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PHARMACOLOGICAL STUDY ON THE PLANT PONGAMIA PINNATA (L.) PIERRE

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Abstract

This study explores the utilization of herbs within the context of current medical trends and approaches. Notably, herbs are observed to provide cost-effective treatment compared to synthetic chemistry, while also causing minimal side effects on the host. Pongamia pinnata, known as 'Karanj' in Hindi, is an herb contributing to traditional medicine, as per Ayurveda and Charaka-Samhita. Widely available in India and several other countries, Pongamia pinnata contains numerous polyphenolic compounds, including flavonoids, polyphenols, and volatile oils. These bioactive alloys predict a crucial part in supportive and preventive care for various conditions.Traditionally, various sections of the plant are utilized for their respective actions, addressing medical conditions such as whooping cough, bronchitis, dyspepsia, leprosy, gonorrhea, rheumatism, and more. The plant extract exhibits a spectrum of activities, including anti-diarrheal, antifungal, antiplasmodial, antiulcer, anti-inflammatory, pain-relieving, blood sugar-lowering, ammonia-reducing, and lipid oxidation-preventing properties, antioxidant, analgesic, and anticancer properties. Additionally, leaves extract demonstrates cardioprotective activity. Observations indicate that flavonoid constituents of the plant manifest hypolipidemic and antihyperlipidemic effects. The ethanolic extract of Pongamia pinnata is noted for its antioxidant and antidiabetic properties, Linked to the presence of flavonoids and active phenols like Pongamol and Karanjin. Furthermore, the oil derived from Pongamia pinnata seeds serves as a source of biodiesel, representing a non-

pollutant and sustainable approach towards environmental conservation. This exploration highlights the therapeutic potential of Pongamia pinnata, emphasizing its diverse pharmacological properties, traditional uses, and modern relevance in medicine and environmental sustainability.

[1] INTRODUCTION

Karanji tree, scientific name- Pongamia pinnata and Family - Fabaceae, Distinctive plant with deep roots in the botanical landscapes of India and surrounding regions. Regional name of this tree by – Karanja , Pongam in Tamilnadu. Geographical spread is remarkable wide area, Around the india of coastal areas and riverbanks, other country like- Myanmar, Southeast Asia, West Pacific region, and North Australia (1).

The Karanja tree (Pongamia pinnata) indeed has a distinctive appearance that makes it stand out. Its moderate height and spreading crown are complemented by lush, pinnate leaves that provide a dense canopy. The twisted trunk adds a touch of rugged charm to its overall structure, while the flowers—delicate, pale purple or pink clusters—add seasonal vibrancy. Karanja tree (P. pinnata) is a species with multiple uses in pharmacological actions and various species of wildlife species. Its oil-rich seeds are used in bio-diesel production, making it an economically valuable plant for energy initiatives. In urban area, its attractive appearance.(2)

P. pinnata contain multiple bioactive compounds with details effective efficacy against various human diseases, and broad spectrum of pharmacological properties of this species of plant. Now a days growing concerns over the side effects, ADRs and complexation of modern pharmaceutical treatments have improved patients and practitioners (HCP) like to reconsider traditional healing methods(Modern pattern of treatment). These approach and process are perceived as more holistic and less prone to adverse effects/ADRs. This process id scientific interest in understanding the mechanisms underlying traditional medicinal(Modern treatment plan) practices. Many studies increase highlight the therapeutic potential of medicinal plants of P. Pinnata, provide valuable insights into their role in various diseases. P. pinnata stands out for its rich sources of phytoconstituents, across various plant parts(Leaves, Flowers, Stem, roots), which improve to pharmacological activities. This comprehensive chemical profile under-scores its potential for inclusion in herbal medicine systems(Modern Treatment Techniques).(3).

[2] TAXONOMY (4)

Plant of P pinnata(Karanzi), belongs to the biological classification system:

Taxonomic Rank	Classification
Plant Kingdom	A vast realm of green, living organisms that encompass everything from tiny mosses to towering trees (Plantea)
Plant Subkingdom	Tracheobionta (Vascular plants with specialized tissue systems for transporting water and nutrients)

Plant Superdivision	Seed-producing plants that can reproduce through seeds (Spermatophyta)
Plant Division	Flowering plants with enclosed seeds and complex reproductive structures (Magnoliophyta)
Plant Class	Dicotyledons, characterized by seeds with two embryonic leaves (Magnoliopsida)
Plant Subclass	A group within the broader dicotyledon classification, specifically the rose-like plants (Rosidae)
Plant Order	Fabales: a group of flowering plants that typically includes legumes
Plant Family	Fabaceae: commonly known as the legume, pea, or bean family
Plant Genus	Pongamia: a specific genus of trees and shrubs
Specific Species	Pinnata, the unique identifying name for this particular plant variety

[3] CHEMISTRY

Plant P. pinnata, known as IndianName- Beech or Karanj, It is a rich and complex chemical composition. Phytochemical profile includes a diverse range of alkaloids like- Demethoxy-kanjeen, Gamatay, Glabrin, Kanugeen, Pinnatin, Pongapin. P. Pinnata is a source of bioactive compounds like Kaempferol, Quercetin, βeta-sitosterol, Saponins, and Tannins(Alkaloidal test).

Chemical analysis of air-dried P. pinnata is a composition of 19% Moisture and 27.5% Fatty oil. O il fraction is rich in the fatty acids, like- Oleic acid - 44.5–71.3%, Linoleic acid at 10.8–18.3%. Other fatty acids likeP palmitic 3.7–7.9%, Stearic Acid 2.4–8.9%, with minor amounts of Lignoceric, Arachidic, Behenic, & Aicosenoic acids.

Kernel composition are protein-17.4%, starch-6.6%, crude fiber-7.3%, & ash-2.4%.

Stem parts of P. pinnata is destructive distillation process, producing a large no. of by products. According to dry weight process, the process yields-charcoal 31%, Pyroligneous acid 36.69%, Organic acids 4.3%, esters 3.4%, acetone 1.9%, methanol 1.1%, tar-9.0%, & residual pitch 4.4%. It generates 0.12 cubic meters of gas/Kg of Stem (5).

[4] PHYTOCHEMISTRY

Scientific species P. pinnata has elaborated a rich and high source of phytochemical profile, through comparative chemical analysis and identification. Characterized and identification of numerous bioactive compounds in Cross multiple molecular classes. The plant part having chemical composition flavonoid-based str, like- flavones, flavones, and chalcones. In this the flavonoid derivatives: the phytochemical of secondary metabolites. Terpene derivatives:- sesquiterpenes to di- and triterpenes, Lipid-based phytochemical: like Fatty acids and corresponding esters, Steroidal molecules. Nitrogenous components: Amino acid derivatives, Carbohydrate phytoconstituents: specific disaccharide.(6).

The plant part leaves of P. pinnata are various phytoconstituents, including- alkaloids,

carbohydrates, flavonoids(kaempferol, quercetin, and rutin, tannins, saponins, phytosterols). The plant seeds of PP contain a complex of phytochemical constituents, compounds such as Karangin and Kaempferol. This rich chemical compound with significant biochemical diversity, Additionally the nutritional and pharmacological value of seeds. The potential in a wide range of applicationsin pharmacological actions, from traditional medicine to modern therapeutic and nutritional uses.

Table-1: of chemical analysis of the bark/stem components:

COMPONENT	DEATAILS
Resins	Present in the bark
Bitter Alkaloids	Present in the bark
Sugar	Present in the bark
Mucilages	Present in the bark
Flavone Compounds	3-methoxy-(3,4-dihydro 3-hydroxy-4-acetoxy)-2,2-dimethylpyrano-(7,8:5,6)-flavone, 3-methoxy-(3,4-dihydro 4-hydroxy-3-acetoxy)-2,2-dimethylpyrano-(7,8:5,6)-flavone
Other Flavone Compounds	Ovaliflavonone A, Isolonchocaprin, Dimethylallylflavonone, Caryophyllene oxide, Obovatachalcone

[5] THERAPEUTIC APPLICATIONS BASED ON DISTINCT PLANT COMPONENTS (7)

Leaves: The medicinal compounds found in the leaves of Pongamia pinnata exhibit a wide range of therapeutic properties, offering natural remedies for gastrointestinal issues, parasitic infections, and various infectious diseases. They having pharmacological actions on anti-inflammatory and anti-pyretic effects.

Flowers: Ethanolic extracts of flowers of Pongamia pinnata is significant use of health benefits, as anti-hyper-ammonemic, anti-oxidant, antibleeding piles, and antihyperglycemic effects. Flowers extract shows as anti-lipid-peroxidative actions.

Oil: Oil extracted from by Clevenger method of extraction, Seeds is broad spectrum of medicinal properties, like as antileprotic, antiulcer, relief from liver pain, stomach cramps and pains, treatment of piles pain and bleeding, Rheumatoid arthritis, Scabies infections, saviors Chronic fever, and Whooping cough. Therapeutical action additionally is antifungal, antibacterial, and antihelminthic activities.

Fruits: Fruits are ethanolic extracts from uses of against Female genital tract diseases, Leprosy, Genetic piles pain and bleeding and related to tumors, ulcers, antifilarial effects, and treatment of abdominal tumors.

Seeds: Extracted seeds having remarkable therapeutic properties. Used as potential relief and support for health conditions, respiratory challenges like bronchitis and whooping cough, inflammatory responses, cognitive function, rheumatoid artheritis and joint discomfort,

additionally CVS, such as high BP, skin health, fever, providing relief from hemorrhoidal issues, blood health in anemic conditions, and respiratory system disease.

Roots: Root extract of the plant is used asantinociceptive and antihelminthic activities. Effectiveness against vaginal infections, skin diseases, and Gonorrhea.

Stem: Extracts from the stem display anti-pyretic activity, along with CNS sedation effects.

Bark: Extracts from the bark of Pongamia pinnata are known for their effectiveness in treating conditions such as edema in the spleen, central nervous system disorders, hemorrhoids, Beriberi, and cough and cold.

[6] BIOLOGICAL AND PHARMACOLOGICAL PROPERTIES

Pongamia pinnata has emerged as a remarkable medicinal plant, attracting significant scientific interest due to its wide range of potential therapeutic applications. Extensive research has revealed its impressive biological properties, including protection against oxidative stress, antimicrobial defense, anti-parasitic actions, anti-inflammatory effects, neurological protection, metabolic regulation, ammonia level management, potential cancer-fighting properties, anti-worm activity, and natural insecticidal qualities. Below is a concise summary of the key findings from these studies:

1. Antihyperglycemic and antilipidoperoxidative

Ethanol extract of Pingomia pinnata flowers was found active against high blood sugar content and lipid peroxidation. Alloxan was used to induce diabetes in rats. Oral administration of the ethanolic extract derived from Pongamia pinnata flowers at a dosage of 300 mg/kg exhibited adverse effects on both blood sugar levels and lipid peroxidation. It also possesses decrement in the activity of oxidative stress markers. As a resultant, the ethanolic flower extract of P. pinnata shows marked antidiabetic, antilipidoperoxidative and antioxidant activity.(8)

2. Anti-inflammatory activity

The researcher found that 70% ethanol extraction of leaves was efficacious in rats, which giving rise to possible anti-inflammatory activity without any ulceration of plant leaves.9

Albino rats were employed as test subjects to assess the anti-inflammatory effectiveness of the stem bark extract in both acute and chronic inflammatory scenarios. This experimental approach aimed to evaluate the extract's ability to mitigate inflammation during distinct and sustained inflammatory episodes in the albino rat model. Oral administration with the doses of 400 & 800 mg/kg were effective in both types of carrageenan-induced rear mitt edema and constant inflammation.10

3. Antiviral property

The extract obtained from the coarse seeds of Pongamia pinnata reveals potent inhibitory capabilities against herpes simplex virus types A and B, demonstrating substantial viral suppression at 1 and 20 mg/ml concentrations. Moreover, a specific compound, Bis (2-methylheptyl) phthalate, extracted from P. pinnata leaf extract, shows remarkable antiviral efficacy targeting the White Spot Syndrome Virus affecting Penaeus monodon Fabricius. These research outcomes underscore the promising antiviral potential of Pongamia pinnata extracts, indicating their possible therapeutic applications in combating herpes simplex viral infections

and White Spot Syndrome Virus.11

4. Biofuel Management

The seeds oil of P. pinnata is also used as a biofuel from last so many decades. Biofuels has clear emission properties than the other petroleum diesel. It produces less poisonous substances. Biofuels generated by the plants, decrease in sulphur substance (350ppm) and cetane value of 51 must be needed. Biofuels may increase the flashpoint (3500C to 5500C) requirement, which is not possible with traditional petroleum diesel.12

5. Anti-inflammatory properties

Kage et al. reported that the utilization of karanjachrome, extracted from the seed oil of the Pongamia pinnata plant, serves as a robust inhibitor of paw edema across all stages of inflammation. This compound effectively suppresses the release of inflammatory mediators throughout the various phases of inflammation. Furthermore, it demonstrates inhibitory effects on acetic acid-induced writhing response by modulating peritoneal mast cells, sensing ion channels, and the prostaglandin pathways. Karanjachrome showcases noteworthy anti-inflammatory and analgesic properties, displaying efficacy against both peripheral and central pain and inflammation. These findings underscore the potential therapeutic value of karanjachrome in mitigating inflammatory responses.13

6. Antioxidant and anti-bacterial properties

Here is a summarized overview of the research findings:

1. Sorna Kumar et al. Study:
   - Flower extracts of Pongamia pinnata exhibit potent antioxidant properties.
   - Seed extracts show effectiveness against microbial growth, specifically active against Brucella melitensis and P. fluorescens.
2. Deshmukh et al. Research:
   - Investigated antibacterial properties of various seed extracts using different solvents (aqueous, chloroform, ethanol, methanol, and petroleum ether).
   - Ethanolic extract showed the most significant antimicrobial activity, especially against Salmonella typhi.
   - Other extracts, like methanol, chloroform, and aqueous, showed moderate antimicrobial potential, while petroleum ether extracts had limited antibacterial effects.
   - The seed extracts contained bioactive compounds such as alkaloids, flavonoids, steroids, phenols, and proteins with antibacterial properties.
3. Bajpai et al. Study:
   - Focused on the antibacterial properties of leaf extracts against food-borne bacterial strains.
   - Chloroform, ethyl acetate, and methanol extracts at 2500 µg/mL showed significant antimicrobial activity.
   - The extracts inhibited bacterial strains such as Bacillus subtilis, Staphylococcus aureus, Listeria monocytogenes, Pseudomonas aeruginosa, and Salmonella typhimurium.
   - MIC values ranged from 125 to 1000 µg/mL, comparable to the standard

antibiotic streptomycin.

- Suggests potential use in food safety and preservation.

4. Sajid et al. Research:
   - Investigated various solvent extracts from the bark, leaves, and seeds.
   - The aqueous methanol bark extract performed exceptionally well, containing higher concentrations of phenolic and flavonoid compounds.
   - The bark extract showed strong antioxidant activity and antimicrobial properties, with large inhibition zones and low MIC values.
   - HPLC analysis identified key phenolic acids: protocatechuic, ellagic, ferulic, gallic, gentisic, 4-hydroxybenzoic, and 4-hydroxycinnamic acids in the bark; sorbic, ferulic, gallic, salicylic, and p-coumaric acids in the leaves; and vanillic, gallic, and tannic acids in the seeds.
   - Highlights the plant's chemical diversity and its potential for pharmaceutical, nutraceutical, and antimicrobial applications.17.

7. Antimicrobial activity

Shirsat et al. reported that the seeds of Pongamia pinnata serve as a rich reservoir of secondary metabolites, as evidenced by High-Performance Thin-Layer Chromatography (HPTLC) profiling revealing distinct bands corresponding to various biomolecules. Additionally, plant callus emerges as an alternative source for the synthesis of secondary metabolites. Results from the studies indicate that methanolic extracts obtained from both seeds and callus exhibit substantial inhibition zones against E. coli bacterial colonies. These findings highlight the potential of Pongamia pinnata as a valuable natural resource for secondary metabolite extraction with promising antimicrobial properties. 18

8. Synergistic effect with Antibiotics

Research conducted by Po-An Su and colleagues revealed remarkable antibacterial potential within the aqueous extract obtained from Pongamia pinnata seed coats. The study demonstrated significant synergistic interactions between the seed coat extract and multiple antibiotics when targeting methicillin-resistant Staphylococcus aureus (MRSA).

Upon investigating combinations with antibiotics such as ampicillin, meropenem, cefazolin, cefotaxime, cefpirome, and cefuroxime at varying concentrations between 70% and 100%, the researchers observed highly promising synergistic outcomes. These interactions were scientifically quantified through a fractional inhibitory concentration (FIC) index consistently measuring below 0.5, indicating robust cooperative antimicrobial effects.

Employing the time-kill methodology and utilizing 0.5 × minimum inhibitory concentrations of the extract alongside different antibiotic concentrations (8, 4, 2, and 1 μg mL−1), the team discovered that nearly all combinations produced synergistic results. Notably, aztreonam stood as the sole exception, while critically, no antagonistic interactions were detected across the experimental parameters.

The research ultimately highlights the seed coat extract of Pongamia pinnata as a potentially valuable complementary agent in antibiotic treatment strategies, particularly for addressing challenging MRSA infections. The extract's capacity to enhance antibiotic efficacy without introducing counterproductive interactions represents a significant advancement in

microbiological therapeutic approaches.19

9. Antifungal Properties

Shahhen L. et al. is investigated the antifungal properties of P. pinnata extract of seed oil and leaf. both action and activity against Sclerotium rolfsii, a fungal pathogen affecting chickpea crops. Evaluation of both extracts effectively inhibited sclerotial production and germination. Study and publication highlights the potential of Pongamia pinnata extracts as antifungal agents for agricultural applications.20

10. Anti- Alzheimer's activity

Publication and study of Saini and colleagues conducted a study to investigate natural compounds with potential protective effects against Alzheimer's disease. The researchers found and focused on two compounds, 1. karanjin 2. embelin, Ethanolic extracted from P. pinnata seeds. They observed that the chemical purity of phtoconstituents compounds through advanced techniques like UV, spectrophotometry and TLC.

Pharmacological study on Using Swiss albino mice, the team induced Alzheimer's-like memory impairments(Disturbance) with diazepam drugs and tested the neuro-protective effects of karanjeen and embelee n. Piracetam drugs used as , a cognitive enhancement medication, was used as a standard for comparison. Behavioral change assessments, including the elevated plus maze and Morris water maze, were employed to evaluate cognitive function and memory retention. 21

11. Anti-tumor activity

Published researcher study of Guo et al. conducted comprehensive laboratory research to explore the anticancer properties of karanjeen. Their study evaluated three different cancer cell populations and found that karanjin effectively inhibited cellular growth and induced programmed cell death. The compound demonstrated its ability to suppress cancer cell proliferation, halt cell cycle progression, and trigger apoptosis in various malignant cell lines. The findings highlighted karanjin's dose-dependent effects, supporting its potential for use in cancer treatment strategies.22

Table-1: describing about the pharmacological properties of all the parts of the plant *Pongamia pinnata:* [23]

S.No.	Pharmacological Activity	Used Plant Part	Description in Detail
1.	Anti-helmintic activity	Seeds of plant	The methanolic seed extract demonstrated strong efficacy in combating helminthic parasites, causing rapid paralysis in the Indian adult earthworm, *Pherentima posthuma*.
2.	Anti-parasitic	Bark and	Extracts from the plant's

	activity	Leaves of plant	bark and leaves effectively inhibited malaria parasite multiplication, with inhibitory doses ranging from 9 to 43 micrograms per milliliter.
3.	Anti-hyperammonemic activity	Leaves of plant	The leaf extract combined with NH4Cl reduced key biochemical markers of nitrogen metabolism, including ammonia, urea, uric acid, and creatinine, without affecting body weight.
4.	Immuno-modulatory	Leaves of plant	The leaf extract stimulated immune responses by increasing Nitric Oxide production in immune cells and promoting the anti-inflammatory protein Interleukin-10.
5.	Cytotoxicity	Leaves of plant	The methanolic leaf extract significantly decreased the survival of Panc-1 pancreatic cancer cells, demonstrating its anti-cancer activity.
6.	Anti-convulsant	Leaves of plant	The leaf extract provided protection against chemically-induced seizures in rats, reducing the duration of convulsive episodes compared to the control group.
7.	Anti-viral	Leaves of plant	An ethanol-based leaf extract improved survival rates in shrimp infected

			with White Spot Syndrome Virus, with survival rates of 40% and 80% at dosages of 200 and 300 mg extract per gram body weight, respectively.
		Seeds of plant	The seed extract effectively inhibited herpes simplex virus (HSV) types 1 and 2 at low concentrations, with 1 mg/ml blocking HSV-1 and 20 mg/ml preventing HSV-2.
8.	Anti-oxidant	Flower of plant	A flower extract administered at 150 mg/kg daily for three months improved antioxidant defenses and reduced liver damage caused by lead acetate in rats.
		Fruit of plant	The fruit extract reduced cholesterol, triglycerides, and phospholipids in hyperlipidemic rats, indicating potential cardiovascular benefits.
		Root of plant	The root extract mitigated tissue damage caused by interrupted blood flow, enhancing antioxidant defenses and modulating hormones.
		Seeds of plant	A methanol extract from seeds demonstrated strong antioxidant activity, neutralizing free radicals and preventing

			β-carotene breakdown, indicating its potential in managing oxidative stress.
9.	Antibacterial	Fruit of plant	The methanolic leaf extract reduced the weight of wet feces in mice induced with diarrhea from *E. coli*, suggesting a potential for alleviating diarrhea.
		Leaves of plant	A decoction of dried leaves showed no antibacterial effect on *E. coli*, *Shigella*, or *Vibrio cholera*, but reduced cholera toxin production and bacterial invasion into cells.
		Oil of plant's seeds	The essential oil demonstrated potent antibacterial activity, with maximum effectiveness at full concentration, targeting bacterial strains like *Yersinia* and *Listeria*.
10.	Antifungal	Oil of plant's seeds	The oil exhibited enhanced antifungal activity against *Aspergillus niger*, with higher effectiveness at full concentration compared to *Aspergillus fumigatus*.
11.	Anti-diabetic	Flowers of plant	The herbal extract, at a dosage of 300 mg/kg, significantly reduced blood sugar levels in diabetic rats, showing

			potential as a natural alternative for managing blood glucose levels.
		Leaves of plant	An alcohol-based leaf extract regulated blood sugar levels in diabetic rats, demonstrating promising results for managing glucose metabolism and offering potential therapeutic benefits for diabetes.

[7] CONCLUSION

Presently, researchers are directing their attention towards exploring the active ingredients and their associated pharmacological properties. Numerous herbal medicines find applications across various diseases, as documented in diverse treatises. The plant Pongamia pinnata, also known as Karanja, plays a versatile role, boasting substantial medicinal and economic worth. Acknowledged as a vital medicinal plant, different parts of Pongamia pinnata are employed in various pharmacological activities and applications.With traditional used of pongamia pinnata extraction of various parts of plants.

Beyond therapeutic medicinal significance, P. pinnata is a valuable resource for bio-fuel(Energy transmission), demonstrating about its dual importance in medicine and sustainable bio-energy. Hence, validate its effectiveness of plants and use for further in-depth studies are implemation. A comprehensive understanding of the phytochemical composition and pharmacological effects of this Pingomia Pinneta species requires more research into its phytochemistry and phytochemical and the mechanisms of its chemical constituents, particularly in elucidating specific biological actions.

[8] AUTHOR(S) CONTRIBUTION

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The authors declare that any kind of violation of plagiarism, copyright, and ethical matters will

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[12] CONFLICT OF INTEREST

The authors declared that no potential conflicts of interest concerning the research, authorship, and/or publication of this article.

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This study do not involve any such criteria or condition.

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