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Antihyperglycemic Effects of *Pterocarpus marsupium* (Vijaysar): Bridging between Folk knowledge and scientific validation. A review

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ABSTRACT

Pterocarpus marsupium, commonly known as Vijaysar or Indian Kino, is an Ayurvedic wood for managing type 2 diabetes and related metabolic disorders. Historically revered for its blood sugar regulating effects, this tree's heartwood and bark are being rigorously studied to understand and validate its antidiabetic properties. A concise summary highlighting the plant's traditional use, phytochemicals, mechanisms of action â cell regeneration, insulin-mimetic effects, antioxidant action, animal and human studies demonstrating significant blood glucose reduction is needed. This paper bridges traditional usage and scientific evidence, spotlighting phytochemical mechanisms, clinical outcomes, and potential therapeutic integration.

Figure : 03 References : 26 Table : 01
KEY WORDS : Ethnopharmacological context, Marsupsin, Pterostilbene, Pterosupin

Introduction

Diabetes mellitus is a chronic endocrine disorder where the body's ability to regulate blood sugar (glucose) is impaired either due to insufficient insulin production by the pancreas or the body's inability to use insulin effectively. This results in persistently high blood glucose levels, which, if unmanaged, can damage the heart, kidneys, eyes, nerves, and other organs. Approximately 537 million adults live with type 2 diabetes in the world and in India, around 77 million people have diabetes, affecting nearly 9% of the population. This type of global burden of type 2 diabetes; needs for safer herbal remedies[14].

Vijaysar, scientifically known as *Pterocarpus marsupium*, is a medium- to large-size deciduous tree native to the Indian subcontinent, including regions of India, Nepal, and Sri Lanka. Commonly referred to as the Indian Kino Tree or Malabar Kino, it holds a significant place in traditional Ayurvedic medicine, particularly for its potent anti-diabetic properties. The antihyperglycemic effects of Vijaysar *(Pterocarpus marsupium)* have been extensively documented in various studies, highlighting its potential as a natural remedy for "Madhumeha" diabetes management[18,26]. This plant, rich in bioactive compounds, exhibits multiple pharmacological activities that contribute to its efficacy in lowering blood sugar levels. Traditionally, water is stored overnight in tumblers made from Vijaysar wood, turning the water reddish-brown. Drinking this water on an empty stomach is believed to help manage diabetes[29].

Additionally, Vijaysar is available in various forms, such as powders, capsules, and decoctions, often used under the guidance of healthcare professionals. Vijaysar *(Pterocarpus marsupium)* is a valuable medicinal plant with a long-standing history in traditional medicine.offering a range of health benefits, particularly

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TABLE-1 : A detailed elaboration with chemical structures and key properties

Compound	Class	Source Part	Structure & Key Functional Groups	Bioactivity Highlights
(-)Epicatechin	Flavan3ol (Flavonoid)	Bark	Flavan core with multiple –OH groups	Promotes insulin secretion and cell regeneration (coconut. natural products.net, phcogrev.com).
Marsupsin	Phenolic stilbenoidlike	Heart-wood	Stilbene backbone with glycosidic link	Enhances glycolysis, improves glucose uptake; shows antidiabetic potential.
Pterostilbene	Stilbenoid (dimethoxy-transstilbene)	Heart-wood	Transstilbene with two methoxy and one hydroxyl (see images above); IUPAC: *4[(E)2(3,5dimethoxyphenyl) ethen1yl]phenol*. High lipophilicity and bioavailability	Antioxidant, insulinlike, enhances glycolysis, inhibits intestinal glucose uptake, shows metforminlike effects and DPP4 activity, and has hypoglycemic effects in STZ diabeticrats .
Pterosupin	Cglycosyl αhydroxy dihydrochal-cone	Roots	Cglycoside attached to dihydrochalcone backbone	Inhibits áglucosidase / αamylase and contributes to antioxidant effects.
Carsupin, Marsupol, Propterol, Garbanzol, Liquiritigenin, Isoliquiritigenin	Phenolics & flavonoids	Leaves, branches, heart-wood, roots	Varied flavonoid/phenolic scaffolds: garbanzol (flavonol), liquiritigenin (flavanone), isoliquiritigenin (chalcone)	Contribute to antioxidant, antiinflammatory effects and inhibit carbohydratedigesting enzymes.
Tannins & Polyphenols	Polyphe-nolic mix	Bark, stem, roots	Highmolecularmass polyphenols	Scavenge free radicals and inhibit αglucosidase/ αamylase—reducing postprandial glucose .

Compound	Class	Source Part	Structure & Key Functional Groups	Bioactivity Highlights
2,3,6trimethyl 1,4na phthoquinone	Naphtho-quinone	Bark/ wood	Quinone ring with methyl substitutions	Adds antioxidant and possible MAO inhibitory properties.
DPP4 Inhibitors	Diverse phenolic/ peptidic molecules	Heart-wood extract	Not fully characterized	Shown to inhibit dipeptidyl peptidase 4, potentially improving incretin signaling

in managing diabetes and supporting liver and heart. Modern medicine faces challenges in managing type 2 diabetes long-term.Synthetic treatments carry side effects like gastrointestinal issues and cardiotoxicity. Hence ,scientific interest in traditional botanicals like *Pterocarpus marsupium* is growing owing to its rich phytochemicals and historical efficacy[9] .

This paper explores ethnopharmacological roots, phytochemical constituents, *in vitro* and in vivo mechanistic studies, antihyperglycemic efficacy with aim to connect folk usage with scientific evidence.

Botanical Profile[3]

- **Family**: Fabaceae (Leguminosae)
- **Height**: Up to 30 meters
- **Leaves**: Compound, imparipinnate with 5–7 leaflets
- **Flowers**: Bright yellow, fragrant, arranged in terminal panicles
- **Fruit**: Flat, circular pods with winged margins
- **Heartwood**: Golden yellow to reddish-brown, exudes a reddish resin known as kino

Ethnopharmacological Context

In Ayurveda, Vijaysar is esteemed as a "Rasayana" herb, denoting its rejuvenating and restorative properties. The heartwood and bark are primarily utilized for their therapeutic benefits, which include [1,5,26]

1. **Antidiabetic** -Helps regulate blood sugar levels by enhancing insulin secretion and sensitivity.
2. **Hepatoprotective**-Protects liver cells from damage due to its antioxidant properties.
3. **Cardioprotective**-Aids in lowering cholesterol levels and improving heart health.
4. **Antiinflammatory and Antimicrobial-**Effective against various infections and inflammatory conditions.
5. **Gastrointestinal Benefits**-Used in treating diarrhea, dysentery, and other digestive disorder.

Early clinical reports[5] documented preliminary antidiabetic effects in humans, but lacked modern controls[7].

Phytochemistry of *Pterocarpus marsupium*

Extensive phytochemical analyses have revealed that *P. marsupium* is rich in phenolic acids, flavonoids, stilbenoids, tannins, alkaloids, terpenoids, and quinones.

Key Bioactive Constituents

- (-) Epicatechin: A flavan-3-ol abundant in bark, known for insulinotropic effects and αcell regeneration [3].
- Marsupsin and Pterostilbene: Phenolic stilbenoids isolated from heartwood; exhibit insulin like metabolic actions by enhancing glycolysis, inhibiting intestinal glucose uptake, and mimicking metformin like effects [16].
- Pterosupin, Carsupin, Marsupol, Propterol, Garbanzol, Liquiritigenin, Isoliquiritigenin, among others identified *via* LCMS profiling across leaves, branches, heartwood and roots [16].
- Tannins and Polyphenols: High levels in bark and stem; demonstrate antioxidant and carbohydrate digesting enzyme inhibition (á-glucosidase, áamylase) [20].
- Naphthoquinones and alkaloids: Minor constituents such as 2,3,6trimethyl1, 4naphthoquinone add to the plant's pharmacological properties [20].
- DPP4 inhibitory compounds: Heartwood extracts show promise in inhibiting dipeptidyl peptidase4 (akin to sitagliptinclass drugs), suggesting potential incretin enhancing action.

Structure Highlights

Pterostilbene

- **Structure**: transstilbene core with two methoxy groups (–OCH*ƒ*) at positions 32 and 52 , and a hydroxyl (–OH) at position 42 .
- **Key features**: Enhanced lipophilicity and metabolic stability due to methoxy substitutions, compared with resveratrol.
- **Pterostilbene** features a doublebonded aromatic scaffold with two methoxy (OCH*ƒ*) groups and a single hydroxyl group, lending increased cell permeability and metabolic stability compared to resveratrol.

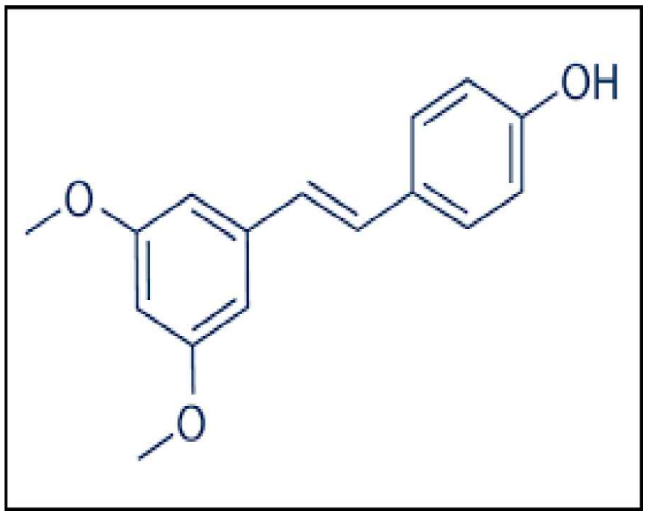

Fig. 1 : Structure of Pterostibene

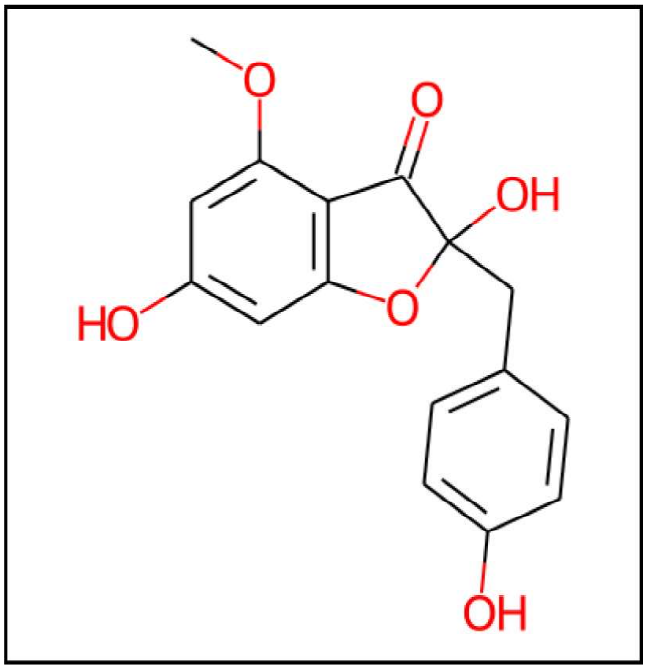

Fig. 2 : Structure of Marsupsin

Marsupsin

- **Structure**: **1benzofuran3(2H)one** core; hydroxy groups at C2 and C6; a methoxy group at C4; plus a 4hydroxybenzyl substituent at C2
- **Key features**: Benzofuranone scaffold supports antihyperglycemic effects through glycosylation potential and metabolic activity (commonchemistry.cas.org)
- **Marsupsin** retains the stilbenelike structure but is glycosylated, which can influence its solubility and bioavailability.

Pterosupin

- **Structure**: Cglycosylâhydroxydihydrochalcone — a dihydrochalcone backbone with a sugar moiety (âDglucopyranosyl) linked directly to the aromatic ring.
- **Key features**: Unique Cglycosylation contributes to stability and enzymeinhibitory activity (*e.g.,* áglucosidase) .

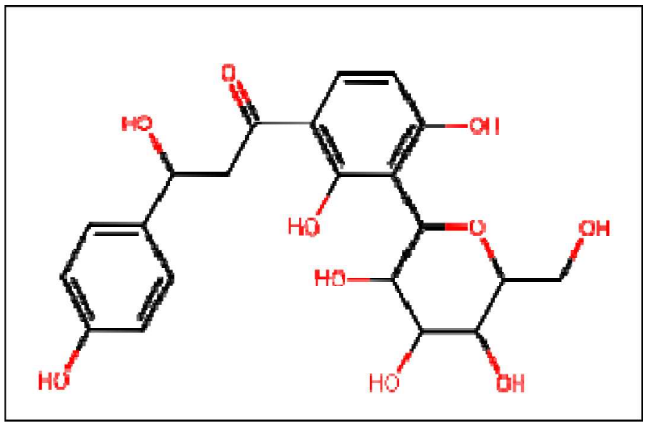

Fig. 3 : Structure of Pterosupin

- **Pterosupin**, identified as a chalcone glycoside, possesses both a flavonoid core and sugar attachment, enhancing enzyme inhibitory effects (degruyterbrill.com).

The phytochemical richness of *P. marsupium* from insulinotropic flavonoids like epicatechin to metforminlikestilbenoids such as marsupsin and pterostilbene underpins its multifaceted antidiabetic actions. The structural variety and synergistic effects contribute to enzyme inhibition, âcell support, antioxidant protection, and DPP4 inhibition, bridging traditional usage with modern therapeutic potential.

Mechanisms of Antihyperglycemic Action

(-)Epicatechin significantly enhances βcell regeneration and insulin secretion in alloxan/STZ induced diabetic models demonstrated *via* histological pancreas studies and increased circulating insulin levels

.Bark and heartwood extracts promote insulin release, reflected in improved glycemic control [17,19].

Marsupsin and pterostilbene mimic insulin by activating glycolytic enzymes and inhibiting intestinal glucose transporters, akin to metformin's actions .Heartwood methanolic extract enhances glucose uptake and GLUT transporter expression in HepG2 liver cells . Bark extracts—rich in tannins and phenolics how strong inhibitory activity against áamylase and áglucosidase, reducing postprandial hyperglycemia *in vitro.* Rich polyphenolic content confers high free radical scavenging ability (DPPH IC… € ~20–100/ µg/mL depending on part), combating oxidative stress, a key driver of βcell damage.[20,26]

In HepG2 models, heartwood extracts significantly reduced ROS and lipid peroxidation while improving mitochondrial and insulin signaling pathways .Heartwood extracts inhibit DPP4, potentially elevating endogenous GLP1, enhancing insulin release and lowering glucagon, which supports glycemic control. Pterostilbene inhibits platelet aggregation (91% at 50/ µM), benefiting vascular health in diabetics. Heartwood extracts display COX2 inhibition, reducing inflammatory stress in metabolic and diabetic contexts [8].

The combined actions of *Pterocarpus marsupium* and its phytochemicals offer a multifaceted approach to diabetes management. Regeneration of âcells enhances endogenous insulin production and restore pancreatic function.Activation of glycolytic pathways and improved glucose uptake enhance insulin sensitivity and helps in Insulin Mimicry and Sensitization.Suppression of amylase and glucosidase activities reduces postprandial glucose spikes and inhibit Carbohydrate Digestion. Reduction of oxidative stress and inflammation preserves cellular function.DPP4 inhibition increases GLP1 levels, promoting insulin secretion and reducing glucagon levels..Antiinflammatory effects and platelet aggregation inhibition support cardiovascular health.[6,11,20,22]

In Vivo Animal Studies

In rats/mice, streptozotocin- or alloxan-induced diabetic models showed significant reductions in fasting and postprandial glucose, improved OGTT results, and restored body weight, serum enzymes, and insulin levels after *Pterocarpus marsupium* extract (100–400/ mg/kg) administration. Postprandial glucose dropped from ~301/ mg/dL to ~112/ mg/dL (100–200/ mg/kg dose) within 4 weeks.[10,22]

100–200/ mg/kg aqueous heartwood extract reduced fasting/postprandial glucose and TNFá by 21.[9] bark/wood extracts showed potent hypoglycemic activity. In PIT-induced rats, extract improved metabolic profile under fructose load[7,15]. Comparison with pioglitazone: ethanol extract (12/ g/kg) showed comparable effects against dexainduced insulin resistance[24].Silver nanoparticles enhanced antidiabetic effects in rat models.[3]

In Vitro Studies

The extract derived from methanol-infused heartwood has been shown to significantly bolster the defense mechanisms against reactive oxygen species (ROS) and facilitate the uptake of glucose in HepG2 liver cells that are subjected to stress induced by elevated glucose levels, thereby indicating a potential therapeutic role in metabolic dysfunctions. Furthermore, it has been observed that phenolic C-glycosides extracted from the n-butanol fraction exhibit a remarkable ability to enhance glucose transport in C_2C_{12} skeletal muscle cells, and this enhancement occurs in a manner that is directly proportional to the increasing doses administered, which underscores the importance of dosage in the modulation of glucose metabolism at the cellular level[2].

Human and Clinical Evidence

A double-blind RCT showed that wood extract's glycemic control matched tolbutamide in type 2 diabetics[12]. A 12-week open-label study in 56 type 2 diabetic patients (on glimepiride/ +/ metformin ± pioglitazone) showed that adding 2–4/ g/day of *Pterocarpus marsupium* wood powder significantly lowered fasting and postprandial glucose and HbA1c with no adverse events. Limited human studies, but extracts have shown COX_2 inhibition and metabolic benefits in healthy volunteers.[13]

Safety and Interactions

High-dose *Pterocarpus marsupium* extracts (100–400/ mg/kg) in animal models were **well tolerated**, with normalization of liver enzymes. Potential interactions include **hypoglycemia risk** when combined with standard drugs and theoretical **antiplatelet effects** due to pterostilbene's COX_2 inhibition, which may affect bleeding risk. Human safety data are limited; we need targeted pharmaco vigilance[26].

Conclusion

Pterocarpus marsupium embodies a successful model of translating traditional herbal knowledge into validated scientific therapeutics. Its heartwood extracts contain active molecules such as epicatechin and pterostilbene that affect glucose metabolism through diverse mechanisms. With robust preclinical and emerging clinical data, *Pterocarpus marsupium* has credible potential as an adjunct in type 2 diabetes

management. *Pterocarpus marsupium* displays significant antihyperglycemic, insulinotropic, antiinflammatory, and antioxidant effects—validating traditional use and positioning it as a promising candidate for complementary diabetes management. Multimodal antihyperglycemic actions confirmed *in vitro,* in animals, and in preliminary human trials. â-cell preservation, antioxidant capacity, metabolic improvements, and comparable efficacy to standard drugs are the strengths of vijaysar. Rigorous profiling of compound concentrations (*e.g.,* marsupsin, pterostilbene), compare isolated pure compounds with holistic extracts, Further evaluation of GLUTs, AMPK pathways, and â-cell signaling are required. Cumulatively, these data validate folk claims of Vijaysar's antidiabetic efficacy. Repeated glucose-lowering effects across diverse models, parallel â-cell regeneration and insulin upregulation, reduced inflammation and oxidative stress, and lipid-modulating benefits. While compelling, most studies remain preclinical. Shortcomings include limited clinical trials, variation in extract standardization, and mechanistic pathways incompletely defined. Human trials focused on bioavailability, pharmacodynamics, and long-term efficacy. *Pterocarpus marsupium* exhibits promising antidiabetic potential *via* multiple pharmacological pathways with minimal toxicity. Further clinical validation is strongly warranted.

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