Therapeutic potential of Pterocarpus: A review of its traditional uses and modern applications

Authors:

Karan Singh[1], Amisha Thakur[2], Dr. Kapil Kumar Verma[3]

[1,2]UG Scholars of Minerva College of Pharmacy, Indora H.P(176401)

Corresponding Author:

Rakesh Kumar[4*], Assistant Professor of Pharmacognosy.

[4*]Department Of Pharmacognosy, Minerva College of Pharmacy, Indora H.P(176401)

Abstract:

Pterocarpus is a genus of Family Fabaceae which has recorded great importance in the traditional medical systems like Ayurveda, Siddha and Unani due to its various therapeutic benefits. The species such as Pterocarpus marsupium, Pterocarpus santalinus, and Pterocarpus indicus are full of bioactive components such as flavonoids, tannins, stilbenoids, and phenolic compounds whose pharmacological properties include anti-hyperglycaemic, anti-inflammatory, antioxidants, hepatoprotective, cardiovascular, anti-microbes and even antineoplastic. This review attempts to close the divide between ethnopharmacological and the modern scientific investigation by assessing the medicinal properties of several Pterocarpus species. It combines data on ethnobotanical records, phytochemical research, in vitro tests, and clinical studies of the recent past. The review also explains the action of major compounds and outlines the issues that are at hand and future opportunities in developing Pterocarpus-based therapeutics. The combination of past applications with the latest evidence leads to the creation of the genus Pterocarpus as a good source of new therapeutic agents. Peterocarpus is a genus of trees in the family Fabaceae, and is famous due to its numerous traditional uses in different societies.

Keywords: Ayurvedic medicine, Indian Kino tree, Antipyretic, Astringent, Anti-inflammatory.

Introduction

Peter carpus marsupium is a plant material that has been widely used as a form of medicine to treat numerous diseases due to its diverse medicinal characteristics .This plant is also known as Malabar kino or Indian kino or gum kino, and has a long history of use as a medicinal plant. Its Latinised scientific name, which is translated as wing fruit, is a reference to the unusual shape of seed pods in this genus. There are several species of Pterocarpus that are employed in the manufacture of padauk timber; all padauks have their origin in either Africa or Asia, and are characterized by strength, usefulness and beauty and are usually tinted to give a reddish color.Most Pterocarpus timbers contain water-soluble or alcohol-soluble compounds which are dyes.Nowadays, Pterocarpus is known to contain 35 species that have a wide distribution all over the world.The pterocarpus marsupium plant, which is a Fabaceae species is a plant that has been used in India and its neighbouring countries over centuries as a traditional home remedy to treat various human illnesses.Its use has been incorporated in the homeopathic system, Ayurvedic system and even the Unani medical system.It is far more common in Madhya Pradesh, Bihar, Gujarat and Orissa, and has a pronounced presence in the Western Ghats and in the Karnataka -Kerala area.In the past, various products made out of this plant have been used in cooling, external anthelmintic action, relieving headaches, antipyretic, anti-inflammatory, aphrodisiac, psychotropic, biliary and ulcerative diseases.

Ayurveda is an Indian based practice that goes beyond pharmacology; it advances holistic view on health and well-being. Ayurveda is based on the Sanskrit notions of Ayur (life) and Veda (knowledge) and aims at preserving the balance between physical, mental and spiritual forces. It incorporates the broad spectrum of lifestyle and natural therapies- yoga, meditation, exercise, herbs and dietary prescriptions in search of health maximisation. The Ayurvedic tradition is based on the concept of Tri-Dosha (Vata, Pitta, and Kapha) balance and boasts a great reservoir of information about patients, diseases, pharmacopeia, therapeutic practices, and diagnoses. The potential in this vast storehouse of knowledge is a huge possibility in designing of so-called designer therapeutics and the provision of holistic and holistic care. The clash of the ancient knowledge and the modern scientific research is sure to influence the future of the modern medicine.

It is observed that about eighty percent of the world population still uses herbal remedies to treat their health problems. The demand of Ayurvedic pharmaceutical products in the various parts of the world is explained by the side effects of allopathic drugs. The Ayurvedic medicine is generally known and used in the populations of developed countries such as China, Japan, Canada, the United States and other European nations. There is cost-efficiency and extensive availability of leveraging generationally distributed plant-based therapies. However, the medicinal flora has been threatened by overexploitation of the plant materials to be used commercially and by frequent over exploitation of natural resources in India.

The fabaceae is a mediumto large family of trees that are mostly deciduous, and includes the fabaceae species Pterocarpus marsupium otherwise known as Vijayasar the Malabar tree and the Indian tree. Being a native species of Nepal, India, and Sri Lanka, the species, of *P. marsupium, is highly familiar in relation to its medicinal benefits and its use in the traditional Ayurvedic medicine. The kino is a clear reddish sap that is a product of the heartwood of the tree that is rich in phytoconstituents, such as epicatechin, quinone, quinotannic acid, 2 -eudesmol, carsupine, marsupol, marsupinol, pterostilbene, liquirtigenin, isoliquiritigenin and many others. A number of these constituents have been studied within a range of biological actions; aphrodisiac, cardiotonic, hepatoprotective, analgesic, antimicrobial, antitumour, anticataract, antidiabetic, antifungal, antihyperlipidaemic, and anti-inflammatory actions. The ability of the tree to host a wide range of wildlife makes it important to the ecology. Foliar preparations are used traditionally to treat boils, sores, dermatological disorders and abdominal pain, floral extracts are used to treat febrile disorders, gum-kino preparations to treat diarrhoea, dysentery, leucorrhoea and other diseases and a folk preparation, bark infusions, to treat dental pain. In the past, the glandular tumours, urethral discharges, and as abortifacents were treated with decoctions made of barks and resins. The heartwood has anodyne, anti-inflammatory, anti-diabetic and astringent effects.

Considering its widespread bioactivity, Pterocarpus marsupium has remained a pillar of medical practice in India and neighboring areas. The broad applicability of homeopathic, Ayurvedic, and Unani systems is an indication of its long-term therapeutic value.

History Of *Pterocarpus Marsupium:*

Pterocarpus marsupium has always been used as an alternative medicine and has a long tradition of usage going many centuries in an attempt to treat a wide variety of ailments. Ayurvedically, the bark, heartwood and resin of this species are used as rejuvenatives and medicinal formulations in metabolism disorders. Normalised extracts of the heartwood are reported to bear a range of pharmacological activity which includes astringent, anti-inflammatory, antimalarial, anti-leperative, antimalarial, antimalarial, antimalarial, antimalarial, antimalarial, antimalarial, antimalarial, antimalarial, antimalarial, antimalarial, antimalarial, antimalarial, antimalarial, antimalarial, antimalarial, antimalarial, Its antilypidemic, hepatoprotective, anti-ulcerative, anti-inflammatory and antidiabetic properties have been established by empirical studies. Carbohydrates, glycosides, saponins, tannins and flavonoids have been identified in phytochemical analysis of methanolic extracts highlighting the key role of the plant in the pharmacological types of alternative medicine advocacy.

Cultural significance:

P. marsupium is a long-standing use of indigenous people in Southeast Asia and India, and ancient documents mention its medicinal effect specially in the management of glycaemic, and its general health improvement.

Timber and forestry:

P. marsupium has a highly appreciated wood color, which is reddish-brown, hard, and durable; it is commonly applied in the construction, flooring, and furniture production. It has a high timber potential that has also helped it to be widely cultivated.

Traditional Medical Use:

P. marsupium has a highly valued medicinal use in Ayurvedic medicine thanks to the medicinal properties of its bark, and the resin, or kino, has applications as an anti-inflammatory agent and a wound healing agent and in the treatment of gastrointestinal disorders. Most trees of the pantropical genus Pterocarpus, a member of the Fabaceae family, are excellent producers of timber, which is sold as padauk, and is also known as mukwa or narra. The naming that is also of Ancient Greek origin is the genus name, which alludes to the characteristic structure of the seed pods. Padauk is a timber that is commonly harvested in Africa and Asia that have a reddish hue and can be stable. Many of the species have water- or alcohol-soluble compounds that are dyes, and 35 species of Pterocarpus are known in the world, mostly in African countries like Nigeria, Cameroon, Sierra Leone, and Equatorial Guinea, the latter having some also in Asia. Peterocarpus santalinus is the most exploited species and therefore the necessity to have the right information to enhance sustainable practices. Recent studies thus explore the pharmacological, phytochemical and therapeutic uses of P. santalinus. P. marsupium Traditional preparations of P. marsupium include various treatment preparations, such as anti-parasitic, analgesic, antipyretic, anti-inflammatory, aphrodisiac, and gastrointestinal preparations. In Indian healthcare system, Ayurveda has been the most common modality and more than 2000 species are recorded in the classic Ayurvedic literature. P. marsupium belongs to the Rasayana (rejuvenative) group of herbs, which is an immunomodulator and stress-relief agent. Its wide range of bioactivities, including anti-oxidant, antidiabetic, hepatoprotective, anti-ulcer, anti-inflammatory, anti-hyperlipidemic, antibacterial, neuroprotective, analgesic, and memory-enhancing properties, have drawn the interest of scientists especially in the glycaemic control and general health promotion.

Ayurvedic Properties:

P. marsupium is a widely used herb in Unani and Ayurvedic medicine systems and was used in various ailments using the bark, leaves, heartwood and kino. It was particularly known as an anti-diabetic plant, which was used in the management of diabetes, and treatment of digestive diseases like dysentery and diarrhoea, which was due to its astringent effect and was known as Vijayasar in Ayurveda. The Western pharmacopoeias of the time of the colonial world also included these astringent properties as a treatment of internal bleeding. The plant has anti-inflammatory, hepatoprotective, antioxidant, and antimicrobial effects and has been used in the treatment of dermatologic diseases such as eczematous and psoriasis. Its coolant and astringent properties were utilized to reduce irritation of the skin and promote the healing of wounds.

Table 1: Various Ayurvedic Names [18]

Rasa	Kashaya, Tikta
Guna	Laghu, Ruksha
Veerya	Ushna
Vipaka	Katu
Prabhava	Hridya
Doshaghnata	Kaphapittashamaka
Rogaghnata	Madhumeha, Prameha

Table 2: Scientific Classification [19]

Domian	Eukaryotes
Kingdom	Plantae
Subkingdom	Viridaeplantae
Phylum	Magnoliophta
Subphylum	Euphyllophytina
Infraphylum	Radiatopsis
Class	Magnoliopsida
Subclass	Rosidae
Superorder	Fabanae
Order	Fables
Family	Fabaceae

Table:3 Verbal Names[20]

English	Gummy Kino, Indian Kino
Hindi	Bija, Vijayasara
Marathi	Biyala lakda, Bibala
Assam	Ajar
Kannada	Bijasara, Asana
Kashmir	Lal Chandeur
Punjabi	Channanlal and Chandan Lal
Sanskrit	Pitasala, Asana, Sarfaka, Pijaka
Tamil	Vegaimaram chakkal, Nengai

Morphological Characters of *Pterocarpus marsupium:*

The different parts of the anatomy of this species have peculiar morphological features, the external bark rough, vertically divided, the inner heartwood golden-yellow, the sapwood light yellow, the leaves compound imparipinnate, the terminal panicles yellow, the fruit flat and circular, and wing-ed, as shown in Figure 1 21. The effects are anthropogenic and other biotic pressures, which have pushed it to the endangered category, a further decline in the number will only increase inbreeding and genetic bottlenecks. Additionally, the high rate of seedling growth can be beneficial in times of low allocation of maternal carbohydrates and following drought, but a general low natural fruit set rate can be ascribed to the compounding effects of these stressors 22. Petercarpus marsupium is a medium to large deciduous tree with a maximum height of 30m and a trunk circumference of 2.5m. The leaves are imparipinnate with the bark dark brown to grey with superficial fissures. Flowers yellow, in terminal panicles; fruit a flat, circular and winged pod; seeds convex and bony. Flowering and fruiting 3. Flowering and fruiting between March and June. The species is distributed in deforested and evergreen forest habitats in the central, western and southern parts of India, especially in the Western Ghats, Gujarat, Bihar, West Bengal, Orissa, Uttar Pradesh, Kerala, Karnataka and Madhya Pradesh and also into Sri Lanka and Nepal. It generally covers heights of 150 to 1100 m above the sea level in hilly, rolling or rocky slopes. The related habitats receive precipitation of between 750 to 2000mm annually with the Southern India registering higher figures. The lowest temperature range is 0 o C to the highest temperature range of 48 o C with range average of 0 o C to 18 o C. There are a variety of soil substrates, such as quartzite, shale, conglomerate, laterite, gneiss, and sandstone, although the species is selective towards sandy, sedimentary soils that drain well 24. The total height of the canopy range is 15 to 30m. Leaves (compound imparipinnate) have no stipules; leaflets (5-7) are oval, blunt, emarginated, glabrous, with rounded ends and the length of as much as 2-2.5CM. It has large pedicels, petioles that are smooth, slightly waved and terminal. There is a rich floral show with a faint shade of yellow. The vexillum has two pitted keels, and the reflexed, wavy, curled, and veined margins having a slender, elongated claw. The basal stamens are a decamerous formation, split into two quintets of globose, bilobed anthers. The ovary is oblong, hairy, pedicelled and rises up in a normal manner. The seeds are reniform, solitary and robust; and their genesis is a crooked stem with widely extended branches 25.

Leaf: The imparipinnate, alternately arranged, glabrous rachis is 1523cm long and 22.5 breadthwise. It has five to seven oblong or elliptic leaflets. These foliage web contains pharmacologically pertinent polyphenols that include pterostilbene and epicatechin, which form part of the traditional medicinal uses.

Leaflets: The 5-7 coriaceous leaflets measure between 6.3-10cm in length and 3.8-5cm in width, have an oblong shape with rounded apices and are smooth on either side with a glossy upper surface and a sub-acute base. There are no stipules, petioles are round, smooth and wavy. It has a composite leaf structure, which is used in a number of Pterocarpus taxa, due to its strong wood and medicinal gums.

Stem: The stem is thick and rough in texture with shallow fissures with a dark brown or grey outer bark which sheds off in irregular scales. Many seemingly yellow, but with a tincture of yellow, bloom in fusco-pubescent racemes that appear both terminal and lateral, these infloescences are typically shorter than the leaves. The buds are recurved.

Calyx: The calyx is tubular-campanulate and is composed of five short, roughly equal, blunt teeth, which are hurriedly developed.

Fig. 1: Different parts of *Pterocarpus marsupium*

Corolla: The corolla is papilionaceous, with almost equal length petals and extended claws, wavy margins; filaments, staminal tube and ten stamens are often the terminal structures in the floral.

Pistil: This is small, pubescent, acuminate and stipulate.

Pods: the pods are indehiscent, petiolate, highly compressed, oval, narrow of a half inch (1.27 cm), falcate, having a broad, crisped, veined, parchment-like wing, which is laterally extended and hard, leathery, and finely silky.

Seeds: The seeds are apomixic, solitary or in pairs, of a kidney shape, with a strong partition between them.

Table 4: Key Phytoconstituents of *Pterocarpus marsupium*

Compound	Class	Part Used	Key Properties
Pterostilbene	Stilbene	Heartwood	Antidiabetic
Epicatechin	Flavonoid	Bark	Antidiabetic
Marsupin	Flavonoid	Heartwood	Hypoglycaemic
Kinotannic acid	Tannin	Bark	Astringent
Marsupinol	Isoflavone	Heartwood	Antioxidant

Pharmacological Activities:

Anti- Inflammatory Activity

The species of pterocarpus have been proven to have anti-inflammatory properties. A study by Hougee et al. (2005) on the inhibitory effect of P. marsupium extract containing pterostilbene on the production of prostaglandin E 2 (PGE 2) in lipopolysaccharide stimulated human peripheral blood mononuclear cells revealed that the extract inhibited the production of PGE 2 in inflammatory cells when present at a concentration of 100mug/L 2. An alcoholic and aqueous extract was both anti-inflammatory in the carrageenan-induced rat paw oedema model at a dosage range of 50-100mg/kg-1 body weight when used at a dosage range of 50 -100mg/kg-1 body weight of the extracts respectively in the model treated with either extractant or saline solution as the control group (see table 6). Other studies that followed the same procedure using carrageenan induced rat paw oedema showed that both methanolic and aqueous extracts of P. marsupium had anti-inflammatory effects at 100 mg/kg/kg each environment 29. These effects are suggested to be caused by flavonoid constituents of the stem bark of the trees of the same genus^29. The selectivity of the extract in the inhibition of cyclo-oxygenase (COX) 1/2 was also determined; the study

was the first to record COX-2 selective inhibition and the trade-off of the inhibitory power of the PGE 2 by the levels of pterostilbene was reported to be correlated to this effect 30.

Antioxidant Activities:

Hypnoid is a herbomineral preparation which contains the extracts of the herbs Momordica -charantia, Melia -azadirachta, Pterocarpus -marsupium, Tinospora -cordifolia, Gymnema -sylvestre, Enicostemma -littorale, Emblica -officinalis, Eugenia -jambolana, Cassia -auriculata, and Curcuma -longa. Hypnoid treatment in a streptozotocin-induced diabetic rat model, reduced the concentrations of α-tocopherol, glycosylated hemoglobin, hydroperoxides, ceruloplasmin, and plasma thiobarbituric-acid-reactive substances and at the same time increased plasma reduced glutathione and vitamin C levels, respectively, by 50 percent or more relative to the control group of streptozotocin-induced diabetic rats (Wang et al., 20 The stem-wood extract of P. marsupium in ethanol, isopropyl alcohol (IPA) and acetone had an antioxidant activity based on the 2, 2-diphenyl-1-picrylhydrazyl (DPPH) radical-scavenging technique 45. Maximum scavenging activity was observed at 100 umg ml -1 of the methanolic extract, then the ethyl acetate extract and aqueous extract, after which no longer increasing scavenging activity could be observed. It was revealed by this study that P. marsupium extract of the bark has strong antioxidant properties in DPPH, superoxide, ABTS, substrated hydroxyl radical, and nitric oxide scavenging tests, and in inhibition of in-vitro lipid peroxidation^32.

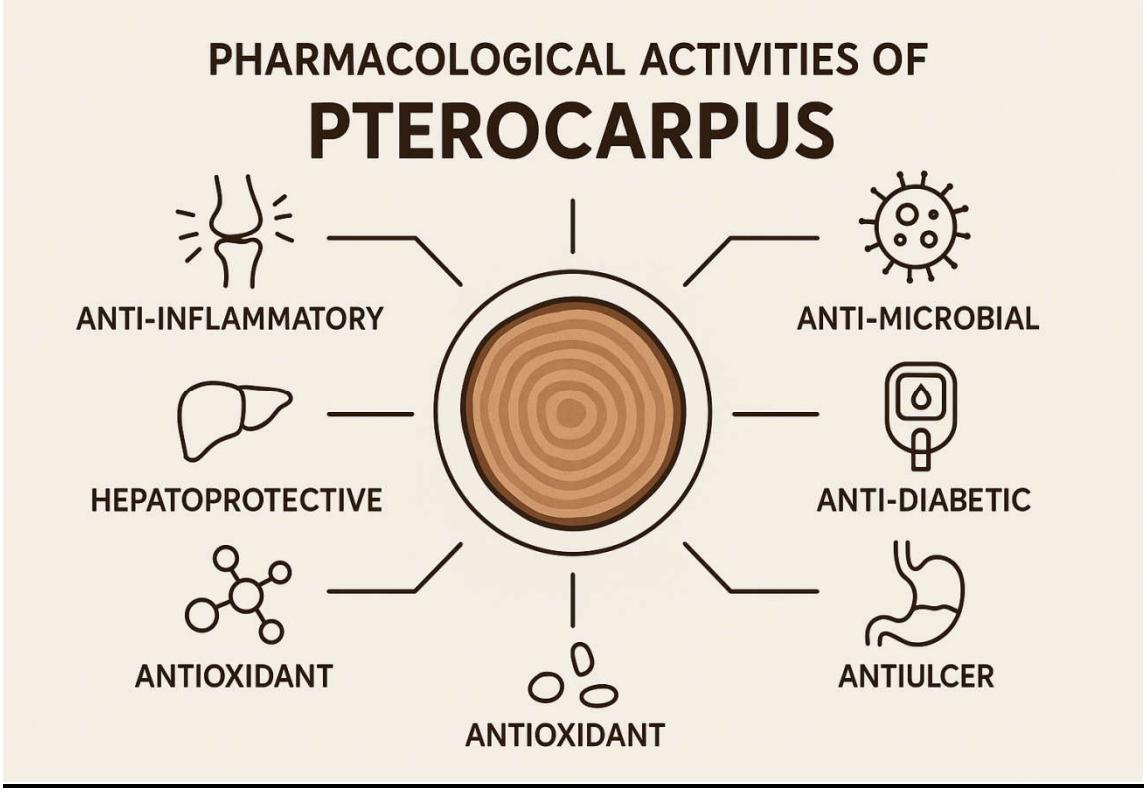

Fig. 2: Various Pharmacological Activities of *Pterocarpus*

Hepatoprotective activity:

In a study conducted by So-Young et al. (2018) in the article titled Ancient Science of Life, oral administration of a 100 mg/kg extract of Pterocarpus marsupium produced a significant decrease in the increases of alanine aminotransferase (ALT), aspartate aminotransferase (AST), alkaline phosphatase (ALP), lactate dehydrogenase (LDH), and total bilirubin caused by carbon tetrachloride in Wistar albino

Carbon tetrachloride-induced hepatotoxicity model assessed by histological examination and liver biomarkers (serum protein, total bilirubin, alanine aminotransferase, alkaline phosphatase and aspartate aminotransferase) demonstrated a potent hepatoprotective action of methanolic and aqueous stem-bark extracts (25^{-1}/kg/day orally 14 days) [34].

The levels of lactate dehydrogenase, aspartate transaminase, alkaline phosphatase, alanine transaminase and bilirubin were significantly lowered in the group that was treated with plant extracts (100 mg/kg orally) in the same model. This observation can be used to imply that the plant is able to alleviate the CCl 4-induced hepatotoxicity [35].

When fed on a rat model of alcohol-induced oxidative and nitrosative hepatic injury, a large proportion of extract of Pterocarpus santalinus methanolic heartwood (250 -1 kg) restored transaminase activities, ALP, LDH, -glutamyltransferase, lipid peroxidation products, nitric oxide levels, and antioxidant enzyme activities (GSH, GPx, GST, GR, SOD, CAT) [36] indicating that it has strong hepatoprotect

A different study published in the Egyptian journal of Biology found that the methanolic extract of Pterocarpus marsupium (100 to 300 mg/kg) improved hepatic antioxidant activities and improved the hyperglycaemia by recovering lipid peroxidation by-products, depleted glutathione, and superoxide dismutase, and restored hepatic liver weight, protein, and glycogen levels [37].

One of the mechanisms through which toxic metabolites are formed involves the generation of electrophiles or free radicals that can form covalent adducts with macromolecules found in the cell and hence interfere with processes of protein, lipid, and nucleic acids [38].

Steam bark (1-14) extract aqueous and ethanol (30 45 mg ml -1) were given as 14-day orally and the hepatoprotective effect was investigated in a CCl 4 induced hepatic injury. Evaluation was done on biochemical parameters including serum bilirubin, total protein, alanine transaminase, aspartate transaminase and alkaline phosphatase, along with histopathological analysis of liver tissue [39].

Another research determined the hepatoprotective effect of the extracts of the bark of the plant, *Pterocarpus*, against hepatotoxicity caused by carbon tetrachloride. The extract-treated groups had the regulated levels of biochemical markers of liver functioning, namely total bilirubin, serum protein, alanine aminotransferase, aspartate aminotransferase, and alkaline phosphatase activities [40].

Antimicrobial activity:

Antimicrobial Antimicrobial Properties

To analyze the antibacterial effect of a stem methanolic extract on Escherichia coli and Bacillus coagulans, Gram-negative bacteria, another method was the paper disc diffusion technique.

At the level of 100mg ml -1, the growth of the two strains of the bacteria was greatly inhibited.

The antimicrobial activity of four particular Gram-positive and Gram-negative bacterial species was exhibited when they were subjected to hexane, ethyl acetate, and methanol prepared bark and leaf extracts of Pterocarpus marsupium.

Another study also indicated promising antimicrobial activities against Candida albicans and against two Gram-positive microbes (Enterococcus spp. and Staphylococcus aureus) and two Gram-negative ones (Escherichia coli and Pseudomonas aeruginosa).

Cyclic voltammetry was used to determine the antimicrobial Bacillus polymyxa, Vibrio cholerae and Candida albicans against the ethanolic extract. The anodic peak potentials were low, the anodic currents were low, which indicated that the active molecules have high reducing powers and the extract has a strong antioxidant potential. It was also found that the antimicrobial activity is significant at a series of dosage.

Extracts of stem bark of pterocarpus marsupium have been found to have antibacterial activity. Gram-negative bacteria (Escherichia coli and Gram-positive bacteria) and Gram-positive bacteria (Bacillus

coagulans and Escherichia coli) were utilized to determine the antimicrobial activity. The disc diffusion assay was done to establish the inhibition areas and Pterocarpus marsupium showed significant findings against the two bacterial groups.

Pterocarpus marsupium bark extracts were also tested using the disc diffusion method to determine their antimicrobial effect on the aqueous and methanol extracts. The findings revealed that Pseudomonas aeruginosa (25 0 -1) and Enterococcus faecalis (12.5 0 -1) and Salmonella typhi (12.5 0 -1) had a zone of inhibition with the methanol extract having a strong effect. In general, Pterocarpus marsupium had a high antimicrobial activity on the microorganisms tested.

A repeat of the research was done to determine the antimicrobial properties of the ethanolic extract of Pterocarpus marsupium on Bacillus polymyxa and Vibrio cholerae. The low anodic currents and low anodic peak potentials were found to demonstrate that the active constituents have a high reducing capacity and the extract depicts strong antioxidant potential. These observations were in line with a strong antimicrobial effect in different doses.

The leaf, root, and stem bark fractions (extracted in dichloromethane, ethyl acetate, butanol, and methanol) had a broad-spectrum antibacterial effect although they were not effective against mold and this was especially evident in the butanol and methanol extracts.

The phytochemical reports show a high concentration of phenols, flavonoids, stilbenoid (including pterostilbene), tannin, and saponins, which are usually associated with antibacterial activity.

Antidiabetic activity:

Pterocarpus marsupium has been in use as an effective antidiabetic herb since antiquity. Its effects are β-cell restoration, anti-β-cell immunization, and the decrease in the glycaemic levels. Hypoglycaemic action of this species is an area that has received a lot of experiment studies of different mammal species including rats, dogs and rabbits. The findings suggest that, P. marsupium alleviates β-cell damage and enhances the recovery of islet repopulation, thus returning normalized insulin secretion to normalcy^50. In another study, alcoholic extracts and individual fractions of P. marsupium (toluene, chloroform, ethyl acetate and butanol) were demonstrated to have positive influences on the levels of blood glucose level^51.

The antidiabetic effects of the P. □. marsupium stemwood are observed in the ethanolic extract. The extract exhibited a better answer to plasma glucose reduction (57.56-59.96) at 200mg/kg and 400mg/kg after 180 minutes, respectively, when compared to the standard drug which is glimepiride (51.30-55.13). The extract had an antidiabetic effect that was dose- and time-dependent 52.

Type 2 diabetes mellitus (T2DM) is associated with reduced quality of life, economic cost, and a continuum of acute and chronic complications, which constitute most death-related diabetes outcomes. There are also estimated 463 million diabetic patients aged between 20 and 79 years in 2019, which is expected to increase to 700 million patients in 2045^53]. Pharmacotherapy should be useful in the disease management. Modern allopathic medicines against diabetes are usually a time-consuming agent, and multiple doses have to be administered daily and this type of medication is usually lifelong. Despite the existence of chemical hypoglycaemic drugs, such as metformin acarbose and meglitinides, they are implicated in such adverse events like hepatotoxicity, diarrhoea, gastric discomfort, gastrointestinal disturbance, and increased cardiovascular risk54.

There is an increase in the use of natural products that have a lesser adverse effect compared to synthetic drugs in the management of diabetes and its complications. They have potent antioxidant properties that can overcome oxidative stress and reduce the damage of cells, providing new treatment options to diabetes mellitus. Based on this, phytochemicals have the potential to act as useful substitutes of allopathic agents^55.

The antidiabetic potential of P. marsupium has not been exploited despite this compound possessing a great variety of bioactive phytochemicals. The mechanistic ground of its antidiabetic action was studied in the present research, and it will help to shape the creation of cost-efficient, minimum side-effects therapeutic interventions.

An in-vitro HepG2 cell model was used to assess the therapeutic effectiveness of a methanolic P.marsupium heartwood extract in-vitro (E)56.

Mechanism of action:

The antidiabetic effects of the Pterocarpus marsupium are mainly credited to the flavonoid epicatechin, which is known to boost insulin secretion, enhance diabetic glycemic absorption, and improve the insulin sensitivity in peripheral tissues. The constituents of the plant also suppress postprandial glycaemic excursions by inhibiting carbohydrate-hydrolysing enzymes alpha-glucosidase and alpha-amylase. Pterocarpus marsupium extracts have been found to significantly decrease the level of blood glucose in diabetic and normal animal models. In one such study, the insulin sensitivity of diabetic rats was greatly improved and the level of fasting glucose reduced with the use of the plant extract. Cup water made out of pterocarpus heartwood, was said to significantly lower the glycaemic index among type 2 diabetes patients as was found in another clinical study conducted in humans57.

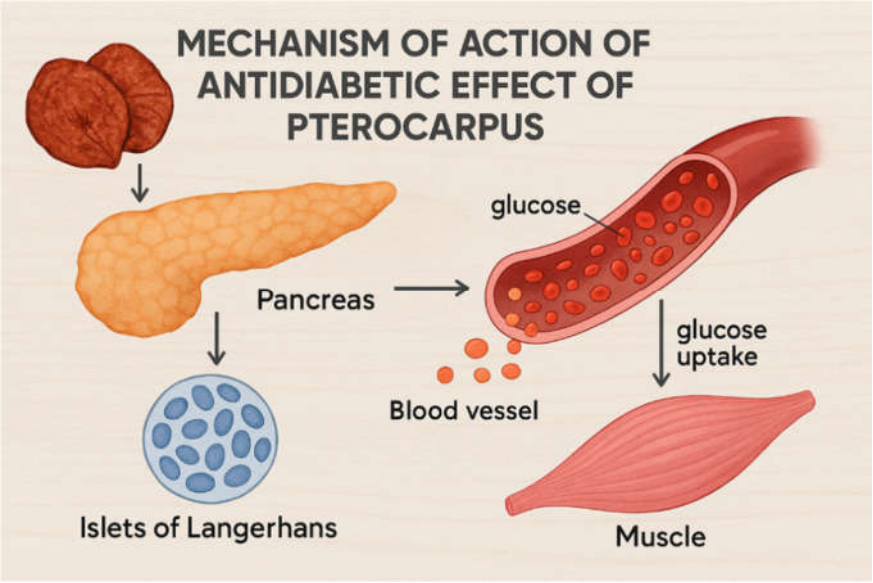

Fig. 3: Mechanism of Antidiabetic Action of *Pterocarpus marsupium*

Conclusion:

Pterocarpus marsupium has played a significant role in traditional medicine for centuries and is now receiving strong backing from modern research. Its bark, heartwood, leaves, and resin contain many active compounds, including flavonoids, tannins, and stilbenes, which have powerful effects against diabetes, inflammation, liver issues, infections, ulcers, and oxidative stress. Scientific studies support many of the traditional uses, especially its ability to lower blood sugar and protect the liver. The plant also shows potential in regenerating pancreatic beta cells, improving glucose uptake, and reducing complications from chronic diseases. Because it holds cultural significance alongside modern scientific proof, Pterocarpus has great potential for developing safe and affordable herbal medicines.

However, overharvesting and loss of habitat pose serious threats to this species. More clinical trials, sustainable harvesting, and conservation efforts are essential to fully harness its benefits while ensuring its survival.

References:

1. Basnayake PI, Gunatilake M. Pharmacological effects of Pterocarpus marsupium. BLDE University Journal of Health Sciences. 2024 Jan 1;9(1):3-15.
2. Okigbo RN, Eme UE, Ogbogu S. Biodiversity and conservation of medicinal and aromatic plants in Africa. Biotechnology and Molecular Biology Reviews. 2008 Dec;3(6):127-34.

3. Gamble JS. Flora of the Presidency of Madras. West, Newman and Adlard; 1928.
4. Kumar RS, Sivakumar T, Sundaram RS, Sivakumar P, Nethaji R, Gupta M, Mazumdar UK. Antimicrobial and antioxidant activities of Careya arborea Roxb. stem bark.
5. Viswanathan MV, Unnikrishnan PM, Komatsu K, Fushimi H, Basnet P. A brief introduction to Ayurvedic system of medicine and some of its problems. Indian J Tradit Knowl. 2003 Apr;2(2):159-69.
6. Katiyar D, Singh V, Ali M. Phytochemical and pharmacological profile of Pterocarpus marsupium: A review. The Pharma Innovation. 2016 Apr 1;5(4, Part A):31.
7. Gamble JS. Flora of the Presidency of Madras. West, Newman and Adlard; 1928.
8. Rahman MS, Mujahid MD, Siddiqui MA, Rahman MA, Arif M, Eram S, Khan A, Azeemuddin MD. Ethnobotanical uses, phytochemistry and pharmacological activities of Pterocarpus marsupium: A review. Pharmacognosy Journal. 2018, 10(6s).
9. Venkatesh P, Dinakar A, Senthilkumar N. Hepatoprotective activity of ethanolic extract of the stems of Anisochilus carnosus against carbon tetrachloride-induced hepatotoxicity in rats. International Journal of Health Research. 2010;3(3):179-83.
10. Sakshi parsutkar*, Dr. Anjali wankhade, Dr. Vivek Paithankar, Therapeutic Potential of Pterocarpus Marsupium: From Traditional Medicine to Modern Pharmacological Applications with Its Phytochemistry, Int. J. of Pharm. Sci., 2025.
11. Heald J, White RJ. International Legume Database & Information Service (ILDIS). Legumes of the world-CD-Rom.
12. Rao SP, Raju AS. Pollination ecology of the Red Sanders Pterocarpus santalinus (Fabaceae), an endemic and endangered tree species. Current Science. 2002 Nov 10:1144-8.
13. Kumar RS, Sivakumar T, Sundaram RS, Sivakumar P, Nethaji R, Gupta M, Mazumdar UK. Antimicrobial and antioxidant activities of Careya arborea Roxb. stem bark.
14. Soniya Pandey1, Sanyogita Shahi2* 1,2*Department of Chemistry Kalinga University, Raipur Chhattisgarh.
15. Mahakal N, Gulhane H, review article on Vijaysar (Pterocarpus Marsupium Roxb): a multidimensional herb, An International Journal of Research in AYUSH and Allied Systems. 2022 Apr; 9(2):138-142.
16. Ahmad A, Ahmad N, Anis M, Faisal M, Alatar AA, Abdel-Salam EM, Meena RP, Sivanesan I. Biotechnological Advances in Pharmacognosy and In Vitro Manipulation of Pterocarpus marsupium Roxb. Plants. 2022 Jan 18;11(3):247.
17. Devgan M, Nanda A, Ansari S. Pterocarpus marsupium Roxb. -A comprehensive review. Pharmacognosy reviews. 2009 Jul 1;3(6):359.
18. Badkhane Y, Yadav AS, Sharma AK, Raghuvanshi DK, Uikey SK, Mir FA, Lone SA, Murab T. Pterocarpus marsupium Roxb-Biological activities and medicinal properties. International Journal of Advances in Pharmaceutical Sciences. 2010 Oct 1;1(4).
19. Rao SP, Raju AS. Pollination ecology of the Red Sanders Pterocarpus santalinus (Fabaceae), an endemic and endangered tree species. Current Science. 2002 Nov 10:1144-8.
20. Warrier PK. Indian medicinal plants: a compendium of 500 species. Orient Blackswan; 1993.
21. Rahman MS, Mujahid MD, Siddiqui MA, Rahman MA, Arif M, Eram S, Khan A, Azeemuddin MD. Ethnobotanical uses, phytochemistry and pharmacological activities of Pterocarpus marsupium: a review. Pharmacognosy Journal. 2018;10(6s).
22. Katiyar D, Singh V, Ali M. Phytochemical and pharmacological profile of Pterocarpus marsupium: A review. Pharma Innov. J. 2016 Apr 1;5(4):31-9.
23. Basnayake PI, Gunatilake M. Pharmacological effects of Pterocarpus marsupium. BLDE University Journal of Health Sciences. 2024 Jan 1;9(1):3-15.
24. Badkhane Y, Yadav AS, Sharma AK, Raghuvanshi DK, Uikey SK, Mir FA, Lone SA, Murab T. Pterocarpus marsupium Roxb-Biological activities and medicinal properties. International Journal of Advances in Pharmaceutical Sciences. 2010 Oct 1;1(4).
25. Maurya R, Ray AB, Duah FK, Slatkin DJ, Schiff Jr PL. Constituents of Pterocarpus marsupium. Journal of Natural Products. 1984 Jan;47(1):179-81.
26. Jahromi MF, Ray AB, Chansouria JP. Antihyperlipidemic effect of flavonoids from Pterocarpus marsupium. Journal of natural products. 1993 Jul;56(7):989-94.

27. Babu PS, Prince PS. Antihyperglycemic and antioxidant effect of hypnoid, an ayurvedic herbomineral formulation in streptozotocin-induced diabetic rats. Journal of pharmacy and pharmacology. 2004 Nov;56(11):1435-42.
28. Abirami B, Gayathri P, Uma D. In vitro antioxidant potential of Pterocarpus marsupium bark. Int J Chem Pharm Sci. 2012; 3:17-24.
29. Kumaravel RS, Begum SF, Parvathi H, Kumar MS. Phytochemical screening and in vitro antioxidant activity of ethyl acetate leaf extracts of Pterocarpus marsupium Roxb (Fabaceae).
30. Sakshi parsutkar*, Dr. Anjali wankhade, Dr. Vivek Paithankar Department of Pharmacology, Vidhyabharti college of Pharmacy, camp road, Amravati 444601, Maharashtra India
31. Yadav M. Herbal drugs and phytoconstituents useful for the management of diabetes. International Journal of Green Pharmacy (IJGP). 2017 Apr 17;11(01).
32. Rahman MS, Mujahid MD, Siddiqui MA, Rahman MA, Arif M, Eram S, Khan A, Azeemuddin MD. Ethnobotanical uses, phytochemistry and pharmacological activities of Pterocarpus marsupium: a review. Pharmacognosy Journal. 2018;10(6s).
33. Devipriya D, Gowri S, Nideesh TR. Hepatoprotective effect of Pterocarpus marsupium against carbon tetrachloride induced damage in albino rats. Anc Sci Life. 2007 Jul;27(1):19-25. PMID: 22557255; PMCID: PMC3330841.
34. Mankani KL, Krishna V, Manjunatha BK, Vidya SM, Singh SJ, Manohara YN, Raheman AU, Avinash KR. Evaluation of hepatoprotective activity of stem bark of Pterocarpus marsupium Roxb. Indian journal of pharmacology. 2005 May 1;37(3):165-8.
35. Hussain F, Malik A, Ayyaz U, Shafique H, Rana Z, Hussain Z. Efficient hepatoprotective activity of cranberry extract against CCl4-induced hepatotoxicity in Wistar albino rat model: Down-regulation of liver enzymes and strong antioxidant activity. Asian Pacific journal of tropical medicine. 2017 Nov 1;10(11):1054-8.
36. Bulle S, Reddy VD, Padmavathi P, Maturu P, N Ch V. Modulatory role of Pterocarpus santalinus against alcohol-induced liver oxidative/nitrosative damage in rats. Biomed Pharmacother. 2016 Oct; 83:1057-1063. doi: 10.1016/j.biopha.2016.08.031. Epub 2016 Aug 19. PMID: 27544549.
37. Lawal B, Shittu OK, Oibiokpa FI, Berinyuy EB, Mohammed H. African natural products with potential antioxidants and hepatoprotectives properties: a review. Clinical Phytoscience. 2016 Nov 9;2(1):23.
38. Watkins PB. Role of cytochromes P45O in drug metabolism and hepatotoxicity. In Seminars in liver disease 1990 Nov (Vol. 10, No. 04, pp. 235-250). 1990 by Thieme Medical Publishers, Inc.
39. Manjunatha, B. K. Hepatoprotective activity of Pterocarpus santalins L.f., an endangered medicinal plant. Indian Journal of Pharmacology 38(1): p 25-28, Jan–Feb 2006. | DOI: 10.4103/0253-7613.19848
40. Mankani KL, Krishna V, Manjunatha BK, Vidya SM, Singh SJ, Manohara YN, Raheman AU, Avinash KR. Evaluation of hepatoprotective activity of stem bark of Pterocarpus marsupium Roxb. Indian journal of pharmacology. 2005 May 1;37(3):165-8.
41. Sharma N, Kachhawa JB, Tyagi S, Gupta RS, Sharma KK. In vitro evaluation of antibacterial activity of Pterocarpus marsupium Roxb. International Journal of Pharmacy and Pharmaceutical Sciences. 2012; 4:67-8.
42. Gayathri M, Kannabiran K. Antimicrobial activity of Hemidesmus indicus, Ficus bengalensis and Pterocarpus marsupium roxb. Indian journal of pharmaceutical sciences. 2009 Sep;71(5):578.
43. Bhat V, Nayak SB, Ballal M, Baliga SB. Evaluation of phytochemical and antimicrobial properties of heart wood of Pterocarpus marsupium Roxb (Fabaceae). World Journal of Pharmaceutical Research. 2014 Jun 20;3(6):1454-8.
44. Deepa R, Manjunatha H, Krishna V, Kumara Swamy BE. Evaluation of antimicrobial activity and antioxidant activity by electrochemical method of ethanolic extract of Pterocarpus marsupium Roxb bark. Journal of Biotechnology & Biomaterials. 2014 Nov 15;2014.
45. Sharma N, Kachhawa JB, Tyagi S, Gupta RS, Sharma KK. In vitro evaluation of antibacterial activity of Pterocarpus marsupium Roxb. International Journal of Pharmacy and Pharmaceutical Sciences. 2012; 4:67-8.
46. Londonkar RL, Hugar AL. Physicochemical, phytochemical pro ling and anti-microbial activity of Pterocarpus marsupium. International Journal of Pharmaceutical Sciences and Research. 2017;8(5):2177.

47. Deepa R, Manjunatha H, Krishna V, Kumara Swamy BE. Evaluation of antimicrobial activity and antioxidant activity by electrochemical method of ethanolic extract of Pterocarpus marsupium Roxb bark. Journal of Biotechnology & Biomaterials. 2014 Nov 15;2014.
48. Khan MR, Omoloso AD. Antibacterial activity of Pterocarpus indicus. Fitoterapia. 2003 Sep;74(6):603-5. doi: 10.1016/s0367-326x (03)00149-7. PMID: 12946726.
49. Patel P, Bharadwaj HR, Al Ta'ani O, Khan S, Alsakarneh S, Malik S, Hayat U, Gangwani MK, Ali H, Dahiya DS. Updates and Current Knowledge on the Common Forms of Gastroenteritis: A Review. Journal of Clinical Medicine. 2025 May 15;14(10):3465.
50. Vats V, Grover JK, Rathi SS. Evaluation of anti-hyperglycaemic and hypoglycaemic effect of *Trigonella Foenum-graecum Linn,* Ocimum sanctum Linn and Pterocarpus marsupium Linn in normal and alloxanized diabetic rats. Journal of ethnopharmacology. 2002 Feb 1;79(1):95-100.
51. Dhanabal SP, Kokate CK, Ramanathan M, Kumar EP, Suresh B. Hypoglycaemic activity of Pterocarpus marsupium Roxb. Phytotherapy Research: An International Journal Devoted to Pharmacological and Toxicological Evaluation of Natural Product Derivatives. 2006 Jan;20(1):4-8.
52. Pant DR, Pant ND, Yadav UN, Khanal DP. Phytochemical screening and study of antioxidant, antimicrobial, antidiabetic, anti-inflammatory and analgesic activities of extracts from stem wood of Pterocarpus marsupium Roxburgh. Journal of Intercultural Ethnopharmacology. 2017 Apr 12;6(2):170.
53. Idf ID. Diabetes atlas. Ninth edition Ninth edition. 2019 Aug 11.
54. Balbi ME, Tonin FS, Mendes AM, Borba HH, Wiens A, Fernandez-Llimos F, Pontarolo R. Antioxidant effects of vitamins in type 2 diabetes: a meta-analysis of randomized controlled trials. Diabetology & metabolic syndrome. 2018 Mar 14;10(1):18.
55. Dar MI, Rafat S, Dev K, Abass S, Khan MU, Abualsunun WA, Murshid SS, Ahmad S, Qureshi MI. Heartwood extract of Pterocarpus marsupium Roxb. offers defense against oxyradicals and improves glucose uptake in HepG2 cells. Metabolites. 2022 Oct 5;12(10):947.
56. Bhat V, Nayak SB, Ballal M, Baliga SB. Evaluation of phytochemical and antimicrobial properties of heart wood of Pterocarpus marsupium Roxb (Fabaceae). World Journal of Pharmaceutical Research. 2014 Jun 20;3(6):1454-8.
57. Sitaram SS. *Mechanistic studies on antidiabetic activity of Pterocarpus marsupium and ITK formulation in rats* (Doctoral dissertation, Pandit Deen Dayal Upadhyaya Pashu Chikitsa Vigyan Vishwavidyalaya).