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(Review Article)

Systemic Review: Pharmacognosy, Phytochemistry, Pharmacology and Clinical Applications of *Pterocarpus marsupium* Roxb.

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ABSTRACT

Many traditional medicines in use are derived from medicinal plants, minerals and organic matter. India is the largest producer of medicinal herbs and is called as botanical garden of the world. Pterocarpus marsupium Roxb (Family-Fabaceae) is one of the oldest medicinal plant reported in the Indian system of medicine. In contest of this, current review is the collection of all the literature i.e. pharmacognosy, phytochemistry and pharmacology of Pterocarpus marsupium Roxb.

Key Words: *Pterocarpus marsupium*, Leaves, Pharmacognosy, Phytochemistry, Pharmacology.

INTRODUCTION

In the last few years there has been an exponential growth in the field of herbal medicine and these drugs are gaining popularity both in developing and developed countries because of their natural origin and less side effects. The World Health Organization (WHO) has listed 21,000 plants, which are used for medicinal purposes around the world. Among these 2500 species are in India, out of which 150 species are used commercially on a fairly large scale. The use of Ayurvedic medicines is common in both adults and children and is increasing in many areas of the world.[1] *Pterocarpus marsupium* Roxb. belonging to the family fabaceae is popularly known as Indian Kino tree or Bijasar or Vijaysar in Hindi.[2] Bark is used as anti-diabetic,[3,4,5] hepatoprotective[6] and also as anti-diarrheal.[7] Leaves are useful as external applications for boils, sores and skin diseases[8] traditionally stem have been used for the treatment of neurological problems.[9]

The Genus *Pterocarpus* consist of 35 species. Various Species of *Pterocarpus* are[10] *P.* acapulcensis, *P. albopubescens, P. mildbraedii, P. amazonum , P. angolensis, P. antunesii , P. brenanii, P. claessensii , P. dalbergioides, P. erinaceus P. echinatus, P. gilletii, P.hockii , P. homblei , P. indicus, P. lucens , P. macrocarpus, P. marsupium , P. mutondo , P.officinalis, P. orbiculatus , P. osun, P. rohrii P. rotundifolius, P. santalinoides , P. santalinus , P. soyauxii , P. ternatus, P. tessmannii , P. tinctorius, P. velutinus , P. villosus , P. violaceus , P.zehntneri, P. zenkeri .*

HABITAT

Bijasar is a large tree that commonly grows in the central, western, and southern parts of India and in Sri Lanka.[11] It is distributed throughout India, Ceylon and most of the temperate countries.[12] It is found to grow in parts of states such as Andhra Pradesh, Bihar, Gujarat, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Orissa, Rajasthan, Tamil nadu, Uttar Pradesh, West Bengal and Goa.[13] Kino is locally called as "Bija" is native to India, Nepal and Sri Lanka where it occurs in parts of the Western Ghats.[14,15]

TAXONOMICAL CLASSIFICATION

Taxonomically it is classified as [16]
Domain: Eukaryote
Kingdom: Plantae
Subkingdom: Viridaeplantae
Phylum: Magnoliophyta
Subphylum: Euphyllophytina
Infraphylum: Radiatopsis
Class: Magnoliopsida
Subclass: Rosidae
Super order: Fabanae
Order: Fabales
Family: Fabaceae
Genus: *Pterocarpus*
Species: *marsupium*

VERNACULAR NAMES

Vernacular names are as in English - *Indian Malabar Kino, Indian Kino, Gummy Kino***,** Hindi - *Bija, Bijasal*, Sanskrit - *Pitasala, Asana, Sarfaka*, Telugu - *Paiddagi Chekka***,** Marathi- *Bibala*
Tamil - *Vegaimaram, chakkal*, Assam – *Aajar*, Bengali - Piyasala, Pitasala, Gujrati - *Biyo Asana*

Kashmiri –*Lal Chandeur*, Malayalam – *Venga*, Orissi – *Piashala*, Punjabi - *Chandan Lal*, Tamil – *Vengai*, Urdu – *Bijasar*.[17]

BOTANICAL DESCRIPTION

Pterocarpus marsupium Roxb. (Fabaceae) is a deciduous tree about 90 ft or more high. Leaves are 3 to 5 inch long, have 5-7 leaflets, oblong, margin wavy and obtuse. The petioles are round, smooth and waved from leaflet to leaflet, 5 or 6 inches long and there are no stipules. Flower about 1.5 cm long, very numerous, white with a small tinge of yellow. The heartwood of this tree is golden yellow. Tree bark yields a reddish gum. Stamens are 10, united near the base, but soon dividing into two parcels of 5 each, anthers are globose and 2-lobed.The legume, which is borne on a long petiole, is three-fourths orbicular, the upper remainder, which extends from the pedicel to the remainder of this style, is straight, the whole surrounded with a waved, veiny, downy, membranous wing, swelled, rugose, woody in the center, where the seed is lodged and not opening.[18,19] Fruit is circular, flat, winged pod. Seed is convex and bony.[20] It gives flowers and fruits in the month of March to June.[21]

PHARMACOGNOSTICAL CHARACTERISTICS

Macroscopy

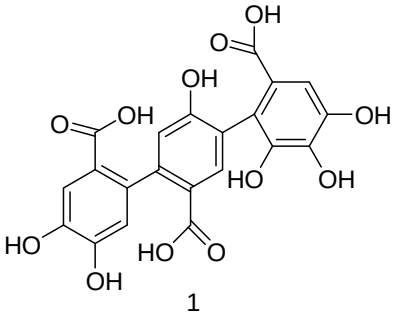
It is of moderate size to large tree (Fig. 1).The height ranges from 15 to 30 meters. The stem is stout and crooked with widely spreading branches. The bark is thick and dark brown to grey in color. Leaves are compound and imparipinnate. Leaflets are 5-7, coriaceous, oblong, obtuse, emarginated or even bilobed at the apex and glabrous on both surfaces. The petioles are round, smooth and waved from leaflet to leaflet, 5 or 6 inches long and there are no stipules. Panicles are terminal and very large; ramifications are bifarious, like the leaves. Peduncles and pedicels are round and a little downy. Bracts are small, caduceus, solitary below each division and subdivision of the panicle. The flowers are very numerous, white, with a small tinge of yellow. Vexillum is with a long, slender claw, very broad; sides reflexed, waved, curled and veined; keel is two pettled, adhering slightly for a little way near the middle, waved, etc., same as the vexillum. Stamens are 10, united near the base, but soon dividing into two parcels of 5 each; anthers are globose and 2-lobed. Ovary is oblong, pedicelled, hairy, generally 2-celled; cells are transverse and 1seeded. Style is ascending. The legume, which is borne on a long petiole, is three-fourths orbicular, the upper remainder, which extends from the pedicel to the remainder of the style, is straight, the whole surrounded with a waved, veiny, downy, membranous wing, swelled, rugose, woody in the center, where the seed is lodged and not opening; generally one but sometimes 2-celled. Seeds are single and reniform.[22] Fig. 2 shows the heartwood (i), leaf (ii), flowers (iii), fruit (iv) and gum (v) of *Pterocarpus marsupium* roxb.

Microscopy

Transverse section shows alternating bands of larger and smaller polygonal cells consisting of tracheids, fiber tracheids, xylem parenchyma and transversed by xylem rays. Xylem vessels are throughout distributed. Tyloses filled with tannins are present. Tracheids are long, thick walled with tapering ends and simple pits. Xylem parenchyma cells are rectangular with simple pits and xylem rays are uni-to-biseriate. The calcium oxalate crystals are present and the starch is absent.[23]

PHYTOCHEMISTRY

Literature survey indicated the presence of flavonoids, alkaloids, resin, fixed oil, saponin, tannin, mucilage, isoflavon glycosides and polyphenol compounds etc. in various parts of the plant. Roots contain flavonoid glycosides 7-Hydroxy-6, 8-dimethyl flavanone-7-O-alpha-L-arabinopyranoside and 7, 8, 4'trihydroxy-3', 5'-dimethoxy flavanone-4'-O-beta-Dglucopyranoside.[24] The heartwood contains pterostilben, isoliquritigenin, liquiritigenin, carpucin, propterol, propterol-B, oleanolic acid, alkaloid and resin 5, 4'-dimethoxy-8-methylisoflavone. The wood also contains a yellow coloring matter and an essential oil and a semi-drying fixed oil. The tree yields a gum-Kino which exudes when an incision is made through the bark up to the cambium. Flowers contains reported two aurone glycosides, 4, 6, 4'-trihydroxyaurone 6-O-rhamnopyranoside and 4, 6, 4'- trihydroxy-7-methylaurone 4-O-rhamnopyranoside.[25] Various pharmacological activities have been reported as shown in Table -1. Following are the chemical structures of few important compounds (**1-36**) isolated from *Pterocarpus marsupium* roxb.



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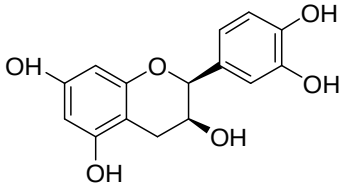

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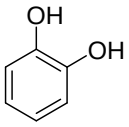

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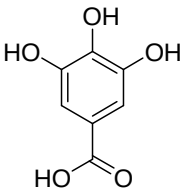

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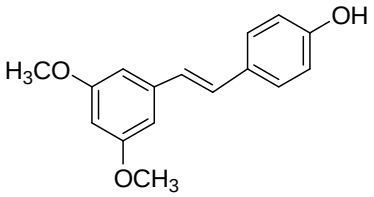

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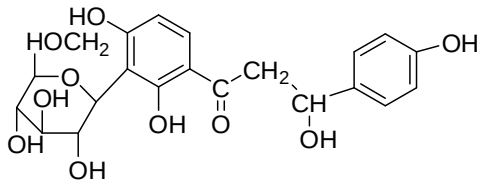

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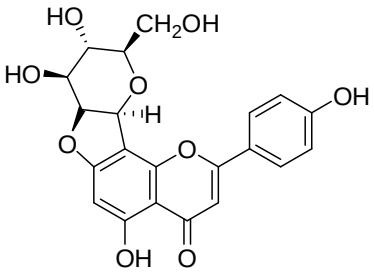

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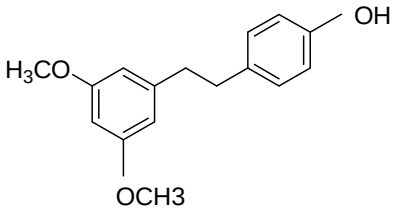

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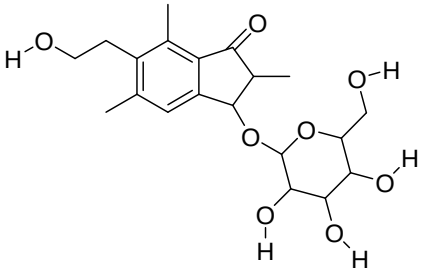

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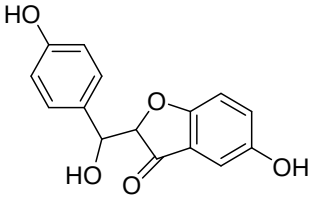

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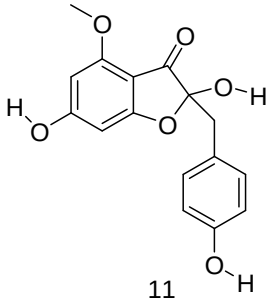

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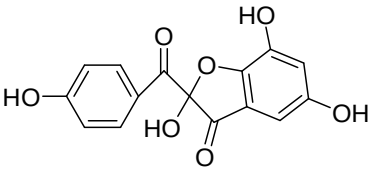

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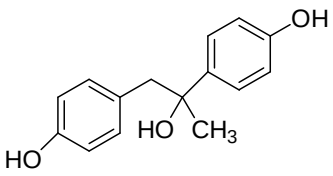

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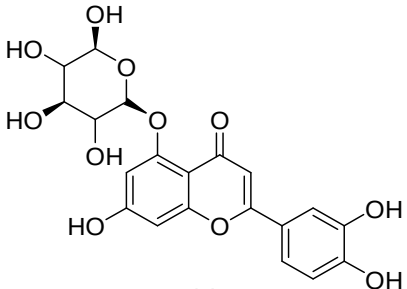

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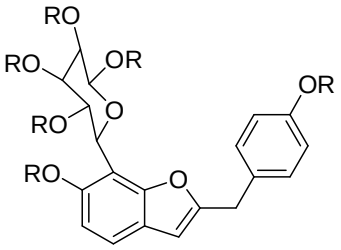

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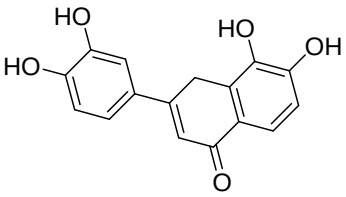

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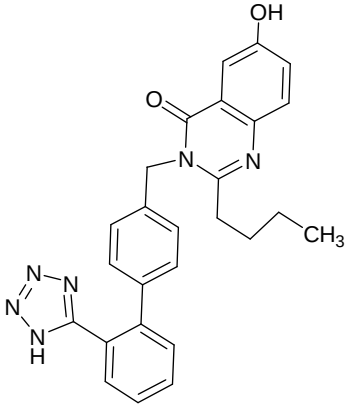

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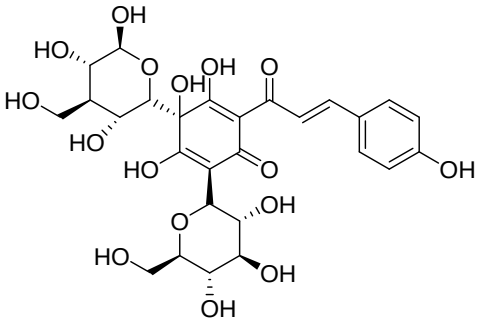

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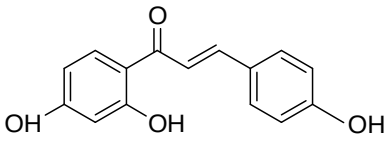

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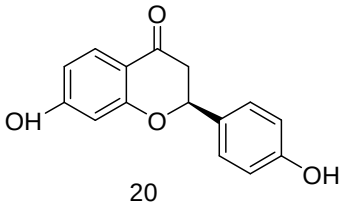

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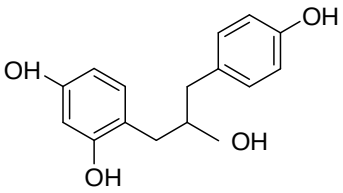

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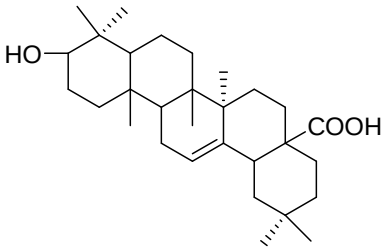

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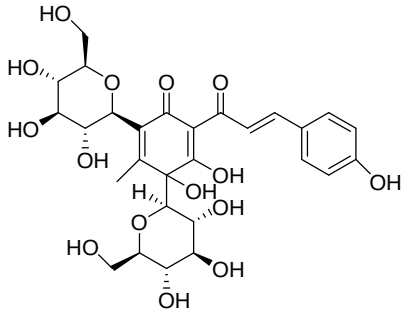

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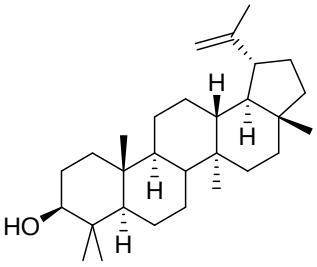

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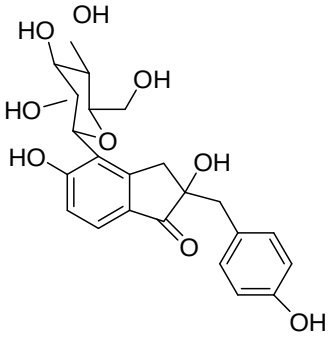

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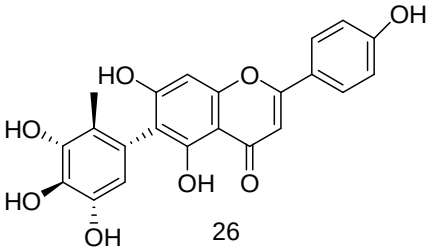

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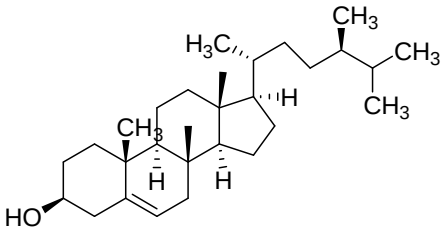

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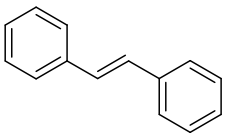

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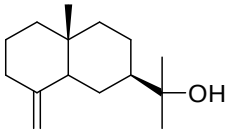

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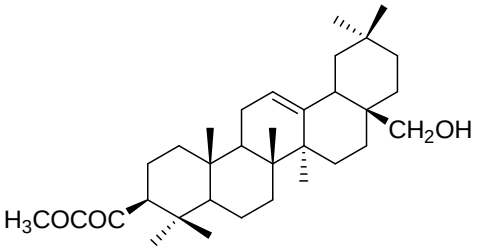

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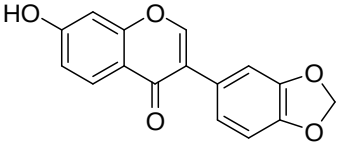

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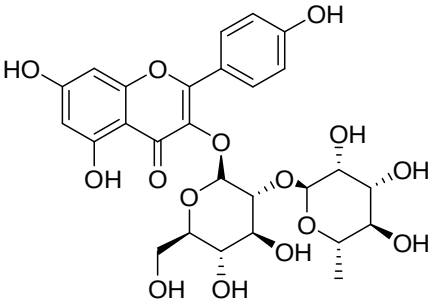

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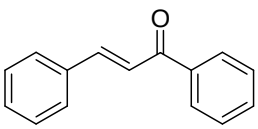

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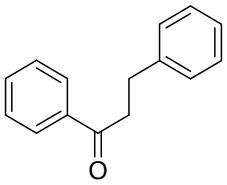

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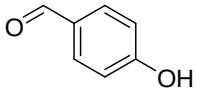

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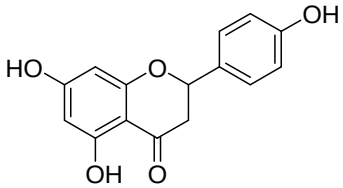

36

Kinnotannic acid (1),[50] Epicatechin (2),[50] Catechol (3),[26] Gallic acid (4),[26] Pterostilbene (5),[27] Pterosupin (6),[27] Flavon-c-glucoside (7),[28] Marsupial (8),[29] C-glucoside (9),[29] 2-hydroxyl-2-benzyl coumaronone (10),[29] Carpusin (11),[29] 2-benzyl-2,4',6-trihydroxyl-4-methoxybenzo furan-3(2H)one (12),[29] Propeterol-B-1-(2,4-ihydroxyphenyl) propanol-2-ol (13),[30] 1,3-bis(4-hydroxyphenyl)propan-2-ol(14),[30] 8C-B-D-glucopyranosyl-3-7-4 trihydroxyflavone (15),[30] 3,7,4'-tetrahydroxyflavone (16),[31] 6-hydroxy-2-(4-hydroxybenzyl)-benzofuran-7-C-beta-d-glucopyranoside (17),[32] 1,2-bis-(2,4-dihydroxy-3-C-gluco pyranosyl)-ethane dione (18),[32] Isoliquiritigenin(19),[32] Liquiritigenin(20), [32] Propterol(21), [(32)] Oleanolic acid(22),[32] Beta-sitosterol(23), [32] Lupeol(24),[32] 6-hydroxy-2-(4-hydroxy benzyl 1)-benzofuran-7-C-B-D-glucopyranoside(25),[32]8-(C-beta-dglucopyranosyl)7,3,4'trihydroxyflavone(26),[33]1,2bis (2,4,dihydroxy,3-C-glucopyranosyl (27),[33] Stilbene (28) ,[34] 7-Epi-beta Eudesmol (29),[34] Erythrodiol-3-monoacetate (30), [34] Pseudobaptigenin (15),[35] 5-Deozykaemferol (32),[35] Chalcone (33),[35] Dihydrochalcone (34),[35] p-hydroxybenzaldehyde (35),[35] Naringenin(36).[35]

SPECTROSCOPIC DATA OF SOME IMPORTANT COMPOUNDS

Epicatechin[36]

Off-white amorphous solid

M.P- 257-258 °C

ES-M m=z 313 [MþNa] þ, 391 [MþH] þ,

^{1}H NMR (400MHz, acetone-d6) d 6.97 (1 H,d, J ¼ 1.7 Hz, H-20); 6.78 (1 H, dd J ¼ 7.5, 1.7 Hz, H-60); 6.74 (1 H, d, J ¼ 7.5 Hz, H-50); 5.94 (1 H, d, J ¼ 2.2 Hz, H-6) 5.91 (1 H, d, J ¼ 2.2 Hz, H-8); 4.81 (H-2, s); 4.17 (H-3, broad s); 2.85 (1 H, dd, J ¼ 4.5, 16.5 Hz, a H-4); 2.73 (1 H, dd J ¼ 2.5, 16.7 Hz, b H-4).

^{13}CNMR (100MHz, acetone-d6) d 29.22 (C-4); 67.74 (C-3); 79.85 (C-2); 95.92 (C-8); 96.46 (C-6); 100.09 (C-10); 115.34 (C-20) 115–92 (C-50); 119.12 (C-60); 132.30 (C-10); 145.72 (C-40); 145.89 (C-30); 157.34 (C-9); 157.61 (C-7); 157.95 (C-5).

Liquiritigenin[37]

Colorless crystals

M.P-203°C

UV (MeOH) λmax 313, 276 nm; [α] D −22.5o (c 0.21, MeOH); IR (KBr, ν) 3200, 1640, 1600 cm^{-1}

EIMS m/z 256 [M]$^+$

^{1}H-NMR (400 MHz, CD_3OD, δH) 7.72(1H, d, J=8.8, H-5), 7.31 (2H, d, J=8.4, H-2', 6'), 6.81 (2H, d, J=8.4, H-3', 5'), 6.47 (1H, dd, J=8.8, 2.0, H-6), 6.34 (1H, d, J=2.0, H-8), 5.35 (1H, dd, J=13.2, 2.8, H-2),3.04 (1H, dd, J=16.8, 13.2, H-3a), 2.67 (1H, dd, J=16.8, 2.8, H-3b).

^{13}C-NMR (100 MHz, CD_3OD, δC) 193.4 (C-4), 166.6 (C-7), 165.4 (C-9), 158.8 (C-4'), 133.8 (C-1'), 129.7 (C-5), 128.9 (C-2', 6'), 116.2 (C-3', 5'), 114.8 (C-10), 111.6 (C-6), 103.7 (C-8), 81.0 (C-2), 44.9 (C-3).

Isoliquiritigenin[38]

M.P-206-210°C

^{1}HNMR (500MHz, acetone-d6),δ 13.62 (OH), 8.12 (1H, d, J=8.5 Hz, H-60), 7.74 (2H, d, J=8.4Hz,H-2,H-6), 7.84 (1H, d, J=15.0Hz,H-β), 7.76 (1H, d, J=15.0 Hz, H-R), 6.93 (2H, d, J=8.4 Hz, H-3, H-5), 6.47 (1H, dd, J =8.5, 2.5 Hz, H-50), 6.37 (1H, d, J=2.5 Hz, H-30).

^{13}CNMR (125MHz, acetone-d6), δ 192.9 (CdO), 167.7 (C-40), 165.5 (C-20), 161.0 (C-4), 145.2 (C-β), 133.4 (C-60), 131.9 (C-2, C-6), 127.7 (C-1), 118.4 (C-R), 116.8 (C-3, C-5), 114.6 (C-10), 108.8 (C-50), 103.8(C-30).

Dihydrochalcone[39]

M.P-131-132°C

$[\alpha]_{20}$ D +4.7 (c 0.17, $CHCl_3$).

UV 215, 241, 286 nm.

IR OH(3377cm^{-1}), aromatic rings (1612, 1510, 810 cm^{-1}).

^{1}HNMR δ 3.01 (t, 2H, J=8.0 Hz) and 3.35 (t, 2H, J=8.0 Hz), OCH_3 δ 3.84, an aromatic signal for H-5′ at δ 5.93, five aromatic protons at δ 7.21-7.33, 7-substituted *p*-ally phenol group11: δ 5.13 (d, 1H, J=18.0 Hz), 5.38 (d, 1H, J=18.0 Hz), 5.40 (d, 1H, J=6.0 Hz), 6.43 (ddd, 1H, J=17.5, 10.5, 6.0Hz), 6.81 (d, 2H, J=8.0 Hz), 7.17 (d, 2H, J=8.0 Hz).

^{13}CNMR two olefin carbons (δ 139.3 and 118.2), one methane (δ 41.9), six aromatic carbons [δ 116.0 (2C), 129.6 (2C), 132.7 and 154.8] . In the HMBC spectrum, H-7 of *p*-ally phenol [5.40 (d, 1H, J=6.0 Hz)] showed long-range correlations with C-3′ (δ 108.3) of uvangoletin.

Oleonolic acid[40]

White amorphous powder.

M.P-271-273° C.

IR υ_{max} (KBr) cm^{-1} 3442, 3022, 2930, 1711, 1610, 1465, 1368, 1214, 789.

EIMS *m/z* (rel. int.): 456(M$^+$, 5), 248(100), 207(16), 203(41), 191(7), 189(7), 133(8).

^{1}H-NMR (400 MHz, $CDCl_3$): 0.75, 0.77, 0.90, 0.91, 0.93, 0.98 (each 3H, *s*, CH_3 ×6), 1.13 (3H, *s*, H-27), 2.82 (1H, dd, J= 3.6, 13.2 Hz, H-18), 3.23 (1H, dd, J=11.2, 4.4 Hz, H-3), 5.27 (1H, t, J=3.5 Hz, H-12).

Lupeol[41,42,43]

M.P-213-215°C

[α]D: +26.0o (c=0.80, $CHCl_3$)

IR (KBr) ν_{max}: 3235, 1640, 1490, 1382, 1185, 1105, 1040, 984 and 943 cm^{-1}.

EIMS: m/z 426 (M+, $C_{30}H_{50}O$).

^{1}HNMR ($CDCl_3$, 400 MHz) δ 4.69 and 4.56 (each 1H,m, H-29), 3.18 (1H, dd, H-3), 2.39 and 1.93 (each1H, m,H-19, 21A), 1.71 (1H, t, H-15A), 1.69 (3H, s, H-30), 1.68(2H, d, H-12A, 1A), 1.67 (1H, t, H-13), 1.61 (1H, d, H-2A), 1.54 (1H, q, H2B), 1.54, 1.49 and 1.42 (each 1H, d,H-6, 16A, 11A),

1.42 (1H, m, H-22A), 1.41 (2H, m, H-7),1.39 (1H, q, H-6B), 1.38 (1H, t, H-16A), 1.37 (1H, t, H-18), 1.33 (1H, m, 21B), 1.28 (1H, d, H-9), 1.29 (1H, q, H-11B), 1.20 (1H, m, H-22B), 1.07 (1H, q, H-12A), 1.04 (3H, s, H-23), 1.01 (1H, d, H-15A), 0.98 (3H, s, H-23),0.97 (3H, s, H-27), 0.91 (1H, t, H-1B), 0.27, 0.84, 0.79.

^{13}CNMR ($CDCl_3$, 100 MHz): δ 150.8 (C-20), 109.3 (C-29), 78.9 (C-3), 55.2 (C-5), 50.3 (C-9), 48.2 (C-18), 47.9(C-19), 42.9 (C-17), 42.7 (C-14), 40.7 (C-8), 39.9 (C-22),38.8 (C-4), 38.6 (C-1), 38.0 (C-13), 37.1 (C-10), 35.5 (C-16), 34.2 (C-7), 29.8 (C-21), 27.9 (C-23), 27.4 (C-15),27.3 (C-2), 25.0 (C-12), 20.9 (C-11), 19.2 (C-30), 18.2(C-6), 17.9 (C-28), 16.1 (C-25), 15.9 (C-26), 15.3 (C-24)and 14.5 (C-7) .

β-Sitosterol[44]

M.P-136-140 °C

IR 3373.6cm^{-1} (OH stretching); 2940.7 cm^{-1} and 2867.9cm^{-1} (aliphatic CH stretching); 1641.6cm^{-1} (C=C absorption peak); 1457.3cm^{-1} (CH_2); 1381.6cm^{-1} (OH def), 1038.7cm^{-1} (cycloalkane) and 881.6 cm^{-1}.

^{1}HNMR ($CDCl_3$, 400MHz) δ3.2(1H, m, H-3), 5.26 (1H, m, H-6), 5.19(1H, m, H-23), 4.68(1H,m,H-22),3.638(1H,m, H-3),2.38(1H, m, H-20), 1.8-2.0 (5H, m) ppm. δ 0.76-0.89 (m, 9H), 0.91-1.05 (m, 5H), 1.35-1.42 (m, 4H), 0.69-0.73 (m, 3H), 1.8-2.00 (m, 5H), 1.07-1.13 m, 3H), 1.35-1.6 (m, 9H) ppm.

^{13}CNMR 150.98, 145.2 (C-5), 139.8 (C-22), 121.7, 118.89(C-6), 79.03 (C-3), 55.3(C-14), 55.18(C-17), 50.45 (C-9), 48.3 (C-9),40.8 (C-20), 40.1(C-12) , 39.2 (C-13), 38.9 (C-4), 38.6 (C-12), 37.18 (C-1), 37.12 (C-10), 36.3 (C-8), 35.59(C-20), 34.29 (C-22), 34.24 (C-7), 32.6 6 (C-8), 29.86 (C-25), 29.71 (C-16), 28.41 (C-2), 28.1 (C-15) , 27.4 (C-28), 26.1 (C-11, 26), 21.6 (C-27), 19.32 (C-19), 17. 71 (C-21), 15.6 (C-18, 29).

FAB-MS m/z 367, 271, 255, 229,189, 175, 161, 133, 121, 105, 107, 95, 81, 69, 55, 41.

Gallic acid[45]

M.P-250 °C

Yellowish oil

[α]20 D +4.7 (c 0.17, $CHCl_3$).

M/z 404.1626 [M]+ (calcd. 404.1624)

UV 215, 241, 286 nm.

IR OH (3377cm^{-1}), aromatic rings (1612, 1510, 810 cm^{-1}).

^{1}HNMR δ 3.01 (t, 2H, J=8.0 Hz) and 3.35 (t, 2H, J=8.0 Hz), OCH_3signal at δ 3.84, an aromatic signal for H-5′ at δ 5.93, five aromatic protons at δ 7.21-7.33, 7-substituted *p*-ally phenol group11: δ 5.13 (d, 1H, J=18.0 Hz), 5.38 (d, 1H, J=18.0 Hz), 5.40 (d, 1H, J=6.0 Hz), 6.43 (ddd, 1H, J=17.5, 10.5, 6.0Hz), 6.81 (d, 2H, J=8.0 Hz), 7.17 (d, 2H, J=8.0 Hz).

^{13}CNMR (δ 139.3 and 118.2), one methine (δ 41.9), six aromatic carbons [δ 116.0 (2C), 129.6 (2C), 132.7 and 154.8].

Erythrodiol-3-acetate[46]

M.P- 230-231 °C

UV (MeOH) λ_{max}: 208 nm

IR ($CHCl_3$) ν_{max}: 3436, 1720, 1654, 1639,1456, 1370, 1248 cm^{-1}.

EIMS (EI, 70 eV) *m/z* 484 [M]+ (calc. for $C_{32}H_{52}O_3$).

^{1}HNMR (400 MHz, $CDCl_3$): *δH* 4.48 (1H, dd, J = 6.9 Hz, H-3*α*), 5.12 (1H, t, J = 3 Hz, H-12), 0.92 (3H, s, Me-23), 0.82 (3H, s, Me-24), 0.95 (3H, s, Me-25), 0.96 (3H, s, Me-26), 1.06 (3H, s, Me-27), 3.18 (1H, d, J = 11 Hz, H-28), 3.51 (1H, d, J= 11 Hz, H-28), 0.97 (3H, s, Me-29), 1.12 (3H, s, Me-30), 2.02 (3H, s, 3-OAc).

PHARMACOLOGY ACTIVITY

1. Anti-diarrheal Activity

Ethanolic extract of *Pterocarpus marsupium* has shown anti-diarrhoeal activity in castor oil and charcoal induced gastrointestinal motility test in rats. Ethanolic extract of it at a dose of 250 an 500 mg/kg, had significantly reduced the frequency and severity of diarrhea and delayed the intestinal transit of charcoal meal in the test animals as compared to the control.[47]

2. Hepatoprotective Activity

Methanolic extract of *Pterocarpus marsupium* has shown hepatoprotective activity.Methanolic extract of it at a dose of 100 and 300 mg per kg-bwt per day for 21 days dose-dependently, had significantly decreased serum glucose level. The higher dose exerted a protective effect on antagonized biochemical parameters such as reduced glutathione, superoxide dismutase and lipid per oxidation, and altered towards the normal levels hepatic mass, protein and glycogen content.[48]

3. Microbicidal Activity

Methanolic extract of *Pterocarpus marsupium* has shown microbicidal activity. Bactericidal potential of methanolic extract of stem bark (Apical bark, middle bark and Mature bark) of *Pterocarpus marsupium* was evaluated with respect to pathogenic bacteria *Bacillus subtilis, Staphylococcus aureus, Escherichia coli, Pseudomonas aeruginosa, Klebsiella pneumoneae, Salmonella typhi, Proteus mirabilis and Micrococcus sp.*.Thus, in the pharmacological point of view, it is important to study the biochemistry of apical bark in order to isolate and screen the new pharmacological active principals which can be useful in designing of new drugs active against various infectious micro-organisms like bacteria.[49]

4. Anti –inflammatory Activity

Methanolic and aqueous extract of *Pterocarpus marsupium* has shown anti-inflammatory activity using carrageenan induced rat paw oedema method. The methanolic extract of it at a dose of (100mg/kg) and aqueous extract (100mg/kg) has exhibited anti-inflammatory activity.Flavonoids present in stem bark may be responsible for anti-inflammatory activity. [50]

5. Anti-bacterial Activity

Stem bark extract of *Pterocarpus marsupium* has shown anti-bacterial activity. Antimicrobial activity was tested against Gram-positive bacteria i.e. *Bacillus coagulans* and *Escherichia coli*, gram negative bacteria. Evaluations were based on the inhibition zone using disc diffusion assay. Results showed that *Pterocarpus marsupium* showed highly significant results against both the bacteria.[51]

6. Anti-cataract Activity

Aqueous extract of *Pterocarpus marsupium* has shown anti-cataract activity. Aqueous extract had significantly decreased opacity index in the alloxan induced diabetic rats. [52]

7. Anti-oxidant Activity

Aqueous extract of *Pterocarpus marsupium* has shown anti-oxidant activity using various *in vitro* radical scavenging assays as well as by using liver slice cultures as a model system. The whole aqueous extract had significantly reduced LDH release along with reduction of lipid per oxidation compared to ethanol treated slices. These results indicate that the *Pterocarpus marsupium* extract may serve as a potential source of natural antioxidant for treatment of diabetes.[53]

8. Anti-diabetic Activity

Ethanolic extracts of Pterocarpus marsupium has shown anti diabetic activity in Wister albino rats. Diabetes was induced in Albino rats by administration of alloxan monohydrate (150mg/kg,i.p). The ethanol extracts of *Pterocarpus marsupium* wood and bark at a dose of 150mg/kg of body weight had significantly reduced the blood glucose ($p<0.01$), lipid parameters except HDL-C, serum enzymes and significantly increased HDL-C and antioxidant enzymes. The extracts also caused significant increase in plasma insulin ($p<0.01$) in the diabetic rats.[54]

9. Antihyperlipidaemic Activity

Ethyl acetate extract of *Pterocarpus marsupium* has shown antihyperlipidaemic activity. Administration of Ethyl acetate extract for 14 consecutive days produced a significant reduction of serum triglyceride, total cholesterol, and LDL- and VLDL-cholesterol levels without any significant effect on the level of HDL-cholesterol. Liquiritigenin and pterosupin were able to effect a significant fall in serum cholesterol, LDL-cholesterol, and atherogenic index, pterosupin being additionally effective in lowering serum triglyceride.[55]

10. Cardiotonic Activity

Aqueous extract of *Pterocarpus marsupium* has shown cardio tonic activity by using the isolated frog heart perfusion technique.This plant species contains 5,7,2-4 tetrahydroxy isoflavone 6-6 glucoside which are potent antioxidants and are believed to prevent cardiovascular diseases. Calcium free Ringer solution was used as vehicle for administration of aqueous extract of *Pterocarpus marsupium* as a test extract and digoxin as a standard.[56]

TRADITIONAL USES

The bark and resin decoction is an astringent for severe diarrhea, dysentery, for the treatment of tumors of gland, urethral discharges, used on ringworm of the scalp and chronic ulcers,Abortifacient.[57] The heartwood is astringent, bitter acrid, anti-inflammatory, and anti-helmintic, anodyne. [58] It is good for elephantiasis, leucoderma, diarrhea, rectalgia, cough and grayness of hair.[59] It is safe and effective in wounds, fever, stomach ache, diabetes, jaundice and anti-ulcer.[60]

CONCLUSION

The present study shows the traditional, pharmacological and phytochemical properties of various bioactive compounds present in *Pterocarpus marsupium* roxb. The plant contains flavonoids, alkaloids, resin, fixed oil, saponin, tannin, mucilage, isoflavon glycosides and polyphenol compounds *etc*, in various parts of it. Its pharmacological actions include antibacterial, antioxidant, anti-inflammatory, anti- diarrheal, anti-diabetic, anti-hyperlipidaemic, anti-cataract, hepatoprotective, anti-inflammatory and Cardiotonic activities. Further investigations should be conducted to isolate and characterize the active components of this plant.

Fig.1: *Pterocarpus marsupium*

(i) (ii)

(iii) (iv)

(v)

Fig. 2:*Pterocarpus marsupium* roxb. Heartwood, *Pterocarpus marsupium* roxb.leaf, *Pterocarpus marsupium* roxb. Flowers, *Pterocarpus marsupium* roxb.fruit, *Pterocarpus marsupium* roxb.gum

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