ISSN: 2249- 5746
International Journal of Ayurvedic and Herbal Medicine 15:6 (2025) 5390-5400
Journal homepage: http://www.interscience.org.uk
DOI: 10.47191/ijahm/v15i6.27
Impact Factor: 8.254

Pharmacognostic, Phytochemical and Pharmacological Profile of Karañja [*Pongamia pinnata* (L.) Pierre] Leaf.

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ABSTRACT

Background: Pongamia pinnata (L.) Pierre, commonly known as Karañja, is a well-documented medicinal plant in traditional systems such as Ayurveda, Siddha, and folk medicine. While the seeds and oil have been extensively explored, increasing scientific attention is being directed toward the leaves due to their rich phytochemical profile and broad pharmacological potential. This review compiles and critically analyzes available literature on the botany, phytochemistry, traditional uses, and experimentally validated biological activities of P. pinnata leaves.

Materials and methods: Journals, articles and various internet publications were referred to compile the relevant information of Pongamia pinnata (L.) Pierre**.**

Result and discussion: Most literature reports indicate that *Pongamia pinnata* (L.) Pierre exhibits a wide range of pharmacological activities, including anti-inflammatory, antimicrobial, antioxidant, anticancer, hepatoprotective, and wound-healing effects. However, well-designed clinical studies are still required to substantiate its therapeutic potential and its role in improving patient quality of life. This review systematically compiles and critically evaluates existing information on the botany, phytochemistry, traditional applications, and experimentally validated biological activities of *P. pinnata* leaves. The findings highlight the need for continued research to elucidate precise molecular mechanisms, and suggest that comprehensive future studies may facilitate the development of safe and effective therapeutic applications in modern medicine.

KEYWORDS: Pongamia pinnata; Karañja; phytochemistry; pharmacological activities

INTRODUCTION

Karañja (*Pongamia pinnata* (L.) Pierre) is a well-known and extensively utilized medicinal plant in Ayurvedic medicine, valued for its wide spectrum of therapeutic applications. It belongs to the family Fabaceae and is commonly referred to as Karanja in Hindi and Indian beech in English. The genus name *Pongamia* is derived from the Tamil term *pinnata*, denoting the characteristic pinnate nature of its leaves. Owing to its long history of use in traditional systems of medicine, Karañja holds an important place in classical Ayurvedic texts for the management of various disorders, including inflammatory conditions, skin diseases, metabolic disorders, and chronic ailments.

P. pinnata is a medium-sized, fast-growing leguminous tree that is widely distributed throughout the Indian subcontinent, thriving in diverse climatic and soil conditions. The tree bears imparipinnate leaves that are

glossy, leathery, and available abundantly throughout the year, making them a sustainable and renewable source of medicinal raw material. From a pharmacotherapeutic standpoint, the leaves are particularly advantageous as they are associated with comparatively lower toxicity than seeds and are easier to process and formulate into various dosage forms. These attributes make *P. pinnata* leaves especially suitable for prolonged administration and for use in chronic disease management.

In recent years, increasing scientific interest has focused on validating the traditional claims associated with Karañja through phytochemical and pharmacological investigations. The leaves have been reported to contain diverse bioactive constituents, including flavonoids, phenolic compounds, and other secondary metabolites, which contribute to their wide-ranging biological activities. Consequently, *P. pinnata* leaves represent a promising plant resource for the development of safe, effective, and evidence-based herbal therapeutics, bridging traditional Ayurvedic knowledge with modern biomedical research.

Distribution

Throughout India, in tidal and beach forests; cultivated often as avenue trees. [1] This tree is found all over India, up to an altitude of 1200m. Commonly found in the coasts of South India and also found in river banks, Central eastern Himalayas and its foothills. [2]

Morphological characters[1, 2]

It is a medium-sized glabrous almost evergreen tree, growing up to 18m height and 1.5m in girth.

Bark: greyish green or brown bark that is frequently speckled with dark brown spots, specks, lines, or streaks.

Leaves: The plant has compound leaves with oblong, acuminate, or elliptic leaflets 5-7 and imparipinnate. Individual leaf measures about 8-10 inch long, pale green, subcoriaceous, midrib and lateral nerves rather prominent beneath.

Flowers: fragrant, lilac or pinkish white flowers in axillary racemes.

Fruit: Pod, thick, woody, smooth, compressed fruits with a short, curved beak. one or two seeds per pod.

Seeds: 1-2, elliptic or reniform, wrinkled, white, marbled with brownish lines and a reddish brown testa.

1. Pharmacognostical study

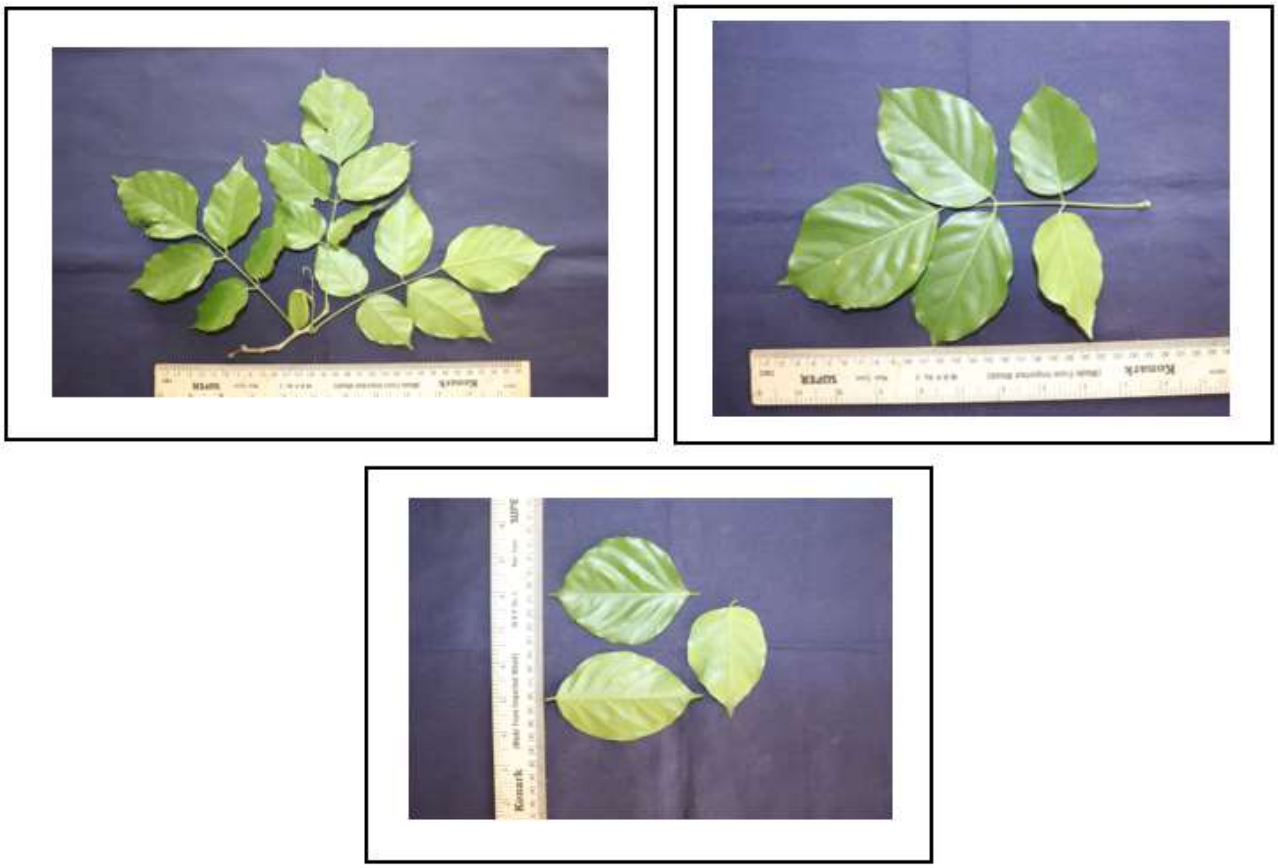
A) Organoleptic evaluation

Fresh leaves were dark green appearance, dried pale greyish green; Odour – Not specific; Taste- Less bitter

B) Macroscopy of Karañja [*Pongamia pinnata* (L.) Pierre]

The leaf and petiole of the plant were used for the study. Macroscopic features of leaves were: - 8-10inch long, pale green, imparipinnate; leaflets 5-7, oblong or ovate, obtuse or shortly acuminate, 2-4-inch-long, sub coriaceous, midrib and lateral nerves rather prominent beneath.

Figure No: 1 Macroscopy of leaf of Karañja [*Pongamia pinnata* (L.) Pierre]



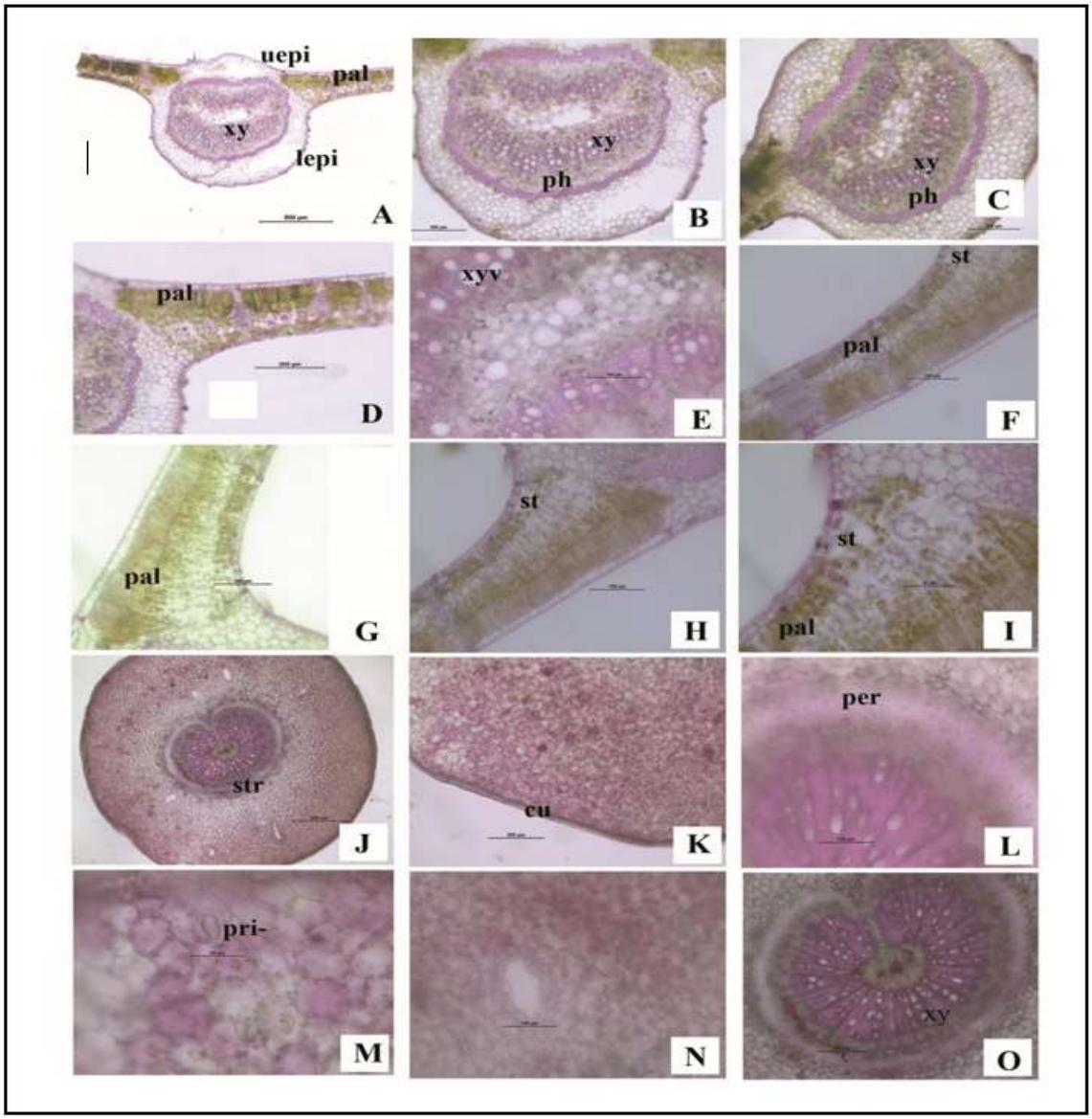
C) Microscopy of *Karañja* [*Pongamia pinnata* (L.) Pierre]

Leaf- Mid rib of the leaf have single layered epidermis of tabular cells covered with thick cuticle. cortex consists of round to oval, thin-walled parenchymatous cells; pericycle present in the form of sclerenchymatous sheath. Vascular bundles are conjoint, collateral and arranged in discontinuous ring. prismatic crystals of calcium oxalate present in cortex, phloem and pith.

Lamina shows single layered Epidermis covered with thick cuticle.Palisade is two layered, spongy parenchyma 3-5 layered. Prismatic crystals seen similar to midrib. Stomata present in lower surface.

Petiole shows circular in outline,single layered epidermis covered with cuticle.cortex consist of parenchymatous cells without intercellular spaces, a few cells containing prismatic crystals of calcium oxalate. Single vascular bundle, arc shaped consists of xylem and phloem. a few schizogenous cavities found in cortex

Figure No: 2 Microscopy of leaf and petiole of *Karañja* [*Pongamia pinnata* (L.) Pierre]

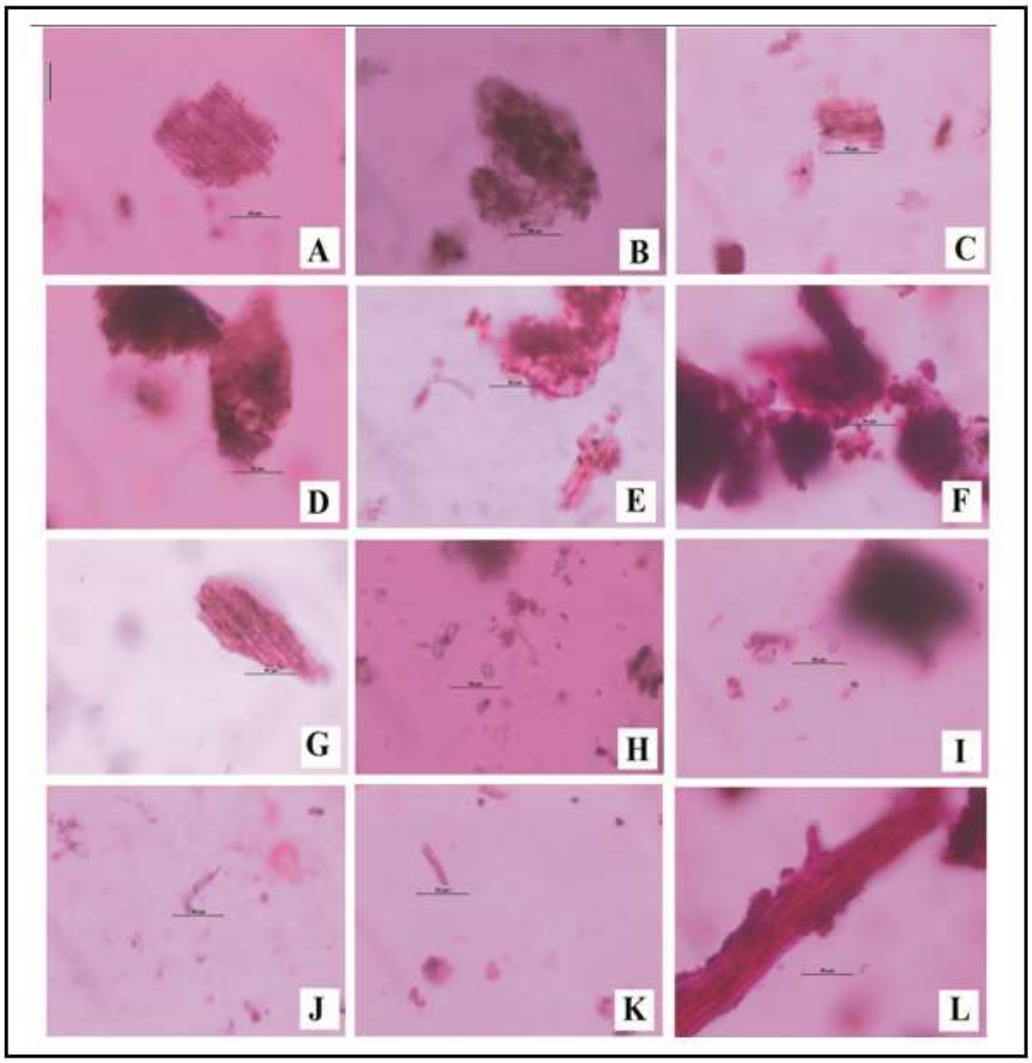


Microscopy of *Pongamia pinnata* Leaf. A. Diagramatic TS of leaf passing through midrib; **B & C.** TS midrib portion enlarged; **D.** TS upper epidermal portion enlarged; **E.** TS stelar portion enlarged;**F & G.** TS lamina portion; **H & I.** TS of lamina showing stomata; **J.** TS of petiole; **K.** Outer portion enlarged; **L.**Enlarged portion of pericycle; **M.** TS showing prismatic crystal of calcium oxalate; **N.** TS of cortex showing schizogenous cavity;**O.** TS of stelar region; cu, cuticle; lepi, lower epidermis; pal, palisade; per, pericycle; ph, phloem; pri, prismatic crystal; st, stomata; str, stelar region; uepi, upper epidermis; xy, xylem; xyv, xylem vessel.

D) Powder microscopy

Powder microscopic features of drug powder showed- Cortical cell fragments, Cork cells in sectional view, Epidermal cells of stem in section, Fibres and vessel fragments, Fragments of pappus hairs, Fragments of pitted vessels, Multicellular trichome, Starch grains, Stone cell, Calcium oxalate crystal etc

Figure No: 3 Powder microscopy of leaf of *Karañja* [*Pongamia pinnata* (L.) Pierre]



Powder Microscopy of *Ponhgamia pinnata* Leaf. A. Epidermal cell. **B** Parenchyma surface view. **C.** Parenchyma with vascular tissue.**D, E, &F.** Stomata. **G** Parenchyma.**H.** Prismatic crystal.**I.** Starch grain.**J.** Trichome.**K.** Fibre. **L.** Vessel.

Phytochemical investigation

Plants produce a number of primary and secondary metabolites. Secondary metabolites, the majority of which are phenols or their oxygen-substituted derivatives, are produced by metabolic pathways such the malonate/acetate and shikimic acid pathways. The majority of the metabolites provide plants their color, flavor, and scent in addition to their defense against insects and herbivores. Furthermore, a large number of the secondary metabolites that plants produce have medicinal properties.

Numerous plant secondary metabolites were identified as a result of developments in chromatographic and spectral analyses, including nuclear magnetic resonance, infrared, gas chromatography mass spectrometry (GC-MS), high-performance column liquid chromatography, high-performance thin-layer chromatography (HPTLC), and column chromatography. [3, 4, 5]

Preliminary phytochemical analysis

2. Phytochemical analysis

Table No: 1 Quantitative phytochemical analysis of leaf of *Karañja* [*Pongamia pinnata* (L.) Pierre]

SL N0	EXPERIMENTS	PERCENTAGE (%W/W)
1	Total ash	4.7%
2	Water insoluble ash	1.8%
3	Acid insoluble ash	0.35%

Table No: 2 Percentage of water and alcohol soluble leaf extractives

SL NO	NAME OF EXTRACT	PERCENTAGE OF EXTRACT (%W/W)
1	Hot water soluble	96.15%
2	Cold alcohol soluble	4.7%
3	Cold water soluble	3.45%
4	Hot alcohol soluble	2.9%

Table No: 3 Qualitative phytochemical analyses of the leaf extracts

Extracts	steroids	alkaloids	phenols	flavonoids	Tannins	saponins	anthraquinones	glycosides
Aqueous	+	_	_	_	+	_	_	_
Hydroalcoholic	+	_	_	+	+	_	_	_

PHARMACOLOGICAL STUDIES

According to pharmacological research, this plant exhibited a wide variety of biological properties. Numerous biological actions, including cytotoxicity, anthelminthic, insecticidal, anti-inflammatory, anti-parasite, anti-convulsant, anti-diabetic, antioxidant, and immunomodulatory properties, have been demonstrated for the plant Pongamia pinnata. Numerous traditional medical systems have reported using Pongamia Pinnata to treat a variety of human ailments. Pongamia plant components are frequently used in Siddha and Ayurvedic Indian medicinal techniques. Pongamia pinnata has a wide range of pharmacological characteristics. First, Plasmodium falciparum-caused malaria can be effectively treated with P. pinnata due to its anti-Plasmodial properties. Secondly, the Pongam tree's leaves have anti-inflammatory and anti-diarrheal properties; additionally, the leaf extracts are antioxidants. Pongamia shields the body from aspirin damage, preventing ulcers. Additionally, it might offer a safer anti-hyperglycemic medication to diabetic patients. Pongamia pinnata roots are effective in preventing gonorrhea, strengthening gums, and cleaning teeth. [6]

1.Toxicity studies

According to the findings of multiple toxicity investigations, extracts and individual chemicals that were separated from this species did not exhibit any appreciable toxicity or result in abnormalities on certain rat organs. Because of its minimal toxicity to mammalian cells, this plant may therefore be employed as an efficient therapeutic cure. Pongamol's biological effects and current toxicological research indicate that it is safe to undergo long-term toxicological research and clinical trials. [7]

2. Anti-Inflammatory Activity [8]

According to Srinivasan et al. (2001), a 70% ethanolic extract of Pongamia pinnata leaf shown anti-inflammatory action against the acute, sub-acute, and chronic phases of inflammation.

3.Anti-microbial Activity [9]

P. pinnata's crude leaf extract's antimicrobial activity assesses how it affects enterotoxin generation and activity. Its extraction possesses antibacterial, antigiardia, and antirotaviral properties, but it also lessens bacterial penetration of epithelial cells and cholera toxin synthesis. This suggests that Pongamia pinnata extract has a specific anti-diarrheal effect that is effective against cholera (Brijesh et al. 2006).

4.Anti-oxidant Activity [10]

Extracts from P. pinnata leaves exhibit antioxidant action and vascular lipid peroxidation.It has been tested in rats with hyperammonium caused by ammonium chloride. In rats given ammonium chloride, this increased lipid peroxidation in the blood led to a marked drop in vitamin A, C, and E levels, which in turn decreased catalase glutathione, glutathione peroxides, and superoxide dismutase (Essa and Subrahmanian, 2006).

5. Anti diabetic Activity [11]

Alloxan-induced diabetic albino rats were used to test the antidiabetic effects of Pongamia pinnata (Family: Leguminosae) leaf extracts. The effects of various P. pinnata extracts and the well-known antidiabetic medication glibenclamide (600 µg/kg b. wt.) were compared. Additionally, experimental diabetic rats were given an oral glucose tolerance test (OGTT). The medication may have an antidiabetic effect.

6.Anti-tumour Activity

According to these investigations, P. pinnata possesses the qualities necessary to be used as a therapeutic agent to treat skin cancers. Drug discovery is predicted by the molecular simulation studies technique, which serves as a foundation for evaluating anti-cancer effectiveness against skin tumors. Therefore, it may be a good source of crude medication for melanomas. [12]

In this work, Plumbagin, a plant-derived polyphenol with demonstrated anticancer action, was compared to two furanoflavanoid derivatives, Pongapin and Karanjin, to assess their antitumor activity. The chemicals have a very low inhibitory effect on the growth of normal mouse embryonic fibroblast cell lines, but they variably impede the growth of several cancer cell lines, with HeLa cells being the most effective. [13]

7.Anti-bacterial Activity [14]

The purpose of this study was to evaluate the antibacterial potential of several organic extracts made from Pongamia pinnata (L.) Pierre (Fabaceae) leaves against a few representative food-borne pathogenic and spoilage bacteria. At a concentration of 2500 µg/mL, the organic extracts of methanol, ethyl acetate, and chloroform demonstrated a promising antibacterial effect against Salmonella typhimurium ATCC2512, Pseudomonas aeruginosa ATCC6432, Bacillus subtilis ATCC6633, Staphylococcus aureus ATCC6538, Listeria monocytogenes ATCC19118, and L. monocytogenes ATCC19166.

Pongamia pinnata leaves possess significant pharmacological potential supported by traditional knowledge and modern scientific evidence. Their rich phytochemical composition underlies a wide range of biological activities, particularly antioxidant, anti-inflammatory, antimicrobial, and anticancer effects. With rigorous validation and standardization, P. pinnata leaves may emerge as valuable candidates for integrative and evidence-based herbal therapeutics.

Ayurvedic aspects

Almost all Āchāryas have described Karañja as possessing Tikta (bitter), Katu (pungent), and Kaṣāya (astringent) Rasa, Laghu (light) and Tīkṣṇa (sharp) Guṇa, Uṣṇa (hot) Vīrya, and Katu Vipāka. Owing to this pharmacodynamic profile, Karañja effectively pacifies Vāta and Kapha Doṣas. *Bhāvaprakāśa Nighaṇṭu* specifically highlights the

therapeutic attributes of Pongamia pinnata leaves, describing them as Kaphavātahara (alleviating Kapha and Vāta), Arśahara (beneficial in piles), Kṛmihara (anthelmintic), Śothahara (anti-inflammatory), Bhedana (mild purgative, relieving constipation), and Pittala, indicating a tendency to enhance Pitta.[15]

Amayika prayogas

1. **कासीसं नक्तमालस्य पल्लवांश्चैव संहरेत् ||**
   कापित्थारसपिष्टानि रोमसञ्जननं परम् ||[16]
   Kasis and tender leaves of Karanja pounded with the juice of Kapitha is useful in Romasanjanan.
2. **पिबेत् यवगूमथवा सिदधां पत्रै: करञ्जै:|** [17]
   Yavagu prepared along with Kwath of leaves of Karanja is administered for all types of Chardi.
3. **प्राग्भक्तान् यमके भृषटान् सक्थुभिश्चावचूर्णितान् |**
   करञ्जपल्लवान् खादेत्वातवर्चोंनुलोमनान् || [18]
   Tender leaves of Karanja fried in the mixture of oil and Ghruta and added with parched grain flour should be given. It acts as carminative and laxative.

DISCUSSION

The pharmacognostical evaluation of Karañja [*Pongamia pinnata* (L.) Pierre] establishes a reliable framework for its correct identification and standardization. Detailed macroscopic, microscopic, and powder microscopic characteristics collectively confirmed the authenticity of the plant material in accordance with API standards. Such comprehensive pharmacognostic profiling is crucial in distinguishing genuine raw drugs from substitutes or adulterants, particularly for widely used medicinal plants like *P. pinnata*. The observed diagnostic features of the leaf and petiole reinforce earlier descriptions and support the use of these parameters as dependable quality-control tools in herbal drug research and industry.

Physicochemical analysis further substantiated the purity and quality of the drug. The comparatively low total ash value (4.7%), along with minimal water-insoluble (1.8%) and acid-insoluble ash (0.35%). These relatively modest ash values suggest minimal inorganic contamination and high purity of the drug samples. Such findings are supported by several studies. In investigations of crude herbal remedies in Northern Nigeria, total ash values ranged widely (3.9–43.9%), and most samples remained within acceptable limits, reinforcing that values near the lower end indicate good quality and low adulteration risk. [19] Similarly, Trianthema portulacastrum a medicinal plant evaluated for its physicochemical properties exhibited total ash values between approximately 9.6% and 15.5%, water-soluble ash ranging from ~7.5% to 9.4%, and acid-insoluble ash between ~0.9% and 4.2%. The authors emphasized that lower proportions of acid-insoluble ash reflect minimal siliceous contamination, underscoring both purity and quality. [20] By comparing these data with our findings, the low acid-insoluble ash (0.35%) in the current study particularly illustrates negligible sand or earthy impurities, affirming the authenticity and high quality of the drug material.

Extractive values were also determined. These are primarily useful for the determination of exhausted or adulterated drugs. The water soluble and alcohol soluble extractive values were determined. Water soluble extracts of the drug mainly represent the percentage of organic constituents such as tannins, sugars, plant acids, mucilage and glycosides. As water is a universal solvent, the maximum percentage (hot water soluble-96.15% and cold water soluble-3.45%) of extract was found in it. Alcohol soluble extracts (cold alcohol – 4.7% and hot alcohol- 2.9%) mainly represent the percentage of organic constituents such as alkaloids, phenols, flavonoids, steroids and sugars present in the drug.

The extraction profile of *Pongamia pinnata* revealed a markedly higher hot-water extractive value (96.15%) compared to cold water (3.45%), indicating the strong influence of temperature in liberating hydrophilic

constituents such as sugars, glycosides, and polysaccharides, a trend consistent with pharmacogenetic studies where heat enhances solubility and disrupts plant matrices to maximize yield. [21] In contrast, the cold-alcohol extractive value (4.7%) exceeded that of hot alcohol (2.9%), suggesting that certain alcohol-soluble compounds likely phenolics, flavonoids, or other thermolabile constituents may undergo degradation or volatilization upon heating, thereby reducing yield. Such patterns are in line with general extraction principles reported for other medicinal plants, where aqueous systems show pronounced heat-dependent increases in extractability, while alcoholic extractions require careful temperature optimization to preserve compound stability. [22] This suggests that hot-water extraction is optimal for recovering polar bioactives from *P. pinnata*, whereas moderate-temperature alcohol extraction or mixed solvent systems may be preferable for alcohol-soluble phytoconstituents.

The qualitative phytochemical analysis of *Karañja* [*Pongamia pinnata* (L.) Pierre] leaf extracts revealed the presence of flavonoids exclusively in the hydroalcoholic extract, while tannins and steroids were detected in both aqueous and hydroalcoholic extracts. Alkaloids, phenols, saponins, glycosides, and anthraquinones were absent in both preparations. These observations are consistent with earlier reports, such as the study by Balamurugan and Karthikeyan (2012), which quantified total flavonoids in hydroalcoholic *P. pinnata* leaf extract at 1.398 mg/100 mg, underscoring the efficiency of this solvent system in extracting flavonoid constituents.Variations in the phytochemical profile among studies are often attributable to solvent specificity. [23] an acetone-based extraction reported by Bhagavathi et al. (2024) yielded a broader spectrum of metabolites, including saponins, phenolics, glycosides, flavonoids, steroids, and proteins, suggesting that the absence of certain compounds in the present study may reflect differences in polarity and solubility profiles of the solvents used. [24] The superior antioxidant potential of hydroalcoholic extracts, likely linked to their enriched phenolic and flavonoid content, is well established in a study by Mohammad et al. (2012) that significantly higher DPPH radical scavenging activity in aqueous–methanol *P. pinnata* leaf extracts compared to other solvent systems. [25]

CONCLUSION

The present study provides a comprehensive pharmacognostical, physicochemical, and phytochemical evaluation of Karañja [*Pongamia pinnata* (L.) Pierre] leaf, establishing reliable parameters for its identification, authentication, and quality assessment in accordance with API standards. The distinct macroscopic and microscopic features confirmed the genuineness of the plant material, while the low ash values indicated minimal inorganic contamination and high purity. The extractive value profile highlighted hot-water extraction as the most effective method for recovering polar bioactive constituents, whereas hydroalcoholic extraction proved superior for isolating flavonoids and steroids. The qualitative phytochemical findings, supported by earlier studies, underscore the therapeutic relevance of these constituents, particularly in relation to antioxidant and anticancer potential. Collectively, these results validate the quality and pharmacological promise of *Pongamia pinnata* leaves and support their further exploration in standardized herbal formulations and cancer chemopreventive research.

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