

# Ethnobotanical Uses, Phytochemistry and Pharmacological Activities of *Pterocarpus marsupium*: A Review

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## ABSTRACT

*Pterocarpus marsupium* is an important therapeutic and medicinal plant belonging to family Fabaceae and commonly named as Indian Kino tree, Bijasal, Venga or Vijayasara. It is a huge deciduous plant and widely distributed in the Central, Western and Southern regions of India. Role of *P. marsupium* is found in Ayurveda, Homeopathic and Unani systems of medicine. It is a decent source of tannins and flavonoids hence, used as influential astringent, anodyne, cooling, regenerating agent and also used for the treatments of leprosy, leucoderma, toothache, fractures, diarrhea, passive hemorrhage, and dysentery, bruises and diabetes. It is also used to treat rheumatoid arthritis, gout, diabetic anemia, indigestion, asthma, cough, discoloration of hair, bronchitis, ophthalmic complications, elephantiasis and erysipelas. Researchers have been stated the presence of several phytoconstituents in *P. marsupium* and also their pharmacological activities. The current review aimed to define the phytochemical and pharmacological aspects of *P. marsupium* which will have been help in the researchers for further qualitative research.

**Key words:** *Pterocarpus marsupium*, Indian Kino, Phytochemistry, Pharmacology, Antidiabetic, Antioxidant, Tannin, Epicatechin.

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## INTRODUCTION

Plants are important to human being for his life. Plants are continuously a common source of remedy in the usage of traditional preparations. All plants phyla produce authorized and unauthorized product of therapeutic importance. The antiquity of herbal remedy is as ancient as human society. The treasure of India is stored in the vast natural flora, which has been boon to mankind. India is virtually herbarium of the planet.<sup>1-2</sup> Although the biologically active phytoconstituents of certain herbal drugs are unknown, they are prescribed commonly owing to their efficacy, least side effects in clinical information and comparatively very low costs.<sup>3</sup>

*Pterocarpus marsupium* plant belonging to family Fabaceae has been used in India and its adjacent countries due to its various biological activities from ancient times. All parts of *P. marsupium* is used as a primitive medicine for domestic remedy against several human diseases. It has been broadly used in Homoeopathic, Ayurvedic and Unani systems of medicine.<sup>4-5</sup> It is a deciduous tree, generally known as Malabar or Indian Kino tree (Table 1).<sup>6-7</sup> It is present especially in Western Ghats areas, Karnataka-Kerala regions and found in Madhya Pradesh, Bihar, Gujarat and Orissa.<sup>8</sup> Traditionally, the plant product are being used as cooling, external application as anthelmintic, headache, anti-pyretic, anti-inflammatory, aphrodisiac, in mental aberrations, biliousness and ulcers.<sup>9</sup> Phytochemical

studies have revealed that the plant contains terpenoids, aurone and isoflavonoids glycosides and associated phenolic compounds, lupenol, epicatechin,  $\beta$ -sitosterol.<sup>10</sup> *P. marsupium* is the very rich sources of flavonoid and polyphenolic compounds.<sup>11</sup> Its heartwood possesses anti-inflammatory, astringent, anodyne and antidiabetic properties and also cataract, hypertriglyceridemia, cardiotoxic, hepatoprotective activity and as a selective inhibitor of COX-2.<sup>12-15</sup>

## Characteristics

*P. marsupium* is a large, deciduous plant which can grow up to 30 meters in height.<sup>18</sup> Its stem bark is of grey brown color. Heart wood is yellowish golden in color and bark products are reddish gum.<sup>19-20</sup> Leaves are large green colored, compound, imparipinnate and having 3-7 inches length, 5-8 leaflets, margin curly and thick. From leaflet to leaflet, the petioles are round, flat, undulated and long up to 5 or 6 inches and not having stipules.<sup>19-20</sup> Different parts of *P. marsupium* are shown in Figure 1. Flowers are 1.5 cm long, white with a minor yellow tinge with 10 stamens. Anthers are 2 lobed.<sup>19</sup> Pods are brown, glabrous, flat, orbicular, winged like, 3-6 cm in width, usually single seeded and curved convexly. There are almost 1500-2000 pods/kg.<sup>21</sup> Seeds are kidney shaped 1 to 1.3 centimeter long, reddish

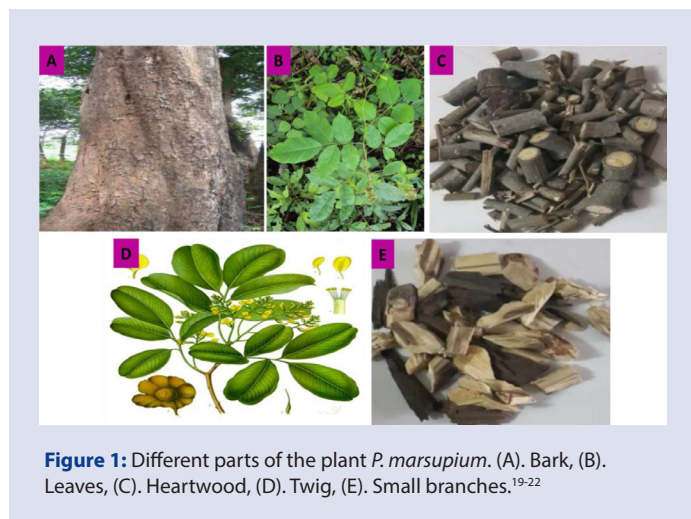
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**Table 1: Scientific classification and vernacular names of *Pterocarpus marsupium*.**

Scientific classification <sup>1</sup>	Vernacular names. <sup>16,1,17</sup>
<b>Synonym:</b> IndianKino, Bijasal, Vijayasagar, Bibla, Malbar kino.	<b>Urdu:</b> Bijasar
<b>Family:</b> Fabaceae.	<b>Sanskrit:</b> Bijaka, Pitasara, Asana, Bijasara
<b>Domain:</b> Eukaryota.	<b>Assamese:</b> Aajar
<b>Kingdom:</b> Plantae.	<b>Bengali:</b> Piyasala, Pitasala
<b>Subkingdom:</b> Viridaeplantae.	<b>English:</b> Indian Kino
<b>Phylum:</b> Magnoliophyta.	<b>Gujrati:</b> Biyo
<b>Subphylum:</b> Euphyllphytina.	<b>Hindi:</b> Vijayasara, Bija
<b>Class:</b> Magnoliopsida.	<b>Kannada:</b> Bijasara, Asana
<b>Subclass:</b> Rosidae.	<b>Kashmiri:</b> Lal Chandeur
<b>Super order:</b> Fabanae.	<b>Malayalam:</b> Venga
<b>Order:</b> Fabales.	<b>Marathi:</b> Bibala
<b>Genus:</b> <i>Pterocarpus</i> .	<b>Oriya:</b> Piashala
<b>Species:</b> <i>Marsupium</i> .	<b>Punjabi:</b> Lal Chandan, Channanlal
	<b>Tamil:</b> Vengai
	<b>Telugu:</b> Yegi, Vegisa

**Table 2: Traditional uses of various parts of *Pterocarpus marsupium*.**

Plant part(s)	Uses	References
Leaves	Fractures, constipation, hemorrhages skin diseases, depurative, ophthalmology, leprosy, rectalgia, and leucoderma, rheumatoid arthritis, skin diseases, external use for sores, boils, stomach pain and gastrointestinal disorders.	[1,25,26,2,19,16]
Bark	Diuretic, cholera, dysentery, stomachache, tongue diseases, urinary complaints and toothache, astringent, treatment of tumors of the gland, urethral discharges, chronic ulcers, abortifacient.	[27,16]
Stem	Neurological problems.	[1,25]
Heartwood	Control blood sugar level.	[1,25,26]
	Astringent, bitter acrid, anti-inflammatory, anthelmintic, anodyne	[12]
Flower	Fever.	[16]
Gum-Kino	Diarrhea, passive hemorrhages, leucorrhoea, dysentery.	

**Figure 1:** Different parts of the plant *P. marsupium*. (A). Bark, (B). Leaves, (C). Heartwood, (D). Twig, (E). Small branches.<sup>19-22</sup>

brown, fairly rigid with smooth glossy leathery testa.<sup>21</sup> Legume is swallowed on a lengthy, petiole is three, fourths or bicular, the upper remains, which spreads from pedicel to the rest of style is straight, the entire covered with a downy, waved, veiny, layered wing, enlarged, woody center and where seed is blocked and not opening.<sup>20</sup>

### Origin, distribution and habitat

*P. marsupium* is growing in defoliate and evergreen jungles of Southern, Western and Central regions of India. It is present generally in Gujarat, Bihar, West Bengal, Orissa, Uttar Pradesh, Western Ghats, Kerala, Karnataka, and Madhya Pradesh, of prominent India, Sri Lanka and Nepal. It develops generally on hills or undulating lands or rocky grounds up to a height of 150 to 1100 meter. The usual rainfall of its habitat ranges starting from 750 to 2000 mm and even more in Southern India. The maximum temperature was ranged from 35°C to 48°C and minimum temperature was ranged from 0°C to 18°C. It can increase in huge variety of soils and geographical situations like quartzite, shale, conglomerates, lateritic, gneiss and sandstone. It favors well-drained sandy and sedimentary soil to loamy soil. The species is adequate light loving and the young seedlings are frost-tender.<sup>18,21,23</sup>

### TRADITIONAL USES

*P. marsupium* has been traditionally used in the treatment of leucoderma, elephantiasis, diarrhea, cough, discoloration of hair and rectalgia.<sup>14</sup> It is nontoxic and useful in jaundice, fever, wounds, diabetes, stomachache and ulcer (Table 2 and 3).<sup>24</sup>

### PHYTOCONSTITUENTS

Earlier researchers recognized the plant *P. marsupium* as a very rich source of flavonoids and polyphenolic compounds. All the active phytoconstituents of *P. marsupium* were thermostable. It contains pterostilbene (45%), alkaloids (0.4%), tannins (5%) and protein.<sup>19</sup> The primary phytoconstituents were liquiritigenin, isoliquiritigenin, pterostilbene, pterosupin, epicatechin, catechin, kinotannic acid, kinoin, kino red,  $\beta$ -eudesmol, carsupin, marsupial, marsupinol, pentosan, *p*-hydroxybenzaldehyde (Table 4, Figure 2).<sup>16,28</sup>

### MARKETED PRODUCT

DRF/AY/5001 composed of *P. marsupium*, *Terminalia chebula*, *Emblica officinalis* and *Momordica charantia* extracts; Diabecon composed of *Pterocarpus marsupium*, *Glycyrrhiza glabra*, *Asparagus* and *Gymnema sylvestre* extracts; Diabeta composed of *Pterocarpus marsupium*, *Zingiber officinale*, *Acacia Arabica*, *Tinospora cordifolia*, *Curcuma langa*, *Gymnema sylvestre* and *Azadiractha indica* extracts; and Silbinol containing *P. marsupium* bark and heartwood extracts are the different marketed formulations of *P. marsupium*.<sup>39-44</sup>

### REPORTED PHARMACOLOGICAL ACTIVITIES OF PTEROCARPUS MARSUPIUM

#### Antidiabetic activity

The ethanolic extract of *P. marsupium* stem wood has antidiabetic activity. The highest blood glucose lowering effect (57.56%) was found in 180 min for standard drug glimepiride along with for ethanolic extract at a dose of 200 mg/kg b. wt. (51.30%) and at 400 mg/kg b. wt. (55.13%). The extract showed antidiabetic activity which is dose and time dependent.<sup>45</sup>

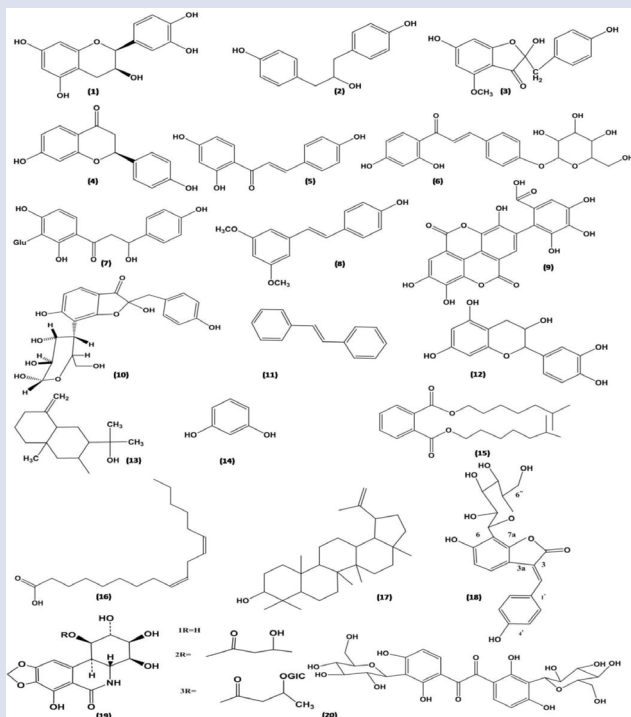
The ethanolic extract of heartwood (1gm/kg *per oral* and 2 gm/kg *per oral*) significantly ( $p < 0.05$ ) reduced the raised glucose levels in Wistar

**Table 3: Ethnobotanical uses of phytoconstituents from *Pterocarpus marsupium*.**

Phytoconstituent(s)	Biological activity	References
4-Hydroxy-4-methyl-2-pentanone	Antimicrobial.	[36]
Furan-2-one,3,4-dihydroxy-5-[1-hydroxy-2-fluoroethyl]	Antiviral.	
Benzoic acid, 2,6-bis[(trimethylsilyloxy)-trimethylsilyl] ester	Antifungal, antibacterial.	
1-Monolinoleoylglyceroltrimethylsilyl ether	Anti-inflammatory, antimicrobial, antiarthritic, antioxidant, antiasthma.	
Ethyl iso-allocholate	Anticancer, diuretic, antimicrobial, antiasthma, anti-inflammatory, antiarthritic.	
Milbemycin b, 13-chloro-5-demethoxy-28-deoxy-6,28-epoxy-5-(hydroxyimino)-25-(1-methylethyl)	Antiparasitic.	
3-O-Methyl-D-glucose	Preservative.	[32]
Tetradecanoic acid	Nematicide, lubricant anti-oxidant, hypocholesterolemic, cancer preventive.	
Dibutyl phthalate	Antimicrobial, antifouling.	
9,12-Octadecadienoic acid	Anti-inflammatory, insectifuge, hepatoprotective, cancer preventive, antiacne, 5- $\alpha$ -reductase inhibitor, antihistaminic.	
1,2-Benzenedicarboxylic acid and di-isooctyl ester	Antimicrobial, antifouling.	
Hexadecanoic acid, ethyl ester	Antioxidant, pesticide, nematocide, lubricant, hypocholesterolemic, flavor, antiandrogenic.	
Lupeol	Antibacterial, antioxidant, antitumor, cancer preventive, immunostimulant, chemopreventive, pesticide.	
Liquiritigenin, isoliquiritigenin, pterosupin	Antidiabetic, antihyperlipidemic.	[37]
Epicatechin	Antidiabetic, antihelmentic.	[37]
Pterostilbene	Blood glucose levels, Antioxidant and antitumor effects.	[38]
Marsupinol	Antihyperlipidemic.	[37]

**Table 4: Phytoconstituents from different parts of *Pterocarpus marsupium*.**

Extract from plant part(s)	Phytoconstituents	References
Gum kino from bark	Kinotannic acid, pyrocatechuic acid, kino-red, kinonin, pyrocatechin and minor quantities of pectin, gallic acid and resin.	[25,19]
Aqueous heartwood extract	3-( $\alpha$ -methoxy-4-hydroxybenzylidene)-6-hydroxybenzo-2(3H)-furanone-7-C- $\beta$ -D-glucopyranoside, 6-hydroxy-2-(4-hydroxybenzyl)-benzo-furan-7-C- $\beta$ -D-glucopyranoside, 2-glucopyranoside, 1,2-bis (2,4-dihydroxy-3-C-glucopyranosyl)-ethanedione, and 8-(C- $\beta$ -D-glucopyranosyl)-7,3,4-trihydroxyflavone, sesquiterpene and C- $\beta$ -D-glucopyranosyl-2,6-dihydroxyl benzene.	[20,25]
Ether extract of roots	6-hydroxy-3,5,7,4-tetramethoxyflavone-6-O-rhamnopyranoside, 8-hydroxy-4'-methoxyisoflavone-7-O-glucopyranoside, 2,4,6-trihydroxy-4-methoxybenzo(b)furan-3(2H)one, carpusin-1,3-bis(4-hydroxyphenyl)propan-2-ol, propterol, 1-(2,4-dihydroxyphenyl)-3-(4-hydroxyphenyl)propan-2-ol, propterol-6-hydroxy-7-O-methyl-3-(3-hydroxy-4-O-methylbenzyl) chroman-4-one.	[29,30,31,26]
Ethyl acetate extract of root	Marsupin, pterosupin, stilbene, dihydro-chalcone, pterostilbene, benzofuranone, homoisoflavone, <i>trans</i> -stilbene, isoliquiritigenin, pteromarsupone and liquiritigenin.	[25,19]
Methanolic extract of heart wood	7-O- $\alpha$ -L-rhamnopyranosyloxy-4'-methoxy-5-hydroxy-isoflavone, irisolidone-7-rhamnoside, retusin-7-glucoside, 5,7-dihydroxy-6-methoxyisoflavone-7-rhamnoside, 2,6-dihydroxy-2-( <i>p</i> -hydroxybenzyl)-3(2H)-benzofuran-7-C- $\beta$ -D-glucopyranoside.	[2,32,33,19]
Heartwood extract	4,6,3',4'-tetrahydroxy-aurone-6-O-rhamnopyranoside, 6,4'-dihydroxy-7-methylaurone 6-O-rhamnopyranoside.	[34,35,32]



**Figure 2: Chemical structures of important phytoconstituents from *P. marsupium*:** Epicatechin (1), propterol (2), marsupin (3), liquiritigenin (4), isoliquiritigenin (5), isoliquiritin (6), pterosupin (7), pterostilbene (8), kinotannic acid (9), 2,6-dihydroxy-2-(*p*-hydroxybenzyl)-3(2*H*)-benzofuran-7- $\beta$ -D-glucopyranoside (10), *trans*-stilbene (11), (-)-catechin (12),  $\beta$ -eudesmol (13), resorcinol (14), 1,2-benzenedicarboxylic acid diisooctyl ester (15), 9,12-octadecadienoic acid (16), lupeol (17), pterocarposide (18), 6-hydroxy-3,5,7,4'-tetramethoxyflavone-6-rhamnoside (19), vijayosin (20).

male albino rats showing antidiabetic effect in dexamethasone-induced hyperglycemia and hyperinsulinemia.<sup>46</sup>

Marsupin and Pterostilbene the most important phenolic compounds of the heartwood after intraperitoneal administration using each dose 40 mg/kg b.wt. Considerably decreased the level of blood glucose in hyperglycemic rat with hyperglycemia caused by streptozotocin mostly useful in non-insulin dependent diabetes mellitus (NIDDM) with obesity matched with control metformin. All these compounds Marsupin, Pterosupin and liquiritigenin decreased the body weight of albino rats.<sup>37,47</sup>

*P. marsupium* methanol extract activates the glucose transport in a PPAR $\gamma$  mediated PI3 kinase dependent fashion on Glut-4, PPAR $\gamma$  and PI3 kinase while the *P. marsupium* isoflavone exerted the same glucose transport activity in an alternate mechanism, PPAR $\gamma$  mediated but PI3 kinase independent fashion.<sup>48</sup>

Aqueous extract (200 mg/kg) considerably ( $p < 0.001$ ) reduced the raised level of chronic systemic inflammation cytokine TNF- $\alpha$  at both doses in type-2 diabetic rats.<sup>49,50</sup>

Aqueous extract showed significant effect in NIDDM induced by administering streptozocin 90 mg/kg i.p on cytokine TNF- $\alpha$  because of its isoflavone components. It was originated to be raised cytokine TNF- $\alpha$  in non-treated diabetic rats because of prolonged systemic inflammation. Aqueous extract at both doses (100 and 200 mg/kg b.wt.) significantly reduced the raised TNF- $\alpha$  level in rats.<sup>51</sup>

Aqueous extract of heart wood *P. marsupium* stimulated the insulin secretion and glucose uptake in mouse muscle and pancreatic tissues with concentration dependent manner which included higher concentration (10 and 100  $\mu$ L) and lower concentration (0.1 and 1  $\mu$ L). Bioassay showed fractionation of extract had potent antidiabetic properties *in vitro* and *in vivo*. The extract acted via different pathways which are utilized by insulin because insulin presence did not show any effect on extract-mediated muscle glucose.<sup>52</sup>

### CNS activity

(-)-Epicatechin was separated from the bark and it was established for its action on CNS of rats, mice and frog. It was examined that (-)-epicatechin don't have any effect on CNS of rats, mice and frog. (-)-Epicatechin had been showing positive chronotropic and inotropic effects on the heart of frog and propranolol use to block this effect. Hyperglycemia is produced in rats at higher doses (200 and 500 mg/kg b. wt.) of this compound and this effect is also prevented by propranolol indicating adrenergic activity.<sup>53</sup>

### Antihyperlipidemic activity

Effect of combination therapy with methanolic extract of *Ocimum sanctum* leaves and *P. marsupium* heart wood was studied on non-diabetic and oxidative stressed alloxan induced diabetic Wistar rats (female). Dosage of 500 mg/kg b.wt. of both mixture of methanolic extract of *Ocimum sanctum* leaves and *P. marsupium* heart wood analyzed has shown significant effect on dyslipidemia and also maintain endogenous antioxidant levels in non-diabetic and oxidative stressed alloxan induced diabetic female Wistar rats model.<sup>54-55</sup>

Ethanollic wood and bark extracts of *P. marsupium* (150+150 mg/kg b.wt.) significantly decreased blood glucose and lipid in albino Wistar rats where diabetes was induced by giving alloxan monohydrate (150 mg/kg, i.p) for 14 days.<sup>32,37</sup>

### Antioxidant activity

Ethanol, isopropyl alcohol (IPA) and acetone stem wood extracts of *P. marsupium* showed antioxidant activity in 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical scavenging method.<sup>45</sup> Methanolic extract (100  $\mu$ g/ml) is achieved to have maximum 2,2-diphenyl-1-picrylhydrazyl free radical scavenging effect followed by ethyl acetate and aqueous extracts. The scavenging effect achieved saturation with further increase in concentration of extracts. This study had showed significant antioxidant activity of *P. marsupium* bark extract in DPPH, superoxide, ABTS, hydroxyl radical, nitric oxide scavenging and suppression of *in vitro* lipid peroxidation.<sup>56</sup>

The *in vitro* antioxidant activity of ethyl acetate leaf extract of *P. marsupium* was studied by using DPPH assay, hydroxyl radical scavenging activity, ABTS assay, FRAP assay, NO radical scavenging activity, TRAP assay, reducing power assay and hydrogen peroxide (H<sub>2</sub>O<sub>2</sub>) radical scavenging activity. The leaf extract has showed higher scavenging activity i.e. 71% in FRAP assay at a concentration of 100  $\mu$ g/ml. This study showed that the ethyl acetate leaf extract of *P. marsupium* have free radical scavenging activity.<sup>57</sup>

Extract prolonged the cardiac arrest time by 14 min when compared with the control in oxidative stress model where it was induced by 1mM of H<sub>2</sub>O<sub>2</sub> and cardiac arrest was the end point. It was found that *P. marsupium* extract had significant antioxidant activity in isolated frog heart.<sup>58</sup>

The alcoholic extract of *P. marsupium* of varying concentrations showed inhibitory effect as evident by IC<sub>50</sub> of 55.39  $\mu$ g/ml, 195.88  $\mu$ g/ml, 151.00  $\mu$ g/ml on advanced glycation end products formation, rat kidney aldose reductase and sorbitol accumulation respectively. This research

suggests that the photo extract exhibited promising role in decreasing/delaying diabetic complications.<sup>59</sup>

### Hepatoprotective activity

Histology and liver biomarkers (serum protein, total bilirubin, alanine amino transaminase, alkaline phosphatase and aspartate amino transaminase) results shown that methanol and aqueous stem bark extracts (25 mg/kg per day *per oral* for 14 days) possesses significant hepatoprotective effect in carbon tetrachloride (CCl<sub>4</sub>) induced hepatotoxicity model.<sup>14</sup>

Levels of the enzymes (lactate dehydrogenase, aspartate transaminase, alkaline phosphatase, alanine transaminase and bilirubin) were considerably reduced in the group treated with plant extracts (100 mg/kg b.wt orally) in CCl<sub>4</sub> induced hepatotoxicity model. The investigation suggested that plant was having good protecting effect on CCl<sub>4</sub> induced hepatotoxicity.<sup>60</sup>

### Antidiarrheal activity

Ethanol extract of *P. marsupium* heartwood (250 and 500 mg/kg b.wt.) significantly decreased the severity and frequency of charcoal and castor oil induced gastrointestinal motility or diarrhea confirming the strength of traditional use of this plant as the modality for diarrhea.<sup>61</sup>

### Anticancer activity

Anticancer activity of pterostilbene, a constituent of plant of *P. marsupium* was evaluated in A-375, HCT-116, Hep-G2, MDAMB-231 and PC-3 cell lines by measuring cell viability after treatment with pterostilbene (1, 10, 50 and 100 µg/ml). The IC<sub>50</sub> of each cell line were 16.0 µM (Hep-G2), 40.6 µM (MDA-MB-231), 45.3 µM (HCT-116), 421 µM (A-375), 3.9 mM (PC-3). This study showed that pterostilbene high activity against Hep-G2 (liver) and HCT-116 (colon) cancers and it was not active in PC-3.<sup>62</sup>

Effects of pterostilbene, an active constituent of *P. marsupium*, on cell viability in human gastric carcinoma AGS cells were investigated. It was found that pterostilbene was able to inhibit cell proliferation and induce apoptosis in a concentration and time dependent manner. Pterostilbene induced apoptosis in AGS cells through activating the caspase cascade via the mitochondrial and Fas/FasL pathway, GADD expression and by modifying cell cycle progress and changes in several cycle-regulating proteins. Antitumor effect of pterostilbene was proved by induction of apoptosis.<sup>63</sup>

### Antimicrobial activity

Antimicrobial activity of aqueous and methanolic bark extracts of *P. marsupium* was evaluated by using disc diffusion method. It showed the zone of inhibition ranges from 11-22 mm for different extracts. Methanol extract showed significant effect by preventing *A. niger* at 25 µg/ml and *E. faecalis*, *S. typhi* at 12.5 µg/ml. It was found that *P. marsupium* showed significant antimicrobial action against microbes.<sup>64</sup>

Antimicrobial activity of ethanolic extract of *P. marsupium* against *Candida albicans*, *Vibrio cholera* and *Bacillus polymyxa* was evaluated by using cyclic voltammetry. The low anodic current and low anodic peak potential was obtained showing the good decreasing ability of the molecules resulting in good antioxidant potential of the extract. The result showed the significant antimicrobial effect at different dosages.<sup>65</sup>

### Antibacterial activity

Methanolic extract of *P. marsupium* stem was tested by using paper disc diffusion method against gram +ve bacteria *Bacillus coagulans* and gram +ve bacteria *Escherichia coli*. 100 mg/ml concentration significantly inhibited growth of both the bacteria.<sup>66</sup>

The acetone and isopropyl alcohol extract of *P. marsupium* (50 mg/ml) showed the antibacterial activity against the Gram +ve bacteria (*Staphy-*

*lococcus aureus* and *Bacillus cereus*) but did not show antibacterial activity against Gram +ve bacteria (*Escherichia coli* and *Salmonella Typhi*). Ethanol extract of *P. marsupium* (50 mg/ml) did not show any antibacterial activity.<sup>45</sup>

### Anti-inflammatory activity

Methanolic and aqueous extract evaluated anti-inflammatory effect by acute inflammation model using carrageenan induced rat paw edema method. Methanol extract at dose 50 mg/kg b. wt. and aqueous extract at dose 100 mg/kg b.wt. indicated significant decrease in paw edema. It was found that both extracts had significant anti-inflammatory activity.<sup>67-68</sup>

*P. marsupium* aqueous extract at doses of 100 mg/kg and 200 mg/kg b.wt was found to decrease the elevated inflammatory cytokine, TNF-α level in NIDDM diabetic rats.<sup>69</sup>

### Toxicity study

Acute toxicity test was performed in mice. For this aqueous extracts of *P. marsupium* bark was administered orally at single dose of 2.5-12.5 g/kg and examined upto 7 days for general behavior and mortality. The no-observed adverse effect level (NOAEL) and lowest-observed adverse effect level (LOAEL) were 5.0 g/kg, 7.5 mg/kg b.wt respectively. Mortality was increased with the dose (LD50>10.75 g/kg b. wt) for the mouse. The sub-chronic toxicity test was performed in rats. For this extract was administered daily 150-600 mg/kg b.wt for 42 days which did not show death or significant changes in biochemical parameters. At the dose of 600 mg/kg b.wt only increased hepatic catalase activity. No alteration was found in food and water intake and body weight. The histopathology of kidney, lungs, liver and pancreas did not show any morphological alteration.<sup>70-71</sup>

### Nootropic activity

Methanolic extract of *P. marsupium* (25 and 50 mg/kg *p.o.*) were administered in adult albino Swiss mice for neurotoxicity test for learning and memory. *P. marsupium* improved scopolamine induced amnesia with evidence increasing inflexion ratio and reduces transfer latency and improves the impairment of spatial memory induced by scopolamine as indicated by formation of reference and working memories.<sup>72</sup>

### Antiulcer activity

Methanolic heartwood extract of *P. marsupium* (750 mg/kg b.wt) lowers the blood glucose level in both normal rats and NIDDM rats. It saved the mucosa by influencing the increase in mucosal offensive (LPO and NO) factors and decrease in defensive factors (superoxide dismutase and catalase). It did not indicate any safety against ulceration caused by aspirin, pylorus ligation, cold restraint stress, and ethanol in normal rats.<sup>73-74</sup>

### Cardiotonic activity

Aqueous heartwood extract of *P. marsupium* shows cardiotonic activity using isolated frog heart perfusion. At a very low concentration (0.25 mg/ml), a considerable rise in force of contraction and reduced heart rate as compared to standard digoxin. At higher dose (4 mg/ml) cardiac arrest occurred. The result showed that *P. marsupium* significantly increases contraction force of heart.<sup>13</sup>

### COX-2 Inhibition

*P. marsupium* extract evaluated for selective cyclo-oxygenase (COX-2) inhibitory action due to presence of pterostilbene. In a whole blood assay method, it is revealed that the dose of *P. marsupium* (450 mg/kg b.wt) did not reduce PGE2 production. During the study, no changes were observed from the base line of the safety parameters and no extract associated adverse effects occurred.<sup>15</sup>

## Analgesic activity

The ethyl acetate, petroleum ether and methanol leaf extracts of *P. marsupium* were evaluated for analgesic activity in Swiss albino mice. Improvement in writhing response of different extract was compared. The methanolic extract at the doses of 120 mg/kg b.wt was more effective than ethyl acetate and petroleum ether extracts.<sup>75</sup>

Central analgesic effects of *P. marsupium* bark extract was evaluated in mice by using hot plate method. *P. marsupium* bark extract at dose of 500 mg/ml significantly improved reaction time as compared to standard.<sup>76</sup>

## Anticataract activity

Aqueous bark extract of *P. marsupium* (1 g/kg/day), alcoholic seeds extract of *Trigonella foenum graecum* (2 g/kg/day) and leaf extract of *Ocimum sanctum* (200 mg/kg/day) were analyzed in growth of cataract in diabetic rats. *P. marsupium* treated group showed less opacity index in comparison with controls group and did not exhibited mature stage of cataract.<sup>77-78</sup>

## Genotoxic assessment

It was studied that stem bark extract of *P. marsupium* administered to mice for longer period of time did not show any genotoxic activity.<sup>79</sup>

## Aphrodisiac activity

It was stated the utility of *P. marsupium* as Vajikaran Rasayana of Ayurveda or Aphrodisiac of New concept.<sup>80</sup>

## Antifungal activity

A study was carried for 10 days in which after 7 and 10 days of therapy 78% and 93% excellent to good response was found from the alcoholic extract compared to 73% from the aqueous extract. Thus, it shows that the ointment prepared from alcoholic extract is more effective than aqueous extract. There was no side effect after continuous uses of drug for 10 days.<sup>81</sup>

## Anthelmintic activity

The anthelmintic effect of ethyl acetate, ethanol, *n*-butanol and petroleum ether leaves extract of *P. marsupium* was analyzed by using Indian earth-worms as trial worm. Different concentrations of different extracts were tested to determine paralysis and death time of the worm. Albendazole (10 mg/ml) was used as standard drug. The outcome of this study shown that between all the extract, petroleum ether and ethanol exhibited significant anthelmintic activity as related to reference drug albendazole.<sup>82</sup>

## CONCLUSION

Pharmacologically reported various activities of *P. marsupium* includes antidiabetic, antihyperlipidemic, antioxidant, hepatoprotective, antidiarrhoeal, anticancer, analgesic, antibacterial, anti-inflammatory, cardiogenic, antiulcer and several other activities. Very few examinations have been carried out involving the anticataract, nootropic activity, antifungal, aphrodisiac and anthelmintic activities. Through various phytochemicals were isolated, it helps to achieve its therapeutic value and plays a significant role in modern system of remedy and it requires supplementary exploitation. It is vital to recognize the active components and their molecular interaction, which will help to examine therapeutic value of the product and also homogenize the product. The most significant bioactive components were saponins, terpenoids, tannins, flavonoids, alkaloids and phenolic compounds. The current review elaborated the pharmacological studies, phytochemical studies and ethnobotanical uses of *P. marsupium* and isolated chief phytoconstituents from them, which

can be evaluated to discover the lead molecules in the examination of new herbal drugs.

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## CONFLICT OF INTEREST

The authors declare that they have no competing interests.

## ABBREVIATIONS

***P. marsupium***: *Pterocarpus marsupium*; **CNS**: Central Nervous System; **b.wt.**: Body weight; **WHO**: World Health Organization; **DPPH**: 2,2-diphenyl-1-picrylhydrazyl; **NMR**: Nuclear Magnetic Resonance; **TLC**: Thin layer chromatography; **COX**: Cyclooxygenase; **ROS**: Reactive Oxygen Species; **ALT**: Alanine transaminase; **AST**: Aspartate transaminase; **MIC**: Minimum inhibitory concentration; **TNF- $\alpha$** : Tumor necrosis factor- $\alpha$ ; **TRAP assay**: Telomeric repeat amplification protocol; **FRAP assay**: Ferric reducing ability of plasma; **NIDDM**: Non-insulin dependent diabetes mellitus.

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## GRAPHICAL ABSTRACT



## SUMMARY

- The current review aimed to define the phytochemical and pharmacological aspects of *P. marsupium* which will have been help in the researchers for further qualitative research.
- Researchers have been stated the presence of several phytoconstituents in *P. marsupium* and also their pharmacological activities.
- *P. marsupium* is a decent source of tannins and flavonoids hence, used as influential astringent, anodyne, cooling, regenerating agent and also used for the treatments of leprosy, leucoderma, toothache, fractures, diarrhea, passive hemorrhage, and dysentery, bruises and diabetes.
- It is also used to treat rheumatoid arthritis, gout, diabetic anemia, indigestion, asthma, cough, discoloration of hair, bronchitis, ophthalmic complications, elephantiasis and erysipelas.

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