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Phytochemical Screening of Fruit Peel and Root Bark of *Pithecellobium dulce* by GC-MS Analysis

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Abstract: The present study is focused on phytochemical analysis of fruit peel and root bark of *Pithecellobium dulce*, a member of the Leguminosae family by gas chromatography-mass spectrometry (GC-MS). The plant material fruit peel and root bark was collected and cleaned with pure water and dried under shade at room temperature. Once dried, the plant materials were ground into powder. About 100 g of powdered materials were subjected to extraction using ethanol as a solvent by Soxhlet apparatus. The extracts were then filtered and kept in oven at 40-45 °C until the solvent was completely evaporated from the extract. The remains turned dark brown residues and they were used for GC-MS analysis. The GC-MS analyses of ethanolic extract of fruit peel and root bark of *Pithecellobium dulce* showed presence of phytocompounds. The ethanolic extract of fruit peel comprising eighteen phytocompounds including 1,2,3-Propane tricarboxylic acid, 2-hydroxy triethyl ester; Hexadecanoic acid, ethyl ester; Oleic acid, trimethyl silyl ester; 9-Methyl heptadecane; Heneicosane; Eicosane and 2-Methyloctacosane known for their diverse activities like antioxidant, antimicrobial, antiviral, anticancer and anti-inflammatory properties. The ethanolic extract of root bark revealed the presence of nineteen phytocompounds including 1-Propene-1,2,3-tricarboxylic acid, tributyl ester; Hexadecanoic acid, ethyl ester; 1,13-Tetra decadiene; (E)-9-Octa decenoicacid ethyl ester; 3-Ethyl-3-methyl heptanes; Di-n-octyl phthalate1,2-Benzene dicarboxylic acid; Octadecane, 1-chloro-; 2-Methyloctacosane and Oleic acid, propyl ester with diverse functionalities like antidiabetic, antioxidant, antitumor and antimicrobial properties. So, the present investigation confirmed the presence of active phytocompounds in fruit peel and root bark of *Pithecellobium dulce*. In conclusion, this study will be useful for further research on isolation of bioactive compounds from fruit peel and root bark of *Pithecellobium dulce* and it may hold promise for discovering novel medications.

Keywords: Phytocompounds, *Pithecellobium dulce*, Fruit peel, Root bark, GC-MS analysis

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Introduction

People have utilized plants as a natural source of therapeutic compounds for thousands of years. A group of plants known as medicinal plants is employed therapeutically and preventively in medicine. Asian nations have long utilized plants and herbs for their analgesic, anti-inflammatory, and antipyretic properties in traditional medicine. Plant is one of the main categories that aid in the development of new drugs. In India, the traditional use of medicinal plants has a significant impact on healthcare and is linked to the body's innate ability to fend off illness. Historically, plants have been utilized to treat a variety of illnesses. Bioactive chemicals are produced in large quantities by medicinal plants (Mahesh and Satish, 2008). For thousands of years, plants have been essential to preserving human health and elevating the standard of living.

Plants have long been used as an efficient form of medicine in many traditional and alternative medical systems, including Ayurveda, Unani, Homeopathy, Naturopathy, Sidha, and others. People from several ethnic groups live in different parts of India, each with their own unique culture, customs, cuisine, and extensive knowledge of traditional medicine (Parinitha *et al*., 2005). They use herbal medicine to treat a wide range of illnesses. For thousands of years, natural products especially plants have been utilized to cure a wide range of illnesses. Since ancient times, terrestrial plants have been utilized as medicines in Egypt, China, India, and Greece. Herbal treatments have been used for centuries to cure a wide range of infectious disorders throughout human history. In many underdeveloped nations, plant materials are still widely used as medicines in basic healthcare today (Zakaria, 1991).

Pithecellobium dulce (Roxb.) Benth, is one such traditional medicinal plant whose pharmacological qualities have been thoroughly investigated. Native to tropical America, *Pithecellobium dulce* is a small to medium-sized, spiky, evergreen tree. The fruits are linear, curved legumes, or pods, that have two borders where they split and range in length from 10 to 13 cm. When the fruits ripen, they change colour from green to reddish brown. For their nutritional and medicinal benefits, the pod fragments can be consumed raw or prepared into a beverage; nevertheless, the majority of the pods' chemical components are currently unidentified and underutilized (Sugumaran *et al*., 2008). *Pithecellobium dulce* sometimes known as the Manila Tamarind, is a versatile tropical fruit tree that is mostly used for its seeds, which are processed and eaten for purposes other than food (Lewis and Ausubel, 2006). Additionally, it is used as an emollient by traditional healers; the stems are said to treat diarrhoea, the leaves to treat digestive ailments, and the seeds to treat ulcers (Chopra *et al*., 1956). For leprosy, intestinal disorders, and dyspepsia for venereal disease pain, the leaves can be used as a plaster (Sugumaran *et al*., 2008). *Pithecellobium dulce* fruits yielded three distinct hetero-polysaccharides that were employed as adjuvants in pharmaceutical products (Preethi and Saral, 2016).

Fruits and their parts have anti-inflammatory, antioxidant, hepatoprotective and nephro-protective properties (Megala and Geetha, 2010; Pal *et al*., 2012; Fatma *et al*., 2024; Rao *et al*., 2024; Srivastava *et al*., 2024; Yadav *et al*., 2024a, b, 2025). Phenols, flavonoids, and saponins are present in fruits and the hydroxyl functional group found in flavonoids and phenolic compounds can scavenge radicals and avert oxidative damage (Katekhaye and Kale, 2012). *Pithecellobium dulce* fruits are highly nutritious, have therapeutic properties and are non-toxic, so people use them as dietary supplements. The fruit extracts included flavonoids, quercetin, rutin, kaempferol, naringin, and daidzein and were shown to be rich in phenolic components (Megala and Geetha, 2010). *Pithecellobium dulce* bark has antivenomic and antibacterial properties (Singh *et al*., 2010). β-sitosterol, saponins, glycosides, oleanolic and echinocystic acids as sapogenins, triterpenoids, flavonoids, saccharides, long-chain aliphatic

hydrocarbons, and tannins were found in the bark and leaves according to phytochemical analysis (Nigam *et al*., 1997; Yoshikawa *et al*., 1997).

Fruits are now frequently used to regulate blood sugar levels. For the same purpose, certain groups of people drink the decoction and eat raw fruit peel. Although there is not a scientific study supporting the use of fruit peels in the treatment or management of diabetes mellitus, ethnomedical research has shown their potential. *Pithecellobium dulce* is a plant with medicinal qualities throughout. Because of its high nutritional content, its leaves are also feed to goats (Olivares *et al*., 2013). There have been reports of using leaf decoction for larvicide, earaches, teethaches, digestive problems, and indigestion (Pradeepa *et al*., 2014). Antifungal and antibacterial properties in the leaves have also been reported (Shanmugakumaran *et al*., 2006). The *Pithecellobium dulce* bark's aqueous preparations were used to treat dermatitis, fever, diarrhoea, and even ocular inflammation (Duke, 2002). Its ability to scavenge free radicals is used to avoid problems related to diabetes (Sukantha and Sripathi, 2015). The *Pithecellobium dulce* fruit peel's cardioprotective benefits were reported by Pakutharivu *et al*. (2015). *Pithecellobium dulce* fruit peels possess four distinct chemicals: stigmasterol, sitosterol, quercetin, and pinitol, which have been identified as medicinally useful molecules (Sukantha and Sripathi, 2015).

Worldwide attention to plant studies has risen recently, and a substantial amount of data has been gathered to demonstrate the great potential of medicinal plants utilised in traditional systems such as Ayurveda, Siddha, and Unani. Research has indicated that medicinal plants may be helpful in the management of human disease. Recently, several plants have also been investigated using a methodology that combines conventional medical knowledge with a novel research instrument, revealing some highly potent phytochemicals. It is unknown how beneficial *Pithecellobium dulce* fruit peel and root bark for treating diseases. Though the fruit peel and root bark of *Pithecellobium dulce* are subjected to a few studies, they have not been thoroughly studied. So, the present study was aimed to analyse the phytochemicals of fruit peel and root bark of *Pithecellobium dulce* by GC-MS method.

Materials and Methods

Collection of plant materials

The fruit peel and root bark of *Pithecellobium dulce* were collected from Kollidam, Nagapattinam District, Tamil Nadu, India. The plant was identified by Dr. R. Murugan, Department of Botany, Government Arts College (Autonomous), Kumbakonam, Tamil Nadu, India. The plant materials were washed by running tap water and finally with distilled water to remove any dirt particles from it. The plant materials were shade dried at room temperature for 15 days and then it had been ground into powder by using a mechanical grinder. The powdered materials were stored in air tight containers until needed.

Preparation of plant extracts

About 100 g of powdered materials of fruit peel and root bark was taken separately and they were extracted with ethanol, methanol, and diethyl ether at appropriate temperature by Soxhlet apparatus. The extractions were continued for 48 h and then the extracts were filtered by using cheese cloth and finally Whatman No.1 filter paper. The extracts were kept in an oven at 40-45 °C till the solvents were completely evaporated from it and then dark brown residues were obtained. The residues were kept in air tight containers separately and stored at 4 °C until the time of use.

GC-MS analysis

The phytochemical screening of the extracts of fruit peel and root bark of *Pithecellobium dulce* were carried out by GC-MS analysis by using the instrument Perkin Elmer Clarus 500. The data were obtained on a Capillary Column Elite-5MS and the following procedure was followed. Helium (99.999%) was used as the carrier gas with a flow rate of 1 ml/min in the split mode (10:1). An aliquot of 1 µl of methanol solution of sample was

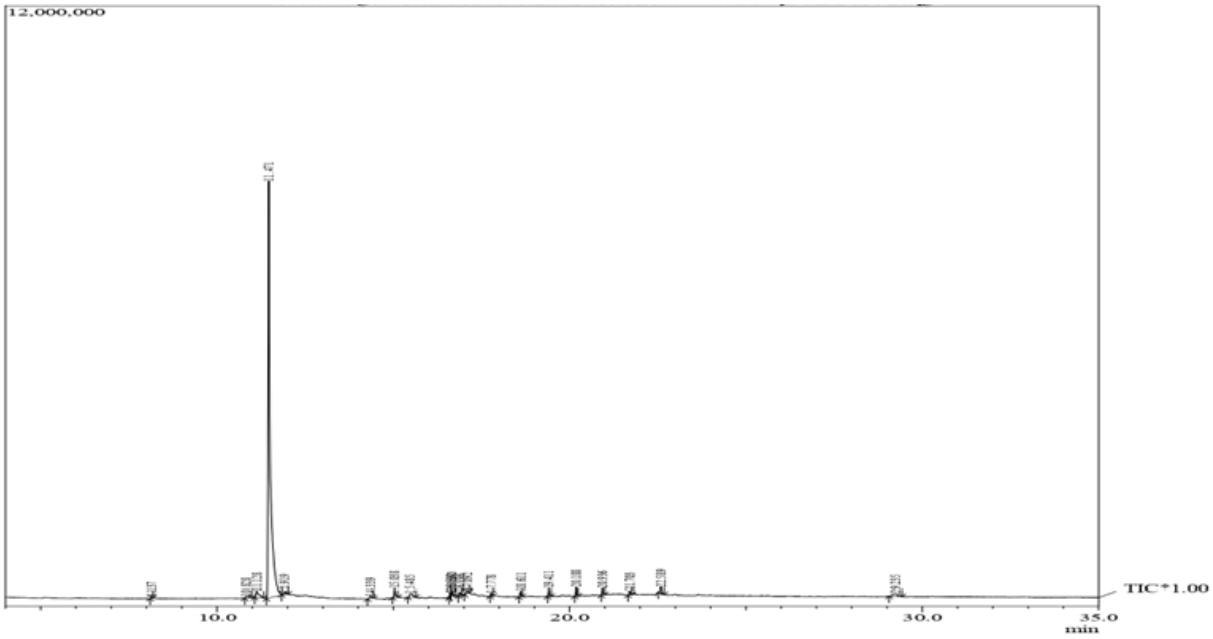

Fig. 1: GC-MS chromatogram of ethanolic extract of fruit peel of *Pithecellobium dulce.*

injected into the column with the injector temperature at 270 °C. GC oven temperature started at 110 °C and holding for 2 min and it was raised to 200 °C at the rate of 10 °C/min without holding. Holding was allowed at 280 °C for 9 min with program rate of 5 °C/min (50 °C @8 °C/min to 150 °C (5 min)@ 8 °C/min to 250 °C (10 min)). GC interface and Ion source temperature was maintained at 200 °C. The mass spectrum of compounds in the samples was obtained by electron ionization at 70 eV and the detector was operated in scan mode from 40-450 amu (atomic mass units). A scan interval of 0.5 sec and fragments from 40 to 450 Da were maintained.

Identification of components

Interpretation of mass spectra of the extracts of fruit peel and root bark of *Pithecellobium dulce* with the database of National Institute of Standard and Technology (NIST) library is having more than 62,000 spectral patterns. The spectrum of the compound was compared with the spectrum of NIST library database. The identity of the spectra above 95% was needed for the identification of compounds. The name, molecular weight, molecular formula, retention time and structure of compounds of the extracts of fruit peel and root bark of *Pithecellobium dulce* were ascertained. The relative percentage amount of each component was calculated by comparing its average peak area with the total area. The spectrum of the Unknown component was compared with the spectrum of the component stored in the NIST library using the Turbomass version 5.2.0. The GC-MS was interpreted using the NIST library database and the prediction of the biological activity of compounds was based on Dr. Duke's phytochemicals and ethnobotanical databases established by Dr. Jim Duke of the Agricultural Research Service, USDA.

Results

The phytochemical screening of ethanolic extract of fruit peel and root bark of *Pithecellobium dulce* was carried out by Gas Chromatography-Mass Spectrometry (GC-MS) analysis. The phyto-compounds were analysed in the ethanolic extract of fruit peel of *Pithecellobium dulce* by GC-MS method and the results are presented in Table 1. The peaks of phytocompounds of the ethanolic extract of fruit peel of *Pithecellobium dulce* are depicted in the chromatogram (Fig. 1). The name

Table 1: List of identified phytocompounds of ethanolic extract of fruit peel of *Pithecellobium dulce* by GC-MS analysis

Name of the compound	Molecular formula	MW	RT	Peak area %	Nature of compound	Activity*
Oxalic acid, 2-Ethyl hexyl ester	$C_{16}H_{30}O_4$	286	8.137	0.11	Allyl nonyl e*ster*	Antioxidant, Plasticizer, Pesticides
1,2-Benzene dicarboxylic acid, diethyl ester,	$C_{12}H_{14}O_4$.	222	10.828	0.63	Aromatic	Antibacterial
1-Propene-1,2,3-tricarboxylic acid, tris (N.-butyl ester)	$C_{18}H_{30}O_6$	342	11.128	1.95	Alkane	NF
Triethyl citrate	$C_{12}H_{20}O_7$	276	11.471	86.93	NF	Cosmetics.
1,2,3-Propane tricarboxylic acid, 2-hydroxy triethyl ester	$C_{12}H_{20}O_7$	276	11.919	0.39	Enzyme inhibitor	Antioxidant, Antimicrobial,
Acetamide, 2-(diethyl amino)-n-(2,6-dimethyl phenyl)	$C_{14}H_{22}N_2O$	234	14.339	0.55	Organic compound	Anesthetic, Antiarrhythmic
Hexadecanoic acid, ethyl ester	$C_{18}H_{36}O_2$	284	15.038	1.16	Fatty acid ethyl ester	Antioxidant, Hemolytic, Hypocholesterolemic, Flavour, Nematicide, Antiandrogenic
Palmitic acid, TMS (Trimethyl silyl ester) derivative	$C_{19}H_{40}O_2$	328	15.485	1.23	Fatty acids	Antifungal, Antitumour, Antibacterial
1,8,11-Heptadecatriene, (Z, Z)-dihydroaplotaxene	$C_{17}H_{30}$	234	16.610	0.29	Alkene	Drug for migraine and cluster headache
Ethyl 9-hexadecenoate	$C_{18}H_{34}O_2$	282	16.660	0.49	Fatty acid ester	Anti-inflammatory
Docosanoic acid, ethyl ester	$C_{24}H_{48}O_2$	368	16.896	0.47	Fatty acid ester	Anticancer
Oleic acid, trimethyl silyl ester	$C_{21}H_{42}O_2$	354	17.092	0.55	Fatty acid	Antifungal, Antibacterial, Antiviral, Anticancer, Cardioprotective
9-Methyl heptadecane	$C_{18}H_{38}$	254	17.778	0.29	Alkane	Antimicrobial
Heneicosane	$C_{21}H_{44}$	296	19.411	0.63	Hydrocarbon	Antimicrobial, Larvicidal, Ovicidal
Eicosane	$C_{20}H_{42}$	282	20.188	0.76	Alkane	Antimicrobial, Anti-inflammatory, Antifungal
2-Methyloctacosane	$C_{29}H_{60}$	408	21.703	0.42	Fatty acid	Antibacterial, Antioxidant, Free radical scavenger
Docosanoic acid, docosyl ester	$C_{44}H_{88}O_2$	648	22.589	0.85	Fatty acid ester	Anticancer
5,11,17,23-Tetratert-butyl Penta cyclo [19.3.1.14-tert-butylcalix [4] arene	$C_{44}H_{56}O_4$	648	29.235	1.20	Alkyl	Electroactive material

RT: Retention Time; MW: Molecular Weight; NF: Not Found; *Dr. Duke's Ethnobotanical database

Table 2: List of identified phytocompounds of ethanolic extract of root bark of *Pithecellobium dulce* by GC-MS analysis

Name of the compound	Molecular formula	MW	RT	Peak area %	Nature of compound	Activity*
1,2-Benzene dicarboxylic acid, diethyl ester	$C_{12}H_{14}O_4$	222	10.811	0.29	Aromatic dicarboxylic acid	Antimicrobial, Antifouling
1-Propene-1,2,3-tricarboxylic acid, tributyl ester	$C_{18}H_{30}O_6$	342	11.115	0.85	Enzyme inhibitor	Antioxidant, Antimicrobial
Triethyl citrate	$C_{12}H_{20}O_7$	276	11.482	91.27	Fatty acid ester	Food additive, Flavouring, Foam stabilizer, Plasticizer, Cosmetics
Octyl formate	$C_9H_{18}O_2$	158	12.923	0.07	Fatty alcohol ester	Formicide, acidifier
Carbonic acid, prop-1-en-2-yl tetradecyl ester	$C_{18}H_{34}O_3$	298	12.981	0.03	Anhydride	Antimalarial
Acetamide, 2-(diethyl amino)-n-(2,6-dimethyl phenyl)	$C_{14}H_{22}N_2O$	234	14.359	0.69	NF	Anaesthetic, Antiarrhythmic, Drug for ventricular arrhythmias, Cardiac surgery
Hexadecanoic acid, ethyl ester	$C_{18}H_{36}O_2$	284	15.044	0.86	Palmitic acid ester	Antioxidant, Hemolytic, Hypocholesterolemic, Flavouring, Nematicide, Antiandrogenic
Palmitic Acid, TMS (Trimethyl silyl ester) derivative	$C_{19}H_{40}O_2Si$	328	15.525	0.69	Carboxylic acid	Antifungal, Antitumour, Antibacterial
1,13-Tetra decadiene	$C_{14}H_{26}$	194	15.789	0.79	Fatty alcohol ester	Antimicrobial, Antioxidant
Silane, trimethyl (9-octa decenyl oxy)-, (z)-(9z)-9-octa decenyl trimethyl silyl ether	$C_{21}H_{44}OSi$	340	16.244	0.36	Alkyl	Antimicrobial, Antioxidant
(E)-9-Octa decenoicacid ethyl ester	$C_{20}H_{38}O_2$	310	16.658	0.41	Fatty acid ester	Antimicrobial, Anti-inflammatory, Antiviral
Docosanoic acid, ethyl ester	$C_{24}H_{48}O_2$	368	16.889	0.22	Fatty acid ester	Anticancer
3-Ethyl-3-methyl heptane	$C_{10}H_{22}$	142	18.606	0.13	Alkane	Antimicrobial, Antioxidant, Free radical scavenger
Di-n-octyl phthalate1,2-Benzene dicarboxylic acid	$C_{24}H_{38}O_4$	390	19.765	0.51	NF	Antibacterial, Antifungal, Cell cycle arrest inducer, Antioxidant, Antitumor, Larvicidal, Antifouling, Chemotactic, Anti-melanogenic, Antiviral, Anti-inflammatory
Octadecane, 1-chloro-	$C_{18}H_{37}Cl$	288	20.185	0.10	Alkane	NF
2-Methyloctacosane	$C_{29}H_{60}$	408	20.930	0.20	Fatty acid	Antibacterial, Antioxidant, Free radical scavenger, Pesticide
Squalene	$C_{30}H_{50}$	410	21.831	0.44	Dehydro triterpenic hydrocarbon	Antioxidant, Antimicrobial
Oleic acid, propyl ester	$C_{21}H_{40}O_2$	324	29.062	0.47	Omega-9 fatty acid	Cardiovascular drug, Antifungal, Antibacterial, Antiviral, Antitumour
(Z)-14-Tricosenyl formate	$C_{24}H_{46}O_2$	366	35.299	1.23	Aliphatic	Antioxidant, Antiproliferative

RT: Retention Time; MW: Molecular Weight; NF: Not Found; *Dr. Duke's Ethnobotanical database

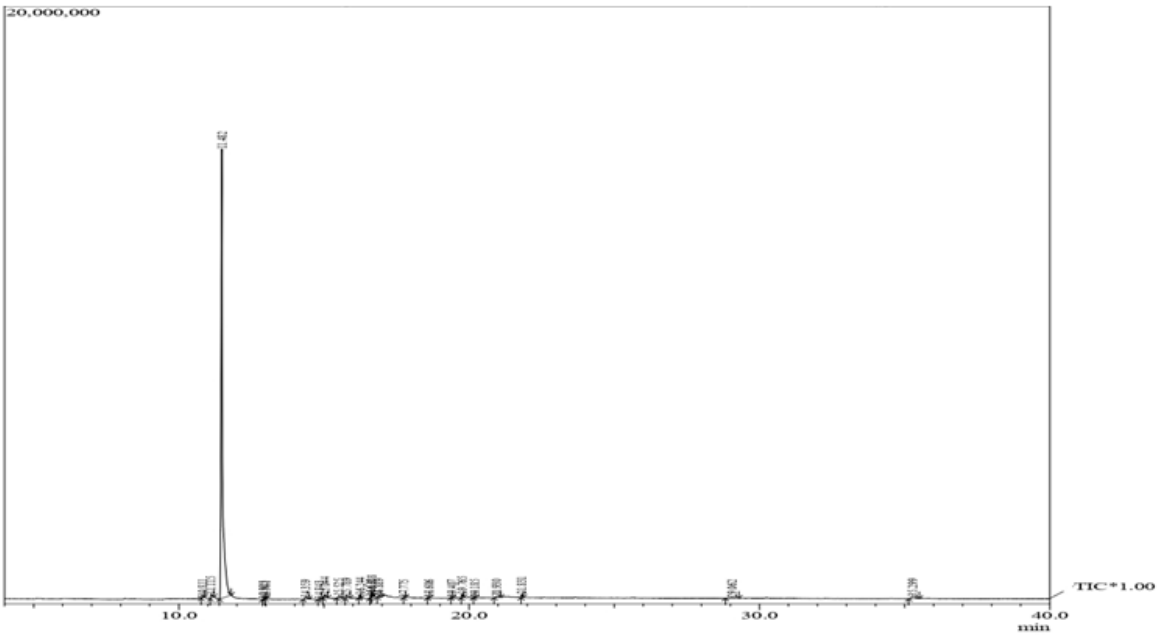

Fig. 2: GC-MS chromatogram of ethanolic extract of root bark of *Pithecellobium dulce.*

of identified phytocompounds with their retention time (RT), Molecular formula (MF), Molecular weight (MW) and peak area percentage are presented in Table 1. The GC-MS analysis of the ethanolic extract of fruit peel of *Pithecellobium dulce* revealed the presence of 18 phytochemical components, such as Oxalic acid, 2-Ethyl hexyl ester (0.11%); 1,2-Benzene dicarboxylic acid, diethyl ester (0.63%); 1-Propene-1,2,3-tricarboxylic acid, tris (N.-butyl ester) (1.95 %); Triethyl citrate (86.93%); 1-2,3-Propane tricarboxylic acid, 2-hydroxy triethyl ester (0.39%); Acetamide, 2-(diethylamino)-n-(2,6-dimethyl phenyl) (0.55%); Hexadecanoic acid, ethyl ester (1.16%); Palmitic Acid, TMS derivative (1.23%); 1,8,11-Heptadecatriene, Ethyl 9-hexadecenoate (0.29%); Ethyl 9-hexadecenoate (0.49%); docosanoic acid, ethyl ester (0.47%); Oleic acid, trimethylsilyl ester (0.55%); 9-Methylheptadecane (0.29%); Heneicosane (0.63%); Eicosane (0.76%); 2-Methyloctacosane (0.42%); Docosanoic acid, docosyl ester (0.85%) and 5-11,17,23-Tetratert-butyl Penta cyclo [19.3.1.1 4-tert-butylcalix [4] arene (1.20%).

The phytocompounds were analysed in the ethanolic extract of root bark of *Pithecellobium dulce* by GC-MS method and the results are presented in Table 2. The peaks of phytocompounds of the ethanolic extract of root bark of *Pithecellobium dulce* are shown in the chromatogram (Fig. 2). The ethanolic extract of root bark of *Pithecellobium dulce* showed the presence of nineteen phytocompounds such as 1,2-Benzene dicarboxylic acid, diethyl ester (0.29%); 1-Propene-1,2,3-tricarboxylic acid, tributyl ester (0.85%); Triethyl citrate (91.27%); Octyl formate (0.07%); Carbonic acid, prop-1-en-2-yl tetradecyl ester (0.03%); Acetamide, 2-(diethyl amino)-n-(2,6-dimethyl phenyl) (0.69%); Hexadecanoic acid, ethyl ester (0.86%); Palmitic Acid, TMS (Trimethyl silyl ester) derivative (0.69%); 1,13-Tetra decadiene (0.79%); Silane, trimethyl (9-octa decenyl oxy)-, (z)-(9z)-9-octa decenyl trimethyl silyl ether (0.36%); (E)-9-Octa

decenoicacid ethyl ester (0.41%); Docosanoic acid, ethyl ester (0.22%); 3-Ethyl-3-methyl heptanes (0.13%); Di-n-octyl phthalate1,2-Benzene dicarboxylic acid (0.51%); Octadecane, 1-chloro- (0.10%); 2-Methyloctacosane (0.20%); Squalene (0.44%); Oleic acid, propyl ester (0.47%) and (Z)-14-Tricosenyl formate (1.23%).

Discussion

The use of medicinal plants is crucial for maintaining both individual and community health. Medicinal plants' medical significance is due to presence of compounds and active ingredients that have specific physiological effects on humans. Phenolic compounds are the most significant of these chemically active plant components. A large number of these naturally occurring medicinal plants and plant extracts serve as the basis for contemporary therapeutic research, allowing to create the empirical medical system. The plant has a wide range of chemical components, including proteins, phlobatannins, carbohydrates, glycosides, emodins, anthro-cyanins, alkaloids, flavonoids, saponins, tannins, terpenoids, and phenolic compounds (Bagchi and Kumar, 2016; Megala and Geetha, 2010). Similar to this, a large number of phytocompounds were found in the ethanolic extract of fruit peel and root bark of *Pithecellobium dulce* in the current investigation. Dr. Duke's Phytochemicals and Ethnobotanical Databases were used to anticipate the biological and pharmacological characteristics of the identified substances (Merlin *et al*., 2009).

In the current investigation, the ethanolic extract of *Pithecellobium dulce* fruit peel was shown to contain eighteen phytocompounds. Triethyl citrate was determined in the ethanolic extract of fruit peel with the peak area of 86.93%. Similar ingredients were also derived from *Rosa canina* for use in cosmetics (Johnson *et al*., 2022). In a similar vein, this compound was reported in *Cayratia pedata* leaf and also presented the same activity in leaf and callus extracts (Tyagi and Agarwal, 2017). The identified compound Hexadecanoic acid, ethyl ester (1.16%), has been reported to possess antioxidant, hemolytic, hypocholesterolemic, flavor, nematicide, and antiandrogenic activity and similarly the antibacterial activity of *Anisopus manni* leaf extract and the cholesterol-lowering action of *Andrographis paniculata* were reported by Kalaivani *et al*. (2012).

The antifungal, antitumor, antioxidant, antibacterial, antidiabetic, and antitumor properties of palmitic acid TMS derivative were reported and the presence of palmitic acid TMS derivative in *Pithecellobium dulce* (1.23%) is confirmed and documented in this study. Similarly, the antioxidant activity of palmitic acid in the peels of *Artocarpus camansi* fruit was reported (Nasution *et al*., 2018). The antitumor properties of palmitic acid discovered as a selective cytotoxic substance in a marine red algae (Kumar *et al*., 2022). The phytocompounds 5,11,17,23-Tetratert-butyl penta cyclo [19.3.1.1] 4-tert-butylcalix [4] arene (1.20%) and Docosanoic acid docosyl ester (0.85%) were found and reported to possess antibacterial activity (Blaskovich *et al*., 2018). Similarly, these compounds with anticancer properties were also reported in the other medicinal plants *Curcuma mutabilis* (Inbathamizh and Padmini, 2013; Soumya *et al*., 2021). The compound Eicosane (0.76%) was found and claimed to have antipyretic, analgesic, and anti-inflammatory qualities.

In a similar vein, Eicosane was found in *Tamarindus indica* leaves (Usha Nandhini *et al*., 2015; Mehdi *et al*., 2021). Additionally, 2-Methyloctacosane (0.42%) was found and reported to exhibit antimicrobial, anti-inflamma-tory, and antifungal activity. Additionally, 1,2-Benzene dicarboxylic acid, diethyl ester (0.63%) was found and reported to possess antifouling, and antibacterial activity. Acetamide, 2-(diethyl amino)-n-(2,6-dimethyl phenyl) (0.55%), was found in this study and reported to have anesthetic and antiarrhythmic properties. The compound Heneicosane (0.63%) was identified and reported to have antimicrobial activity. Similarly the presence of this compound was

reported in endophytic fungi *Chaetomium globosum*, *Cladosporium tenuissimum*, and *Penicillium janthinellum* (Yayli *et al*., 2006; Kanjana *et al*., 2019).

In this study, Ethyl 9-hexadecenoate (0.49%) was determined which has been reported to possess anti-inflammatory activity. Oleic acid, trimethyl silyl ester (0.55%) was determined and reported to possess antidiabetic activity. This is also present in other medicinal plants *Meriandra dianthera* and *Aloe camperi* (Sium *et al*., 2017). The compound 1,2,3-Propane tricarboxylic acid, 2-hydroxy triethyl ester (0.39%) was identified and reported to possess antioxidant and antimicrobial activities. The compounds 1,8,11-Heptadecatriene, (Z, Z)-dihydroaplotaxene (0.29%), medication for cluster headaches or migraines according to the National Library of Medicine (Sansevere and White, 2021), and Oxalic acid, 2-ethyl hexyl ester (0.11%) were found and reported to possess natural antioxidant properties.

Nineteen phytocompounds were identified in the ethanolic extract of root and bark of *Pithecellobium dulce*. The compound Z-14-Tricosenyl formate (1.23%) was identified in this study and reported to possess antioxidant and antitumor activities. The present study showed the presence of 1,2-Benzene dicarboxylic acid, diethyl ester (0.29%) which possess antibacterial and antifouling activity. The same biologically active compound was also reported in *Valeriana dioscoridis* extracts (Ucar *et al*., 2021) and possess antioxidant and antimicrobial activity. The biologically active compound 1-Propene-1,2,3-tricarboxylic acid, tributyl ester is present in root bark and the peak area is 0.85%. In the present study, the phytocompound Triethyl citrate was determined and the peak area is 91.27%. The compound possesses antioxidant, hemolytic, hypocholesterolemic, flavouring, nematicide and antiandrogenic properties. In the present study, the compound hexadecanoic acid, ethyl ester is present with the peak area of 0.86%. The same compound was also reported in the ethanolic extract of *Pistia stratiotes* and *Eichhornia crassipes* (Tyagi and Agarwal, 2017). In this study, the compound Palmitic acid TMS derivative, which was found at a peak area of 0.69%, and reported to possess antioxidant, hypercholesterolemic, nematicide, and antidiabetic properties (Tyagi and Agarwal, 2017). The bioactive compound Phthalate ester, di-n-octyl phthalate 1,2-benzene dicarboxylic acid (0.51%) was determined in this study and reported to exhibit antibacterial, antifungal, antioxidant, antitumor, larvicidal, anti-fouling, chemotactic, anti-melanogenic, antiviral, and anti-inflammatory activities (Roy, 2020). Acetamide, 2-(diethyl amino)-n-(2,6-dimethyl phenyl) compound was determined in this study and a peak area of 0.69%, which possess anaesthetic effect. The present study confirmed the presence of Oleic acid, propyl ester with a peak area of 0.47%. The compound possesses biological activities as cardiovascular drugs, and the pharmacological basis of therapeutics, antifungal, antibacterial, and antiviral drugs (Kohn *et al*., 1980; Priyadarshini and Tulpule, 1980; El-Khatib and Cora, 1981). Squalene was found in the peak area of 0.44%, and its biological activities include antioxidant and antimicrobial activity. The natural squalene with potent antioxidant and antimicrobial activity has been reported (Biswas and Chakraborty, 2013).

The phytocompound 1,13-Tetradecadiene was determined with the peak area of 0.79%. The compound (E)-9-Octadecenoic acid ethyl ester was present in the extract of root bark with the peak area of 0.41%. The antibacterial effects of several compounds derived from oleanolic acid and other natural triterpenic compounds. Another study explores the bioactive nature of derivatives of phthalate ester derived from this compound (Hichri *et al.*, 2003). Docosanoic acid, ethyl ester with the peak area of 0.22% was found in this study and reported to possess anticancer activity. The phytocompound Silane, trimethyl (9-octadecenyloxy)-, (z)-(9z)-9-octadecenyl trimethylsilyl ether with peak area of 0.36% was present in the extract of root and bark and which is reported to possess antibacterial and antioxidant activities (Lukevics, 1978; Nuerxiati *et al*.,

2021). The compound 2-Methyl octacosane was found in the extract of root bark with the peak area of 0.20% and reported to possess antimicrobial, anti-inflammatory, and antifungal properties (Holanda Pinto *et al*., 2008; Akihisa *et al*., 2010; Inbathamizh and Padmini, 2013). In the present study, the compound 3-Ethyl-3-methyl heptanes was found with the peak area of 0.13% which possess antimicrobial, antioxidant, and free radical scavenger properties (Geethalakshmi and Sarada, 2013). The same compound was also reported with the assessment of the antimicrobial and antioxidant activities of *Trianthema decandra* essential oil (Geetha Lakshmi and Sarada, 2013).

The compound Octadecane, 1-chloro with the peak area of 0.10% found in the extract of root bark and Carbonic acid, prop-1-en-2-yl tetradecyl ester with the peak area of 0.03% was determined in the extract of root bark of *Pithecellobium dulce* and reported to possess antimalarial property (Enenebeaku *et al*., 2021). The compound Octyl formate with the peak area of 0.07% was determined which has been reported to possess biological activities as acidifier and formicide (Enenebeaku *et al*., 2021). Many nations employ plants as a source of medicinal substances since they are powerful producers. Numerous therapeutic properties of herbal remedies and their components have been demonstrated (Janakiraman *et al*., 2012). Herbal treatments made from therapeutic plants are secure and reliable and the traditional medicine uses numerous plant species to treat various illnesses.

Conclusion

The results of the present study confirmed the presence of biologically active compounds in the ethanolic extracts of fruit peel and root bark of *Pithecellobium dulce* using GC-MS analysis. The compounds were found in fruit peel and root bark of *Pithecellobium dulce* may contribute to its therapeutic properties. In the future, the separation, purification and their experimental proves on pharmacological activities of the aforementioned compounds might aid in the development of innovative medications for disease treatment.

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Conflict of Interest

The author declares that there are no conflicts of interest regarding the publication of this paper.

References

Akihisa T, Kojima N, Kikuchi T, Yasukawa K, Tokuda H, Masters ET, Manosroi A and Manosroi J. (2010) Anti-inflammatory and chemopreventive effects of triterpene cinnamates and acetates from shea fat. J Oleo Sci. 59(6): 273-280.

Bagchi S and Kumar KJ. (2016) Studies on water soluble polysaccharides from *Pithecellobium dulce* (Roxb.) Benth. seeds. Carbohydr Polym. 138: 215-221.

Biswas SM and Chakraborty N. (2013) Shedded *Artocarpus* leaves-good plant sources of natural squalene with potent antioxidant and antimicrobial activity-alternative to marine animals. J Nat Pharm. 4(1): 21-27.

Blaskovich MA, Hansford KA, Gong Y, Butler MS, Muldoon C, Huang JX, Ramu S, Silva AB, Cheng M, Kavanagh AM and Ziora Z. (2018) Protein-inspired antibiotics active against vancomycin and daptomycin resistant bacteria. Nat Commun. 9(1): 22.

Chopra RN, Nayar SL and Chopra IC. (1956) Glossary of Indian medicinal plants. Council of Scientific and Industrial Research. New Delhi.

Duke JA. (2002) Handbook of medicinal herbs. CRC Press, New York.

El-Khatib SM and Cora EM. (1981) Role of high-fat diet in tumorigenesis in C57BL/1 mice. J Natl Cancer Inst. 66(2): 297-301.

Enenebeaku UE, Duru CE, Mgbemena IC, Ukwandu NC, Nwigwe HC, Enenebeaku CK and Okotcha EN. (2021) Phytochemical evaluation and molecular docking of bioactive compounds from the roots of *Dictyandra arborescens* (Welw.) against *Plasmodium berghei* protein targets. Trop J Nat Prod Res. 5(2): 370-381.

Fatma Nikahat, Kushwaha VB, Srivastav Sunil K, Suzuki Nobuo and Srivastav Ajai K. (2024) Protective effect

of amla (*Emblica officinalis*) fruit pulp extract and selenium on dimethoate induced alterations in biochemical parameters of liver in rats. Intern J Zool Invest. 10(2): 1159-1170.

Geethalakshmi R and Sarada DV. (2013) Evaluation of antimicrobial and antioxidant activity of essential oil of *Trianthema decandra* L. J Pharm Res. 6(1): 101-106.

Hichri F, Jannet HB, Cheriaa J, Jegham S and Mighri Z. (2003) Antibacterial activities of a few prepared derivatives of oleanolic acid and of other natural triterpenic compounds. Comptes Rendus Chimie 6(4): 473-483.

Holanda Pinto SA, Pinto LMS, Cunha GMA, Chaves MH, Santos FA and Rao VS. (2008) Anti-inflammatory effect of α, β-Amyrin, a pentacyclic triterpene from Protium heptaphyllum in rat model of acute periodontitis. Inflammopharmacology 16(2): 48-52.

Inbathamizh L and Padmini E. (2013) *Moringa oleifera* flower compounds as potent ligands to drug targets in PC3 cell lines - an *in silico* analysis. Int J Pharm Pharm Sci. 5: 377-383.

Janakiraman N, Johnson M and Sahaya SS. (2012) GC–MS analysis of bioactive constituents of *Peristrophe bicalyculata* (Retz.) Nees. (Acanthaceae). Asian Pac J Trop Biomed. 2(1): S46-S49.

Johnson W, Bergfeld WF, Belsito DV, Hill RA, Klaassen CD, Liebler DC, Marks JG, Shank RC, Slaga TJ, Snyder PW and Gill LJ. (2022) Safety assessment of *Rosa canina* - derived ingredients as used in cosmetics. Int J Toxicol. 41(1): 44S-60S.

Kalaivani CS, Sathish SS, Janakiraman N and Johnson M. (2012) GC-MS studies on *Andrographis paniculata* (Burm. f.) Wall. ex Nees - a medicinally important plant. Int J Med Aromatic Plants 2(1): 69-74.

Kanjana M, Kanimozhi G, Udayakumar R and Panneerselvam A. (2019) GC-MS analysis of bioactive compounds of endophytic fungi *Chaetomium globosum*, *Cladosporium tenuissimum* and *Penicillium janthinellum*. J Biomed Pharm Sci. 2(1): 1-10.

Katekhaye SD and Kale MS. (2012) Antioxidant and free radical scavenging activity of *Pithecellobium dulce* (Roxb.) Benth wood bark and leaves. Free Radicals Antioxidants 2(3): 47-57.

Kohn A, Gitelman J and Inbar M. (1980) Unsaturated free fatty acids inactivate animal enveloped viruses. Arch Virol. 66(4): 301-307.

Kumar V, Singh D, Kumar P, Chaudhary G, Singh AP and Gupta R. (2022) Turn-on fluorescent detection of nickel and zinc ions by two related chemosensors containing naphthalimide ring (s). J Mol Struct. 1261: 132901.

Lewis K and Ausubel FM. (2006) Prospects for plant-derived antibacterials. Nat Biotechnol. 24(12): 1504-1507.

Lukevics E. (1978) Biological activity of nitrogen-containing organosilicon compounds. In: Biochemistry of Silicon and Related Problems, Springer, Boston, MA, pp. 435-445.

Mahesh B and Satish S. (2008) Antimicrobial activity of some important medicinal plants against plant and human pathogens. World J Agricult Sci. 4(5): 839-843.

Megala J and Geetha A. (2010) Gastro protective and antioxidant effects of hydro alcoholic fruit extract of *Pithecellobium dulce* on ethanol induced gastric ulcer in rats. Pharmacol Online 2: 353-372.

Mehdi MA, Alawi AH, Thabet AZ, Alarabi F, Omar GM and Pradhan V. (2021) Analysis of bioactive chemical compounds of leaves extracts from *Tamarindus indica* using FT-IR and GC-MS spectroscopy. Asian J Res Biochem. 8(1): 22-34.

Merlin NJ, Parthasarathy V, Manavalan R and Kumaravel S. (2009) Chemical investigation of aerial parts of *Gmelina asiatica* Linn. by GC-MS. Pharmacogn Res. 1(3): 152-156.

Nasution RO, Fitrah CN, Helwati HI, Murniana AB and Cutchamzurni C. (2018) Antidiabetes activities extract hexane from the peels of *Artocarpus camansi* Blanco fruit. Asian J Pharm Clin Res. 11(13): 12-17.

Nigam SK, Gopal M, Uddin R, Yoshikawa K, Kawamoto M, Arihara S and Pithedulosides AG. (1997) Oleanane glycosides from *Pithecellobium dulce*. Phytochemistry 44(7): 1329-1334.

Nuerxiati R, Wubulikasimu A, Mukhamedov N, Mirzaakhmedov SY, Gao Y, Aisa H and Yili A. (2021) Biological activity of fatty acids from lipids of *Orchis chusua*. Chem Nat Compd. 57(2): 1-4.

Olivares-Pérez J, Avilés-Nova F, Albarrán-Portillo B, Castelán-Ortega OA and Rojas-Hernández S. (2013) Nutritional quality of *Pithecellobium dulce* and *Acacia cochliacantha* fruits, and its evaluation in goats. Livestock Sci. 154(1-3): 74-81.

Pakutharivu T, Anitha A, Usha V, Sharmila S and Chitra S. (2015) Cardioprotective activity of *Pithecellobium dulce* fruit peel on isoproterenol-induced myocardial infarction in rats. Int J Pharm Sci. 30(1): 133-136.

Pal PB, Pal S, Manna P and Sil PC. (2012) Traditional extract of *Pithecellobium dulce* fruits protects mice against CCl_4 induced renal oxidative impairments and necrotic cell death. Pathophysiology 9(2): 101-114.

Parinitha Mahishi PM, Srinivasa BH and Shivanna MB. (2005) Medicinal plant wealth of local communities

in some villages in Shimoga District of Karnataka, India. J Ethnopharmacol. 98(3): 307-312.

Pradeepa S, Subramanian S and Kaviyarasan V. (2014) Evaluation of antimicrobial activity of *Pithecellobium dulce* pod pulp extract. Asian J Pharm Clin Res. 7(1): 32-37.

Preethi S and Saral M. (2016) Screening of natural polysaccharides extracted from the fruits of *Pithecellobium dulce* as a pharmaceutical adjuvant. Int J Biol Macromol. 92: 347-356.

Priyadarshini E and Tulpule PG. (1980) Effect of free fatty acids on aflatoxin production in a synthetic medium. Food Cosmet Toxicol. 18(4): 367-369.

Rao Archana, Upadhyay RK, Srivastav Sunil K, Suzuki N and Srivastav Ajai K. (2024) Protective effects of amla (*Emblica officinalis*) fruit pulp extract and selenium against dimethoate induced nephrotoxicity in Wistar Rats. Intern J Zool Invest. 10(1): 1104-1113.

Roy RN. (2020) Bioactive natural derivatives of phthalate ester. Crit Rev Biotechnol. 40(7): 913-929.

Sansevere ME and White JD. (2021) Quality assessment of online complementary and alternative medicine information resources relevant to cancer. Integr Cancer Ther. 20: 15347354211066081.

Shanmugakumar SD, Amerjothy S and Balakrishna K. (2006) Pharmacognostical, antibacterial and antifungal potentials of the leaf extracts of *Pithecellobium dulce* Benth. Pharmacogn Mag. 2(7): 163-167.

Singh M, Khatoon S, Singh S, Kumar V, Rawat AK and Mehrotra S. (2010) Antimicrobial screening of ethnobotanically important stem bark of medicinal plants. Pharmacogn Res. 2(4): 254.

Sium M, Kareru P, Kiage-Mokua B, Sood K, Langley J and Herniman J. (2017) *In vitro* anti-diabetic activities and phytochemical analysis of bioactive fractions present in *Meriandra dianthera*, *Aloe camperi* and a Polyherb. Am J Plant Sci. 8(3): 533-548.

Soumya T, Lakshmipriya T, Klika KD, Jayasree PR and Manish Kumar PR. (2021) Anticancer potential of rhizome extract and a labdane diterpenoid from *Curcuma mutabilis* plant endemic to Western Ghats of India. Sci Rep. 11(1): 552.

Srivastava Akansha, Upadhyay RK, Srivastav Sunil K, Suzuki Nobuo and Srivastav Ajai K. (2024) Protective effects of jamun (*Syzygium cumini*) seed and orange (*Citrus sinensis*) peel extracts against cadmium - induced nephrotoxicity in rats. Intern J Zool Invest. 10(2): 1149-1158.

Sugumaran M, Vetrichelvan T and Quine SD. (2008) Locomotor activity of leaf extracts of *Pithecellobium dulce* Benth. Ethnobotanical Leaflets 12: 490-493.

Sukantha TA and Sripathi SK. (2015) Isolation and characterization of secondary metabolites from *Pithecellobium dulce* Benth fruit peel. Int J Pharm Pharm Sci. 7(11): 199-203.

Tyagi T and Agarwal M. (2017) Phytochemical screening and GC-MS analysis of bioactive constituents in the ethanolic extract of *Pistia stratiotes* L. and *Eichhornia crassipes* (Mart.) Solms. J Pharmacogn Phytochem. 6(1): 195-206.

Ucar E, Atas M, Cilesiz Y, Cinbilgel I, Eruygur N and Karakoy T. (2021) Variation of bioactivities and phytochemical compositions of *Valeriana dioscoridis* Sm. extracts. KSU J Agric Nat. 24(4): 738-746.

Usha Nandhini S, Sangareshwari S and Kumari L. (2015) Gas chromatography–mass spectrometry analysis of bioactive constituents from the marine Streptomyces. Asian J Pharm Clin Res. 8(2): 244-246.

Yadav Ram Prataap, Srivastav Sunil K, Suzuki Nobuo and Srivastav Ajai K. (2024a) Toxic effects of cadmium on liver biomarkers in Wistar rats (*Rattus norvegicus*): protective effects of jamun (*Syzygium cumini*) seed and orange (*Citrus sinensis*) peel extracts. European J Biol Res. 14(3): 87-96.

Yadav Ram Prataap, Srivastav Sunil K, Suzuki Nobuo and Srivastav Ajai K. (2024b) Protective effect of jamun (*Syzygium cumini*) seed and orange (*Citrus sinensis*) peel extracts against lead-induced alteration in liver biomarkers of rats.. Intern J Zool Invest. 10(1): 242-252.

Yadav R.P., Srivastav Sunil K., Suzuki N and Srivastav Ajai K. (2025) Jamun (*Syzygium cumini*) seed and orange (*Citrus sinensis*) peel extracts ameliorates toxic effects of lead on kidney biomarkers in rats. Acta Scientiarum Anim Sci. 47: E70282.

Yayli N, Gulec C, Ucuncu O, Yasar A, Ulker S, Coşkunçelebi K and Terzioglu S. (2006) Composition and antimicrobial activities of volatile components of *Minuartia meyeri*. Turk J Chem. 30(1): 71-76.

Yoshikawa K, Suzaki Y, Tanaka M, Arihara S and Nigam SK. (1997) Three acylated saponins and a related compound from *Pithecellobium dulce*. J Nat Prod. 60(12): 1269-1274.

Zakaria M. (1991) Isolation and characterization of active compounds from medicinal plants. Asia Pacific J Pharmacol. 6: 15-20.