptamethyl-3,3bis(trimethylsiloxy) tetrasiloxane	$C_{13}H_{36}O_4Si_4$	368.76	49.31	0.22	87867-97-8
3.	1,3-Benzenedicarboxylic acid, bis(2-ethylhexyl) ester	$C_{24}H_{38}O_4$	390.55	29.51	3.27	6422-86-2
4.	1,5,7,9,11,13-Hexamethyl-3,15-diphenyloctaprismo Octasilasesquioxane	$C_{18}H_{28}O_{12}Si_8$	661.09	42.87	2.62	NA
5.	10-Heneicosene (c,t)	$C_{21}H_{42}$	294.56	16.69	0.61	95008-11-0
6.	1-Monolinoleoylglycerol trimethylsilyl ether	$C_{27}H_{54}O_4Si_2$	498.88	37.60	0.34	54284-45-6
7.	2-Bromotetradecane	$C_{14}H_{29}Br$	277.28	36.43	2.18	74036-95-6
8.	2-Cyclohexen-1-one, 3-(3-hydroxybutyl)-2,4,4-trimethyl	$C_{13}H_{22}O_2$	210.31	37.29	0.40	27185-79-1
9.	2-methyltetracosane	$C_{25}H_{52}$	352.68	27.00	0.19	NA
10.	2-Methyl-Z, Z-3,13-octadecadienol	$C_{19}H_{36}O$	280.49	26.13	27.34	NA
11.	2-Piperidinone, N[4-bromonbutyl]-	$C_9H_{16}BrNO$	234.13	38.39	0.28	195194-80-0
12.	3,7,11,15-Tetramethyl-2-hexadecen-1-ol	$C_{20}H_{40}O$	296.53	21.19	0.20	102608-53-7
13.	3-Hexadecene, (Z)	$C_{16}H_{32}$	224.42	12.60	0.20	34303-81-6
14.	3-Isopropyl-6a,10b-dimethyl-8-(2-oxo-2-phenyl-ethyl)-dodecahydro-benzo[f]chromen-7-one	$C_{26}H_{36}O_3$	396.56	38.72	0.10	NA
15.	4,8,12-Tetradecatrien-1-ol, 5,9,13-trimethyl-	$C_{17}H_{30}O$	250.42	38.04	0.25	NA
16.	6-Octadecenoic acid, methyl ester, (Z)-	$C_{19}H_{36}O_2$	296.49	25.42	0.74	2777-58-4
17.	7,9-Di-tert-butyl-1-oxaspiro(4,5)deca-6,9-diene-2,8-dione	$C_{17}H_{24}O_3$	276.37	22.26	0.24	82304-66-3
18.	8-Methyl-6-nonenamide	$C_{10}H_{19}NO$	169.26	31.32	3.99	NA
19.	9,10-Secocholesta-5,7,10(19)-triene-3,24,25-triol,(3á,5Z,7E)-	$C_{27}H_{44}O_3$	416.63	37.72	0.30	40013-87-4
20.	9,12,15-Octadecatrienoic acid, 2,3-bis(acetyloxy)propyl ester, (Z,Z,Z)-	$C_{25}H_{40}O_6$	436.58	32.84	0.31	55320-02-0

21.	9,12-Octadecadienoic acid (Z,Z), methyl ester	$C_{19}H_{34}O_2$	294.47	25.30	0.84	2462-85-3
22.	9,12-Octadecadienoic acid, ethyl ester	$C_{20}H_{36}O_2$	308.50	26.34	6.38	7619-08-1
23.	9-Octadecenoic acid, methyl ester	$C_{21}H_{40}O_4$	356.54	53.88	2.17	3443-84-3
24.	á-Amyrin	$C_{30}H_{50}O$	426.72	45.98	0.31	638-95-9
25.	Allopregnan-3á, 9à-diol-20-one, 3acetate	$C_{23}H_{36}O_4$	376.53	43.17	2.19	24587-69-7
26.	Androst-4-en-3-one, 17-acetoxy-19-(N-formylmethylamino)	$C_{23}H_{33}NO_4$	387.51	35.89	0.84	NA
27.	á-Sitosterol	$C_{31}H_{52}O_2$	456.74	43.73	0.28	915-05-9
28.	Benzoic acid, 2-(dimethylamino)ethyl ester	$C_{11}H_{15}NO_2$	193.24	23.06	1.40	2208-05-1
29.	Bisphenol, bis(tert-butyldimethylsilyl) ether	$C_{27}H_{44}O_2Si_2$	456.81	44.50	0.18	NA
30.	Butyl 9-tetradecenoate	$C_{18}H_{34}O_2$	282.46	38.54	0.23	NA
31.	Cedran-diol, (8S,14)-	$C_{15}H_{26}O_2$	238.36	47.95	0.32	62600-05-9
32.	Corymbolone	$C_{15}H_{24}O_2$	236.35	38.91	0.71	97094-19-4
33.	Ç-Sitosterol	$C_{29}H_{50}O$	414.70	39.70	0.63	83-47-6
34.	Cyclohexanepropanol, 2,2-dimethyl-6-methylene-	$C_{12}H_{22}O$	182.30	29.20	0.18	95452-04-3
35.	Cyclooctane, (methoxymethoxy)-	$C_{10}H_{20}O_2$	172.26	33.31	0.27	42604-11-5
36.	Di-n-decylsulfone	$C_{20}H_{42}O_2S$	346.61	40.93	0.19	111530-37-1
37.	E-11-Hexadecenoic acid, ethyl ester	$C_{18}H_{34}O_2$	282.46	26.85	0.13	NA
38.	Eicosanoic acid, phenylmethyl ester	$C_{27}H_{46}O_2$	402.65	35.71	0.58	77509-04-7
39.	Hexadecanoic acid, ethyl ester	$C_{18}H_{36}O_2$	284.48	23.75	1.78	628-97-7
40.	Hexadecanoic acid, octadecyl ester	$C_{34}H_{68}O_2$	508.90	48.36	2.11	2598-99-4
41.	Lupeol	$C_{30}H_{50}O$	426.72	45.51	0.50	545-47-1
42.	n-Hexadecanoic acid	$C_{16}H_{32}O_2$	256.42	23.30	6.52	57-10-3
43.	Octadecanoic acid, octadecyl ester	$C_{36}H_{72}O_2$	536.95	54.64	0.79	2778-96-3
44.	Phthalic acid, cyclobutyltridecyl ester	$C_{25}H_{38}O_4$	402.57	21.47	0.33	NA
45.	Pyrimidine, 2-(4'-butyl[1,1'-biphenyl]-4-yl)5-ethyl-	$C_{22}H_{24}N_2$	316.44	41.38	2.46	130827-90-6
46.	Silicic acid, diethyl bis(trimethylsilyl) ester	$C_{10}H_{28}O_4Si_3$	296.58	44.71	0.26	3555-45-1
47.	Stigmastan-3,5-diene	$C_{29}H_{48}$	396.69	39.27	0.81	NA
48.	Sulfurous acid, 2-propyl tridecyl ester	$C_{16}H_{34}O_3S$	306.50	23.92	0.11	NA
49.	Tetracosamethyl-cyclododecasiloxane	$C_{24}H_{72}O_{12}Si_{12}$	889.84	27.40	0.30	18919-94-3
50.	Tetradecanoic acid, 10,13-dimethyl-, methyl ester	$C_{17}H_{34}O_2$	270.45	22.63	0.33	267650-23-7
51.	Vinyl 10-undecenoate	$C_{13}H_{22}O_2$	210.31	33.54	0.70	5299-57-0

LIU & al. (2008) isolated compounds including heneicosanoic acid, β-sitosterol, propyl palmitate, and catechin from *G. biloba*. AHAMED & al. (2009) and ULLAH & al. (2012) also identified lactone, gluonic acid, and derythro-2-hexenoic acid from the same plant. Additionally, NATARAJAN & al. (2015) reported compounds with anti-diabetic potential from *Grewia hirsuta*, and REHMAN & al. (2022) identified tridecanoic acid, octanoic acid, eicosanoic acid, and octadecatrienoic acid from *G. tenax*. Based on these findings, it is plausible to explore similar medicinal properties in Dhaman fruit.

Significance of this study

Medicinal plants have long been employed to prevent diseases, maintain health, and treat various ailments. Plants rich in compounds such as triterpenoids, flavonoids, hentriacontane, 16-hentriacontanone, adiantone, isoadiantone, ß-sitosterol, fernene, 2-methoxy-5,40-dimethylbenzenebutanal, methyl octadecanoate acid, kaempferol, quercetin, 3,4',7-trihydroxy-3',5-dimethoxyflavone, catechin, epicatechin, afzelechin, epiafzelechin, mesquitol, ophioglonin, aromadendrin, phenol, dichloromethane, phytol, coumarins, glycosides, etc., have demonstrated significant biological activities, which are gaining increasing attention [PRABHADEVI & al. 2012; ABAYOMI & al. 2014; LIU & al. 2015; AMAN & al. 2016; QAMAR & al. 2021]. The present study identified numerous phytomolecules in Dhaman fruit through GC-MS analysis. Consequently, this fruit holds potential for treating various human ailments such as dementia, exhibiting antimicrobial properties, antiandrogenic properties, antioxidant and neuroprotective activities, anti-diabetic and anti-leukemic effects, analgesic and anti-inflammatory properties, immune-stimulant and antitumor activities, and more. The local community has long revered this plant due to its important role in their daily lives. This study highlights the need for further research on specific plants to explore their unique curative properties. The implications of these findings for rural communities could contribute to their well-being and safety.

Conclusion and future perspectives

This study elucidated the presence of diverse phytomolecules in abundance in Dhaman fruit. GC-MS analysis revealed the identification of forty-eight distinct phytomolecules, including esters, hydrocarbons, fatty alcohols, and ester compounds. These bioactive molecules are well-known for their antimicrobial, antiandrogenic, antioxidant and neuroprotective, anti-diabetic, anti-leukemic, analgesic, anti-inflammatory, immune-stimulant, antitumor, anti-alopecic, lubricant, hemolytic, 5-α reductase inhibitory, diuretic, and antifungal properties. Hence, Dhaman fruit shows significant potential for combating various human diseases and promoting overall well-being. Moreover, the fruit could serve as a beneficial feed supplement in agro-animal sectors such as poultry farming, dairy cattle industry, and fish farming, enhancing health and productivity. Consequently, this phytochemical characterization study of Dhaman fruit lays the groundwork for future research in the development of pharmaceutical drugs and feed additives.

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