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

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Keywords

Karanj, Pongamia Pinnata, Phytoconstituents, Traditional uses, Ethanolic extract, Charak samhita

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 a 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 compounds play a crucial role in supportive and preventive care for various conditions.

Traditionally, different parts 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, anti-plasmodial, anti-ulcer, anti-inflammatory, anti-nociceptive, anti-hyperglycemic, anti-hyper-ammonic, antilipoxidative, antioxidant, analgesic, and anticancer properties. Additionally, leaves extract demonstrates cardio protective

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, attributed 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 comprehensive exploration underscores the multifaceted therapeutic potential of Pongamia pinnata, offering insights into its diverse pharmacological activities, traditional applications, and contemporary relevance in the realms of medicine and environmental sustainability.

1. Introduction

Pongamia pinnata (L.) Pierre, a member of the Fabaceae (Leguminocae) family, is commonly known as 'Karanja' in various regions of India, 'Pongam' in Tamil, and 'Indian beech' in English. This plant is prevalent in India, Southeast Asia, the West Pacific, and North Australia, often found along coasts and riverbanks in India and Myanmar (1). It is characterized by its moderate height, short crooked trunk, and spreading branches, resembling a crown.

The diverse parts of Pongamia pinnata contain multiple active ingredients with efficacy against various human diseases, exhibiting different pharmacological actions. The increasing reliance on modern medicines has been associated with numerous side effects and adverse reactions. Consequently, there is a growing interest in traditional medicinal systems due to their perceived effectiveness and minimal adverse effects. Researchers are actively studying traditional medicinal systems to understand the science behind their therapeutic actions. Numerous studies emphasize the potential of medicinal plants as effective means to combat diseases, contributing valuable data to this field (2). Pongamia pinnata is particularly noteworthy due to its rich composition of phytoconstituents across different plant parts, endowing it with a range of pharmacological properties. This comprehensive profile qualifies it for recognition and inclusion in herbal medication (3).

2. Taxonomy[4]

Taxonomic Rank	Classification
Kingdom	Plantae
Subkingdom	Tracheobionta
Superdivision	Spermatophyta
Division	Magnoliophyta
Class	Magnoliopsida
Subclass	Rosidae
Order	Fabales
Family	Fabaceae
Genus	Pongamia
Species	pinnata

3. Chemistry

Pongamia pinnata, commonly known as Indian Beech or Karanj, is recognized for its diverse chemical composition, containing alkaloids such as demethoxy-kanugin, gamatay, glabrin, glabrosaponin, kanjone, kaempferol, karangin, kanugin, quercetin, pinnatin, neoglabrin, pongamol, pongapin, b-sitosterol, saponin, and tannin. An analysis of air-dry kernels reveals a composition with 19.0% moisture, 27.5% fatty oil (comprising stearic 2.4–8.9%, palmitic 3.7–7.9%, lignoceric 1.1–3.5%, arachidic 2.2–4.7%, linoleic 10.8–18.3%, oleic 44.5–71.3%, behenic 4.2–5.3%, and eicosenoic 9.5–12.4%), 17.4% protein, 6.6% starch, 7.3% crude fiber, and 2.4% ash.

Furthermore, the wood of Pongamia pinnata undergoes destructive distillation, yielding various components on a dry weight basis: charcoal (31.0%), pyroligneous acid (36.69), acid (4.3%), ester (3.4%), acetone (1.9%), methanol (1.1%), tar (9.0%), pitch and losses (4.4%), and gas (0.12 cu m/kg). These findings highlight the comprehensive chemical profile of Pongamia pinnata, showcasing its potential significance in various applications, from pharmaceuticals (due to alkaloid content) to energy production (through wood distillation products).[5]

4. Phytochemistry

Phytochemical investigations of Pongamia pinnata have led to the identification of flavonoid derivatives, including flavones, flavans, and chalcones. Additionally, various compounds belonging to different classes have been identified in this species. These include a sesquiterpene, diterpene, triterpenes, steroids, amino acid derivatives, disaccharide, fatty acids, and esters. The diverse array of chemical constituents underscores the rich phytochemical profile of Pongamia pinnata, suggesting its potential utility in multiple fields, such as medicine, nutrition, and industrial applications. (6)

The leaves of the plant contain: Alkaloids, Carbohydrates, Flavonoids- Kaempferol, Quercetin, Rutin, Tannins, Saponin and other Phytosterols.

The seeds of the plant encompass a spectrum of crucial active ingredients, including Karangin, Kaempferol, Kanugin, Kankone, Alkaloidal dimethoxy kanugin, Glabrin, Gamatay, Glabrosaponin, Tannins, beta-Sitosterol, Saponin, Quercetin, Pongapin, Pinnatin, Pongamol, Neoglabrin, and more. This diverse array of bioactive compounds underscores the nutritional and pharmacological significance of the plant's seeds, suggesting their potential in various applications, from traditional medicine to modern therapeutic and nutritional interventions.

The analysis of bark components reveals a diverse array, including resins, bitter alkaloids, sugar, mucilages, and distinctive flavone compounds. Notably, these flavone compounds encompass 3-methoxy-(3,4-dihydro 3-hydroxy-4-acetoxy)-2,2-dimethylpyrano-(7,8:5,6)-flavone and 3-methoxy-(3,4-dihydro 4-hydroxy-3-acetoxy)-2,2-dimethylpyrano-(7,8:5,6)-flavone the other significant flavone compounds identified in studies include Ovaliflavonone A, Isolonchocaprin, Dimethylallylflavonone, Caryophyllene oxide, and Obovatachalcone. This comprehensive examination underscores the varied chemical composition of the barks of the studied specimen, highlighting the presence of unique flavone compounds alongside other flavonoids, resins, and alkaloids. Such detailed insights into the bark's chemical constituents provide valuable information for potential applications in pharmaceutical and research endeavors.

5. Therapeutic applications based on distinct plant components[7]

Leaves: Extracts from the leaves of the plant exhibit diverse therapeutic properties, including anti-diarrheal, anti-lice, dyspepsia relief, anti-viral, anti-filarial, anti-microbial, and activities against Gonorrhea and Leprosy. Additionally, they demonstrate anti-inflammatory and anti-pyretic effects.

Flowers: Extracts from the flowers demonstrate notable health benefits, including anti-hyperammonemic, anti-oxidant, anti-bleeding pile, and anti-hyperglycemic activities. They also exhibit anti-lipidperoxidative properties.

Oil: The oil extracted from the plant's seeds is associated with a spectrum of medicinal actions, such as anti-leprotic, anti-ulcer, relief from liver pain, treatment of piles, Rheumatism arthritis, Scabies, Chronic fever, and Whooping cough. It also shows anti-fungal, anti-bacterial, and anti-helminthic activities.

Fruits: Extracts from the fruits of the plant manifest activities against Female genital tract diseases, Leprosy, genetic piles related to tumors, ulcers, anti-filarial effects, and the treatment of abdominal tumors.

Seeds: Extracts from the seeds exhibit a wide range of health benefits, including actions against bronchitis, Whooping cough, inflammation, Nootropic activity, Rheumatic arthritis, Hypertension, Skin ailments, chronic fevers, Hemorrhoids, Anemia, and Pectoral diseases.

Roots: The root extract of the plant is noted for its anti-nociceptive and anti-helminthic activities. Additionally, it shows 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 are associated with actions against swelling of the spleen, mental disorders, bleeding piles, Beriberi, and treatment of cough and cold.

6. Biological and Pharmacological properties

Pongamia pinnata warrants thorough investigation regarding its diverse pharmacological properties. This plant has demonstrated a spectrum of pharmacological activities encompassing antioxidant, antimicrobial, anti-parasitic, anti-inflammatory, anticonvulsant, anti-diabetic, anti-hyperammonemic, cytotoxicity, anthelmintic, and insecticidal properties. A concise overview of the outcomes from these investigations is presented below:

1. Antihyperglycemic and antilipidoperoxidative:

Ethanol extract of P. 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 derived from the coarse seeds of Pongamia pinnata demonstrates inhibitory effects on both herpes simplex virus A and B, exhibiting significant activity at concentrations of 1 and 20 mg/ml. Additionally, Bis (2-methylheptyl) phthalate, isolated from the leaves extract of P. pinnata, exhibits notable antiviral activity against the White Spot Syndrome Virus of Penaeus monodon Fabricius. These findings highlight the potential antiviral properties of Pongamia pinnata extracts, suggesting their significance in the development of therapeutic interventions against herpes simplex viruses 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:

A study by R. S. A. Sorna Kumar et al shown in his study that flower extracts of the plant possess potent antioxidant property and the seeds extract was found effective against

microbial growth. It has been cleared that the flower extract was active against Brucella melitensis and P.fluroscens. [14]

Another study done by Deshmukh et al also shown the antibacterial activity of the different seeds extracts. The objective of this investigation was to assess the in vitro phytochemical composition and antibacterial potential of various seed extracts, namely aqueous, chloroform, ethanol, methanol, and petroleum ether, against bacterial strains including E. coli (ATCC 25922), Salmonella Typhimurium (734 MTCC), Staphylococcus aureus (25923 ATCC), Klebsiella pneumonia (MTCC), and Pseudomonas aeruginosa (ATCC 27853). The study aimed to explore the diverse extracts' efficacy in inhibiting the growth of these specific bacterial strains, providing valuable insights into the potential antimicrobial properties of the tested plant material. Alkaloids, Flavonoid, Steroid, Phenols, Glyceroids, Triglycerides Amino acids and Proteins were also found in the seeds extracts which often possess antibacterial properties against pathogens. As resulted, the ethanolic extract exhibited the most potent anti-S. typhi activity and demonstrated effectiveness against all tested bacterial strains. Methanol, chloroform, and aqueous extracts displayed moderate activity, while petroleum ether exhibited minimal inhibitory activity. These findings underscore the notable antibacterial potential of the ethanolic extract, positioning it as a promising candidate for further exploration in antimicrobial research. Meanwhile, the varied activities observed across different solvent extracts highlight the importance of solvent selection in extracting bioactive compounds from the source material.[15]

Bajpai et. al designed this study to examine the antibacterial efficacy of organic leaves extract of the plant Pongamia pinnata against some food-borne pathogens, who generally responsible for food spoilage. Chloroform, ethyl acetate, and methanol extracts, each at a concentration of 2500 µg/mL, demonstrated significant efficacy against various bacterial strains, including Bacillus subtilis ATCC6633, Staphylococcus aureus ATCC6538, Listeria monocytogenes ATCC19118, L. monocytogenes ATCC19166, Pseudomonas aeruginosa ATCC6432, and Salmonella typhimurium ATCC2512. The observed zones of inhibition for these organic leaf extracts against the pathogens ranged from 8.1 to 18 mm, accompanied by their respective Minimum Inhibitory Concentration (MIC) values, spanning from 125 to 1000 µg/mL when compared to streptomycin. These findings underscore the potential of leaf extracts from this source as antimicrobial agents, particularly in the food industry. The demonstrated effectiveness against a range of bacterial strains suggests a promising application for these extracts in enhancing food safety and preservation.[16]

Sajid et al. conducted a comprehensive study on various solvent extracts (including absolute methanol, aqueous methanol, absolute ethanol, aqueous ethanol, absolute acetone, aqueous acetone, and deionized water) obtained from the bark, leaves, and seeds of Pongamia pinnata (L.) Pierre. Notably, the aqueous methanol extract from the bark exhibited superior levels of total phenolics, total flavonoids, inhibition of linoleic acid peroxidation, and DPPH radical

scavenging activity when compared to extracts from leaves and seeds. Furthermore, the bark extract demonstrated robust antimicrobial activity against a range of bacterial and fungal strains, as evidenced by the largest inhibition zone and the lowest minimum inhibitory concentration (MIC) in comparison to leaves and seeds extracts. High-Performance Liquid Chromatography (HPLC) analysis of aqueous methanol extracts from the bark, leaves, and seeds revealed the presence of various phenolic acids. In the bark, protocatechuic, ellagic, ferulic, gallic, gentisic, 4-hydroxybenzoic, and 4-hydroxycinnamic acids were identified; in the leaves, sorbic, ferulic, gallic, salicylic, and p-coumaric acids were prominent; and in the seeds, vanillic, gallic, and tannic acids were identified as the main phenolic acids. These findings underscore the diverse and valuable chemical composition of Pongamia pinnata, with potential applications in antioxidant and antimicrobial contexts.[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:

Po-An Su et al. discovered that the aqueous extract derived from the seed coats of Pongamia pinnata exhibits antibacterial properties, particularly in combination with various antibiotics against methicillin-resistant Staphylococcus aureus (MRSA). When the seed coat extract was combined with ampicillin, meropenem, cefazolin, cefotaxime, cefpirome, and cefuroxime at concentrations ranging from 70% to 100%, synergistic effects were observed, as indicated by a fractional inhibitory concentration (FIC) index of < 0.5.

In the time-kill method, employing 0.5 × minimum inhibitory concentrations (MIC) of the extract in combination with 8, 4, 2, and 1 μg mL−1 of various antibiotics, almost all combinations demonstrated synergistic effects, except for aztreonam. Importantly, no antagonistic effects were noted in any of these combinations. These findings underscore the potential of Pongamia pinnata seed coat extract as an effective adjunct to certain antibiotics, particularly in combating methicillin-resistant Staphylococcus aureus, with promising synergistic effects and minimal risk of antagonism.[19]

9. Antifungal Properties:

Shahhen l. et al investigated antifungal properties of the plant seed oil and leaf diffusates. The extracts derived from Pongamia pinnata exhibited noteworthy activity against Scelotium

rolfssi, a fungal pathogen affecting Chickpea crops. The study conducted a comprehensive analysis, comparing the antifungal properties of the seed oil and leaf extract. The findings revealed that both extracts demonstrated substantial inhibition of Sclerotial production and germination. Notably, there was a negligible difference of approximately 20% v/v in inhibition concentrations when the extracts were applied before autoclaving. However, a significant distinction emerged among concentrations after autoclaving. This disparity indicates that the proteins present in the extracts underwent denaturation due to the heating process. The study sheds light on the potential antifungal efficacy of Pongamia pinnata extracts, emphasizing their application as promising agents for mitigating fungal pathogens in agricultural settings.[20]

10. Anti- Alzheimer's activity:

In a study by Saini et al investigated the anti-Alzheimer's activity of karanjin isolated from seed extract and embelin. The purity of these compounds was verified through Ultraviolet spectrophotometric and thin-layer chromatography analyses. The assessment of the anti-Alzheimer's potential of the isolated compounds utilized the elevated plus maze and Morris water maze models on Swiss albino mice. Alzheimer's-like effects (amnesia) were induced in Swiss albino mice by intraperitoneally administering 1mg/kg of body weight diazepam. Piracetam, administered orally at 200 mg/kg body weight, served as the standard treatment. The study provides valuable insights into the potential anti-Alzheimer's properties of karanjin and embelin, supported by rigorous purity confirmation and evaluation through established behavioral models on experimental subjects.[21]

11. Anti-tumor activity:

Guo et al explored the potential anticancer properties of karanjin, a primary furanoflavonol constituent. The investigation involved employing cytotoxic assays, examining cell cycle progression, and evaluating apoptosis induction in specific cancer cell lines (A549, HepG2, and HL-60 cells). The MTT cytotoxic assay revealed that karanjin effectively hindered the proliferation and viability of all tested cancer cells. The induction of cell cycle arrest at the G2/M phase was observed using a PI (propidium iodide)/RNase Staining Buffer detection kit and analyzed through flow cytometry. Notably, karanjin exhibited a dose-dependent ability to induce cell cycle arrest in the three cell lines. Assessment of cell apoptosis was conducted using Annexin V-FITC/PI staining. These findings underscore the promising anticancer potential of karanjin, highlighting its impact on cell viability, cell cycle regulation, and apoptosis induction in the studied cancer cell lines.[22]

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

S.No.	Pharmacolo-gical activity	Used plant's part	Description in detail

1.	Anti-helmintic activity	Seeds of plant	Indian adult earthworm, Pherentima posthuma etc. grow rapidly and causes paralysis and time within minimal time period. The efficacy of the methanolic seed extract proved to be substantial in combatting these helminthic parasites.
2.	Anti-parasitic activity	Bark and Leaves of plant	The anti-plasmodial activity against Plasmodium falciparum was demonstrated by the bark and leaf extract, exhibiting low Half-maximal inhibitory concentration values ranging from 9 to 43µg dry extract/ml.
3.	Anti-hyperammonemic activity	Leaves of plant	The concurrent administration of leaf extract and ammonium chloride resulted in a notable reduction in blood ammonia levels, circulatory urea, uric acid, non-protein nitrogen, and creatinine. This effect was observed in contrast to the group that solely received ammonium chloride. Furthermore, there were no significant alterations in body weight when compared to the control group.
4.	Immuno-modulatory	Leaves of plant	The hydrophilic leaf extract demonstrated significant enhancement of Nitric Oxide activity in RAW246.7 cells. Additionally, it elicited notable production of Interleukin-10.
5.	Cytotoxicity	Leaves of plant	The cytotoxic potential of the methanolic extract (100 mg/ml) was investigated against the pancreatic adenocarcinoma cell line Panc-1 (human pancreatic cancer) through a label-free biosensor assay. Utilizing a 24-hour exposure to the plant extract, the anti-proliferative effects were quantified as the fraction of Panc-1 cell survival in comparison to untreated controls. The observed anti-proliferation activity of the extract amounted to 0.14±0.07, indicating a significant impact on Panc-1 cell survival. Control cultures and blank wells devoid of cells were treated with 100µL of medium containing 0.5% (v/v) ethanol.
6.	Anti-convulsant	Leaves of plant	The pentylenetetrazole-induced convulsions in Wistar albino rats were mitigated by the

			administration of the ethanolic leaf extract at a dose of 250mg/kg via intraperitoneal injection. This intervention notably reduced the extension phase duration in comparison to the control group, which solely received 1% normal saline orally.
7.	Anti-viral	Leaves of plant	Orally administering the ethanolic leaf extract (at concentrations of 200 and 300 g extract per gram of body weight of shrimp per day) demonstrated a notable enhancement in the survival rates of White Spot Syndrome Virus-infected shrimp, reaching 40% and 80%, respectively.
		Seed of plant	The aqueous seed extract demonstrated complete inhibition of HSV type-1 and type-2 growth at concentrations of 1 mg/ml and 20 mg/ml (w/v), respectively.
8.	Anti-oxidant	Flower of plant	The administration of a methanolic flower extract at a dosage of 150 mg per kilogram of body weight per day through oral intake for a period of 90 days demonstrated a significant elevation in both enzymatic and non-enzymatic antioxidant levels. This effect was observed in a rat model with hepatic damage induced by lead acetate. The findings suggest that the methanolic flower extract holds promise in mitigating the adverse effects of lead acetate on the liver, showcasing its potential as a protective agent against oxidative stress in this experimental setting.
		Fruit of plant	The plant's fruit extract exhibited a substantial decrease in hyperlipidemic rats, leading to a noteworthy reduction in plasma levels of total cholesterol (by 29%), triglycerides (by 21%), and phospholipids (by 21%). These observations suggest a potential therapeutic role for the fruit extract in mitigating elevated lipid levels, indicating its promising impact on the cardiovascular health of the experimental subjects.
		Root of plant	The oral administration of the ethanolic root extract at a dosage of 50mg/kg for a

			duration of 5 days resulted in a reduction of ischemia-reperfusion injury. This effect was evidenced by an increase in lipid peroxidation and superoxide dismutase activity, accompanied by a decrease in Thyroid-stimulating hormone levels. These findings imply a potential protective role of the ethanolic root extract against ischemia-reperfusion injury, highlighting its impact on oxidative stress and hormonal regulation in the experimental setting.
		Seeds of plant	The methanolic extract from the seeds demonstrated notable effects, enhancing the ferric reducing/antioxidant power (1179 mmol Fe (II)/mg extract). It also exhibited significant inhibition of β-carotene degradation (41.13%) and displayed potent radical scavenging activity against 2,2-diphenyl picrylhydrazyl (54.64%) and superoxide (54.53%). These outcomes suggest that the seeds' methanolic extract holds promise as a source of antioxidants, showcasing its potential in combating oxidative stress and related processes.
9.	Antibacterial	Fruit of plant	Prior application of the methanolic leaf extract, administered 30 minutes before the oral introduction of castor oil to induce diarrhea in mice (caused by E. coli), resulted in a notable reduction in the weight of wet feces. Specifically, for concentrations of 3 mg and 7.5 mg, the weights recorded were 232 mg and 126.6 mg, respectively. In the absence of pre-treatment with the extract (considered as the control group), the weight of wet feces reached 401 mg. These outcomes underscore the potential of the leaf extract to attenuate diarrhea in this experimental model..
		Leaves of plant	The decoction obtained from dried leaves in its crude form demonstrated no activity against E. coli, Shigella flexneri, and Vibrio cholera. However, it exhibited a notable effect in diminishing the production of cholera toxin and the invasion of bacteria

			into epithelial cells. These findings suggest a specific impact of the decoction on certain aspects of bacterial activity, emphasizing its potential relevance in mitigating toxin production and cellular invasion in the context of these pathogens.
		Oil of plant's seeds	(a) The oil demonstrated antibacterial efficacy against S. aureus and P. aeruginosa. The highest activity was observed at 100%, while a diminished activity was noted at 12.5%. The minimum inhibitory concentration indicated that the oil displayed bacteriostatic effects at higher dilution levels. Clotrimazole and Ampicillin (1 mg/ml) were employed as controls for comparison.
			(b) Maximum antibacterial efficacy against Yersinia enterococcai was observed with the seed oil, followed by activity against Listeria monocytogens, E. coli, and Salmonella paratyphi, respectively. Interestingly, the 90% oil, when combined with dimethyl sulfoxide, demonstrated higher inhibitory effects compared to the 100% seed oil alone. Ampicillin (50 mg/ml) served as the standard for comparison in this study. These findings underscore the nuanced antibacterial potential of the seed oil and highlight the impact of formulation considerations on its inhibitory effects against various bacterial strains.
10.	Antifungal	Oil of plant's seeds	The oil exhibited increased antifungal efficacy against Aspergillus niger compared to Aspergillus fumigatus. The highest activity was observed at a concentration of 100%, while a diminished activity was noted at 12.5%. Clotrimazole and Ampicillin (1 mg/ml) were employed as control agents for reference.
11.	Anti-diabetic	Flowers of plant	The significant anti-hyperglycemic effects were evident upon the oral administration of the ethanolic extract (300 mg/kg BW). This resulted in a substantial reduction in blood glucose concentration, comparable to the

			effects observed with the reference drug glibenclamide (600 µg/kg BW), in alloxan-induced diabetic rats. These findings underscore the potential therapeutic efficacy of the ethanolic extract in managing hyperglycemia, highlighting its performance parallel to the established anti-diabetic medication in the experimental model.
		Leaves of plant	Consistent administration of the ethanolic extract over a period of 21 days demonstrated significant hypoglycemic activity in both oral glucose tolerance tests and normoglycemic rats. Additionally, the extract displayed anti-diabetic effects in rats induced with alloxan-induced diabetes. These findings suggest the extract's potential as a hypoglycemic agent and its possible application in managing diabetes-related conditions.

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 a history of traditional use in India and inclusion in the renowned Charak Samhita, it stands as a conventional remedy for diverse ailments.

Beyond its medicinal significance, Pongamia pinnata is a valuable resource for biofuel, demonstrating its dual importance in medicine and sustainable energy. However, to validate its effectiveness, further in-depth studies are imperative. A comprehensive understanding of the phytochemical composition and intricate pharmacological effects of this species requires more research into its phytochemistry and the mechanisms of its chemical constituents, particularly in elucidating specific biological actions.

8. Authors Contribution

The writers affirm that they have no connections to, or engagement with, any group or body that provides financial or non-financial assistance for the topics or resources covered in this manuscript.

9. Conflict Of Interest

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article**.**

10. Plagiarism Policy

All authors declare that any kind of violation of plagiarism, copyright and ethical matters will taken care by all authors. Journal and editors are not liable for aforesaid matters.

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