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A valuable insight into the phytochemistry, Pharmacognosy and pharmacology of Palash

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Abstract
India has one of the largest medicinal garden consists of millions of plants and their species. Nowadays, applications of herbal medicines and their scope is far most important for researchers. In leu of this the present discussion is based on one of the most precious plant named as Palash. Here some pharmacognostics and phytochemical characteristics of the plant are discussed with their appropriate references. This study also opens the door for further research in this direction which would be of our kind interest.

Keywords: phytochemistry, Pharmacognosy, pharmacology, Palash

1. Introduction

Butea monosperma is a moderate sized deciduous tree which is widely distributed throughout India, Burma and Ceylon, popularly known as 'palash', commonly known as 'Flame of forest'. The family Fabaceae compromises of 630 genera and 18,000 species. Different Species Available of Genus *Butea: Butte acuminata, Butea affinis, Butea Africana, Butea apoensis, Butea balansae, Butea braamiana, Butea bracteolate, Butea cuneiforms, Butea crass folia, Butea dubia, Butea ferruginous, Butea gyrocarpa, Butea harmandii, Butea laotica, Butea listeri, Butea littoralis, Butea loureirii, Butea macroptera, Butea maingayi, Butea merguensis, Butea minor, Butea oblong folia, Butea parviflora, Butea pellita, Butea peltata, Butea philippinensis, Butea potting, Butea pulchra, Butea purpurea, Butea ridleyi, Butea riparia, Butea rosea, Butea sanguinea, Butea sericophylla, Butea spirei, Butea squirmier, Butea suberecta, Butea superba, Butea varians, Butea volubilis*

The crude extracts of various parts and pure isolates of *Butea monosperma* was reported to possess antibacterial, antifungal, hypoglycemic, anti-inflammatory activities. *Butea monosperma* have been found to possess tonic, astringent, aphrodisiac and diuretics properties. The widespread uses of *Butea monosperma* in traditional systems of medicine have resulted in their extensive chemical analysis for their bio-active principles [1, 2].

B. monosperma is a tree of tropical and subtropical climate. Found throughout the drier parts of India, often gregarious in Forests, open grasslands and wastelands. It is a characteristic tree of the plains, often forming pure patches in grazing grounds and other open places, escaping extermination owing to its resistance to browsing and its ability to reproduce from seed and root suckers. In its native habitat, most of the rain is received during the monsoon season, while the autumn and summer months are generally dry. The tree is very drought resistant and frost hardy, although the leaves turn white and fall off.

1.1 Taxonomy

Kingdom: Plantae; Division: Magnoliophyta; Class: Magnoliopsida; Order: Fabales; Family: Fabaceae; Genus: *Butea;* Species:-*Monosperma*

1.2 Local names

Bengali- palas, kinaka, peras, polashi; English- flame-of-the-forest, bastard teak; Hindi- chichratesu, polak, tellamoduga, dhak, palas, desukajhad, khankrei, chalcha; Urdu- palash,papra; Sanskrit- brahmopadapa, lakshataru, palasha [42]

1.3 Biological source

It is obtained from whole tree of *Butea monosperma*. Family-Fabaceae [3]

1.4 Botanical description

Butea monosperma is a small to medium-sized deciduous tree, 5-15 (max.20) m tall, up to 43 cm; trunk usually crooked and tortuous, with rough greyish-brown, fibrous bark showing a reddish exudates; branch lets densely pubescent.

1.5 Stem

Wood is greenish white in colour. It is porous and soft in texture and has annual rings though not very distinct.

1.6 Leaves

Petiole 7.5-20 cm long with small stipules; leaflets more or less leathery, lateral ones obliquely ovate, terminal one rhomboidobovate,12-27 x 10-26 cm, obtuse, rounded or emarginated at apex, rounded to cuneate at base, with 7-8 pairs of lateral veins, stipellate.

Fig: 1

1.7 Flowers

Flowers in racemes, 5-40 cm long, near the top on usually leafless branch lets; calyx with campanulate tube and 4 short lobes; corolla 5-7 cm long, standard, wings and keel recurved, all about the same length, bright orange-red, more rarely yellow, very densely pubescent.

Fig 2

1.8 Fruit

Fruit an indehiscent pod, (min. 9) 17-24 x (min. 3) 4-6 cm, stalked, covered with short brown hairs, pale yellowish-brown or grey when ripe, in the lower part flat, with a single seed near the apex. Seed ellipsoid, flattened, about 3 cm long.

1.9 Seeds

The seeds are flat, from 25 to 40 mm long, 15 to 25mm wide, and 1.5 to 2 mm thick. The seed-coat is reddish-brown in color, glossy, and wrinkled, and encloses two large, leafy, yellowish cotyledons. The hilum is conspicuous, and situated near the middle of the concave edge of the seed. The odor is faint, and the taste slightly acrid and bitter.[42]

1.10 Microscopy

1. Pedicel

Shows more or less wavy outline, single layered epidermis covered with thick cuticle, unicellular, 2 or 3 celled trichomes, followed by ground tissue consisting of 6 to 8 celled, thin-walled, oval to polygonal parenchymatous cells; endodermis single layered; vascular bundle radially arranged, collateral, consisting of usual elements.

2. Sepal

Shows single layered epidermal cells, uniseriate, multicellular trichomes and club shaped secretory ducts present on lower surface, epidermis followed by 3 or 4layered, thin-walled, loosely arranged parenchymatous cells on both surfaces, thin walled, wavy epidermal cells showing on the surface view.

3. Petal

Shows single layered, thin-walled, epidermal cells, covered with numerous, unicellular, pointed trichomes and a few glandular hairs; thin-walled, capitate or cone shaped papillae present on both surface; mesophyll consisting of thin-walled, loosely arranged, parenchymatous cells; a large number of larger and smaller vein found scattered in this region, some of the cells contain a few of oil globules [42].

4. Seeds

Single layered epidermis of testa interrupted by balloon shaped cells; malphighian cells palisade like, thick-walled, red, unlignified,lumen large but not uniform; discontinuous transparent Linea lucida in upper half of Malphighian layer; osteosclereids irregular, non-lignified, highly thick walled, columnar, compressed and superposed; mesophyll occupies major portion of testa, upper and lower mesophyll cells small,isodiametric to elliptic, middle layers large, angular, condensed with small intercellular spaces; inner epidermis reddish brown, distinct with small thick walled elongated cells externally covered by thin culticle. The T.S of cotyledon shows single layered, thick-walled epidermis having angular cells, followed by beaded parenchymatous cells containing starch and protein inform of spiral, as revealed by freshly prepared Millions Reagent; starch grains, rod shaped orovoid, simple, 20 to 40 µm, hilum indistinct, lamellae distinct. Embryo is straight having aradicle with well-marked hypocotyl, epicotyl with a plumule and a pair of thick cotyledons.

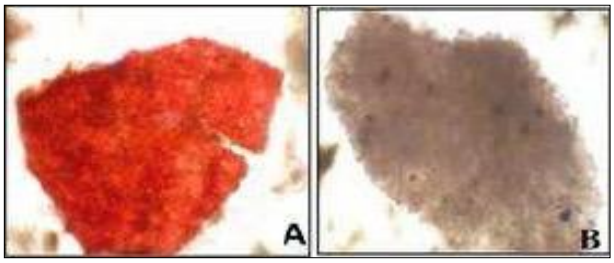
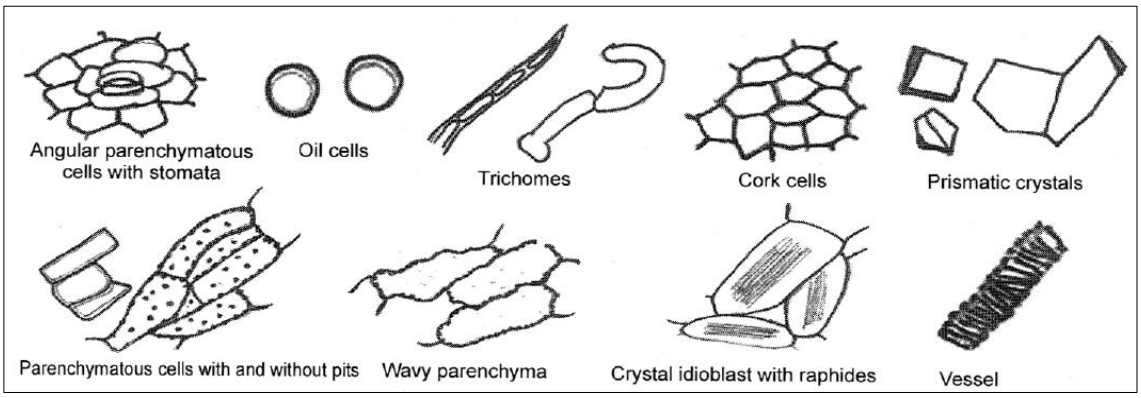


Fig 3

A=parenchymatous tissue with reddish content
B= cream color fragments of testa [42].

1.11 Powder Microsccopy

Powder yellowish-brown; acrid and bitter with oily flavor and pleasant smell; small fragments of testa, broken and intact malphighian cells, osteosclereids, mesophyll cells isolated or in groups, cotyledonary parenchyma containing a few starch grains, abundant spiral protein bodies, mucilage and oil globules; when treated with 50% H_2SO_4, emits yellow fluorescence under UV-254 nm.



[28, 29].

Fig 4

1.12 Ethnomedicinal uses

1. Root

Root powder is applied on injury of snake-bite. Root powder mixed with water is drunk as an antidote for snake bite.

2. Stem

Stem bark powder is used to apply on injury caused due to axe.
Stem juice is helpful to treat goitre of human being.
Body swelling is reduced by applying paste of stem bark.

3. Leaf

Petiole is chewed and juice is sucked to cure cough, cold and stomach disorders.
Leaf juice is dropped into eyes to treat conjunctivitis.
Leaf powder taken with water useful in treatment of diabetes.
Fresh leaves extract is employed to kill intestinal worms
Leaf extract is used as gargle in case of sore throat.
Leaf extract about one cup is administered regularly at night for a month to a useful in treatment of diabetic patient.
Leaf extract about 3-4 spoon is drunk at night for 2-3 month. It checks irregularly bleeding during menstruation.
Flower
About 20 ml Fresh flower extract is taken orally useful in spermatorrhoea.
It is useful to prevent pus from urinogenital tract of male.
A mixture of crushed flower, milk and sugar help to reduce body heat and chronic fever in dose of 2-3 spoons per day.
Flower is soaked in water overnight and infusion is prepared, a cup of this is drunk every morning against leukoderma till cure.

4. Seed

Powder of 2-3 seeds given to children as a remedy against intestinal worm.
crushed seed taken with milk helpful in treatment of urinary complication and also against urine stone.

5. Gum

It is used to treat crack on foot sole.
Two spoons of dilute gum are used for dysentery, till it was cured [4, 5, 6].
Phytochemical review

6. Flower

Triterpene, Butein [4], Butin [3], Isobutrin [2], Coreopsin [5], isocoreopsin [6] (butin 7-glucoside), Sulphurein [10], monospermoside [12] (butein 3-e-D-glucoside) and isomonospermoside [9], chalcones, aurones, flavonoids (palasitrin) [9], prunetin [12] and steroids.

7. Seed

Oil (yellow, tasteless), proteolytic and lipolytic enzymes, plant proteinase and polypeptidase. (Similarto yeast tripsin). A nitrogenous acidic compound, along with palasonin [13] is present in seeds. It also contains monospermoside [12] (butein 3-e-D-glucoside) and Isomonospermoside [14]. From seed coat allophonic acid has been isolated and identified.

8. Bark

Kino-tannic acid, Gallic acid, pyrocatechin. The plant also contains palasitrin [9], and major glycosides asbutrin, alanind, allophanic acid, butolic acid, cyanidin,histidine, Lupenone [14], lupeol [15], (-)-medicarpin [20], palasimide [21] and shellolic acid.

9. Stem

3-Z-hydroxyeuph-25-ene [22] and 2,14-dihydroxy-11,12-dimethyl-8-oxo-octadec-11-enylcyclohexane [23]. Stigmasterol-e-D-glucopyranoside [25] and non acosanoic acid

10. Leaves

Glucoside, Kino-oil containing oleic and linoleic acid, palmitic and lignoceric acid.

11. Gum

Tannins, mucilaginous material, pyrocatechin

12. Resin

Jalaric esters I, II and laccijalaric esters III, IV,Z- amyrin, e-sitosterone its glucoside and sucrose(26),lactone-nheneicosanoic acid-delta-lactone [27].

1.13 Characterization

1. TLC studies

T.L.C. of alcoholic extract of the drug on Silica gel 'G' plate using n-Butanol Acetic Acid: Water (4:1:5) shows in visible light six spots at Rf. 0.42 (light brown), 0.48 (brown),0.58 (yellow), 0.82 (brown), 0.88 (yellow) and 0.96 (light brown). On spraying with phosphomolybdic acid reagent and heating the plate at 105°C for about ten minutes nine spots appear at Rf. 0.08 (blue), 0.19 (blue), 0.32 (blue), 0.42 (blue), 0.48 (yellow), 0.58(blue), 0.82 (yellow), 0.88 (blue) and 0.96 (blue). On spraying with 5% Methanolic-Sulphuric acid reagent and heating the plate at 105°C for about fifteen minutes seven spots

appear at Rf. 0.19 (light red), 0.32 (light red), 0.42 (light red), 0.58 (red), 0.82 (red), 0.88(red) and 0.96 (grey) [37].

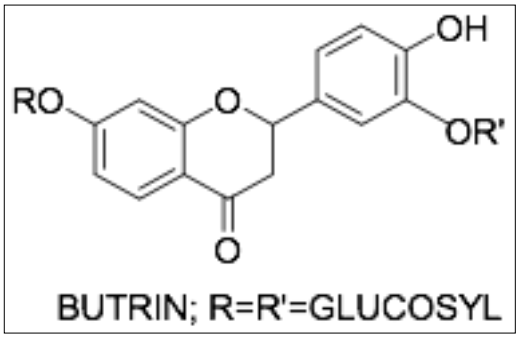


Fig 5

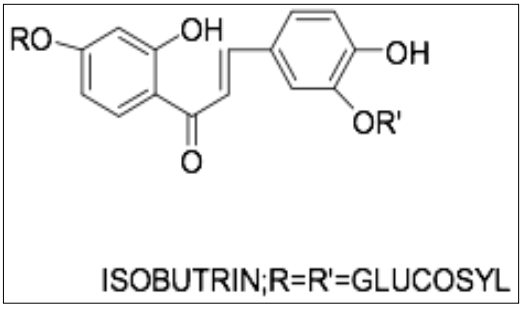


Fig 6

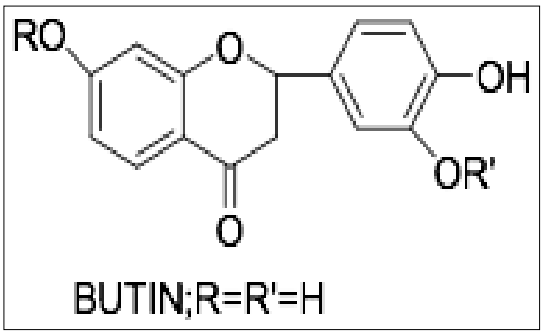
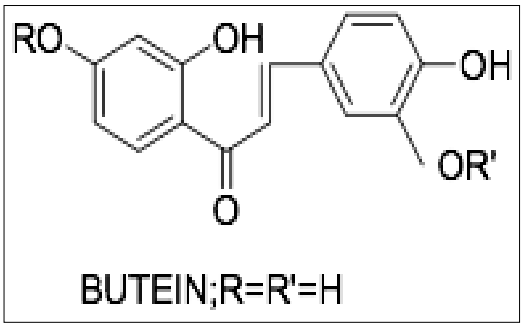


Fig 7



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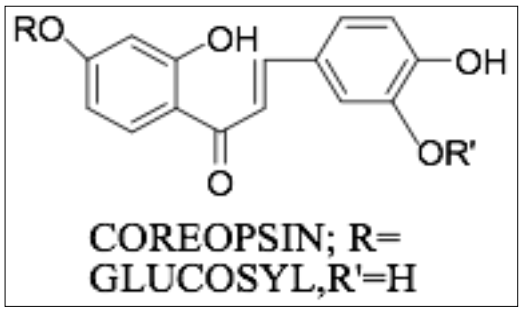


Fig 9

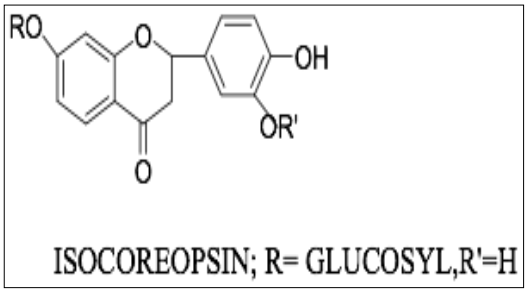


Fig 10

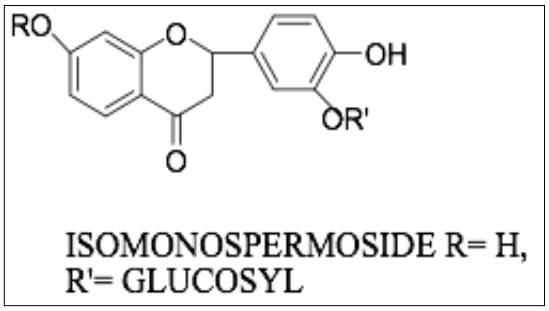


Fig 11

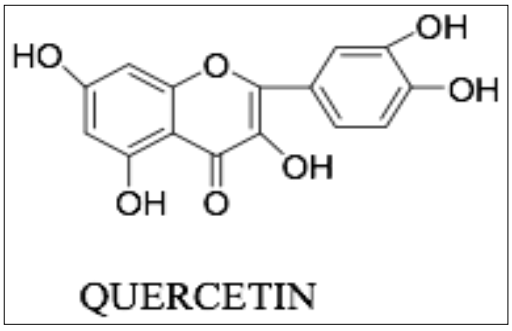


Fig 12

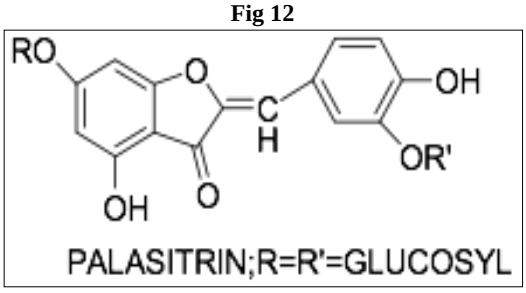


Fig 13

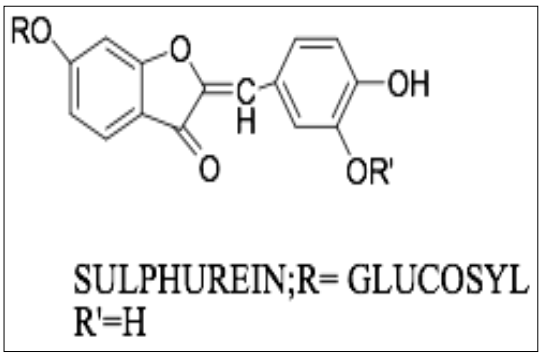


Fig 14

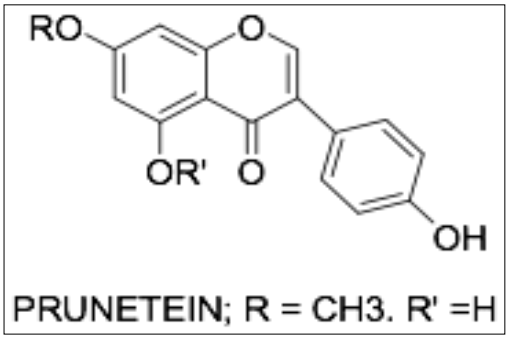


Fig 15

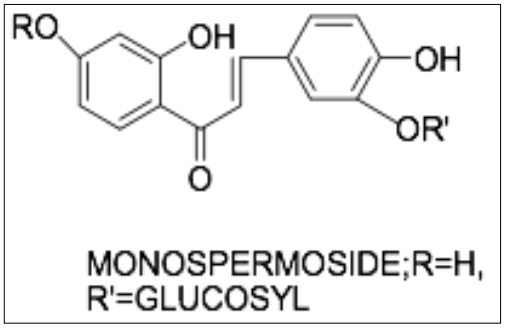


Fig 16

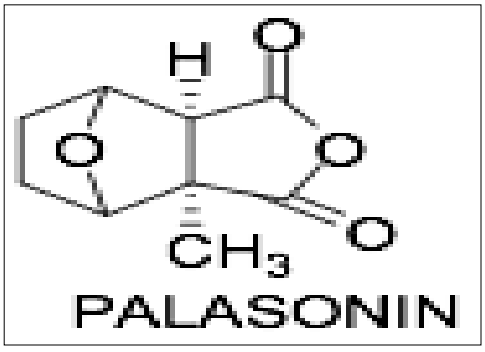
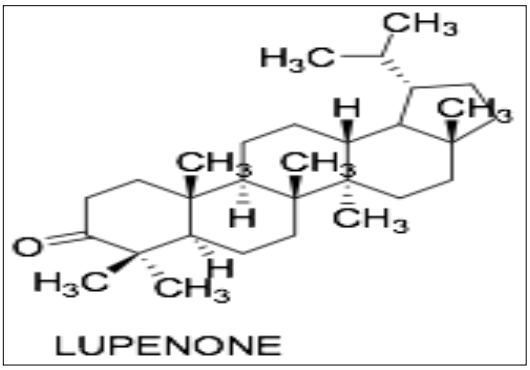


Fig 17

Sterols strcture



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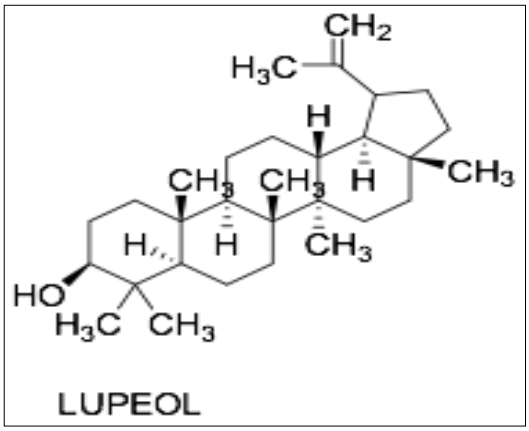


Fig 18

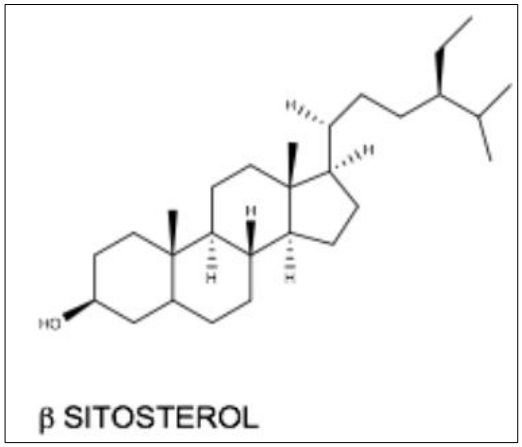


Fig 19

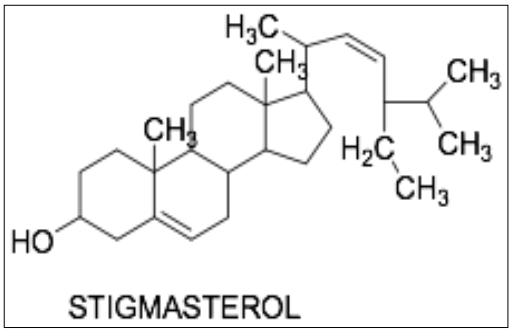


Fig 20

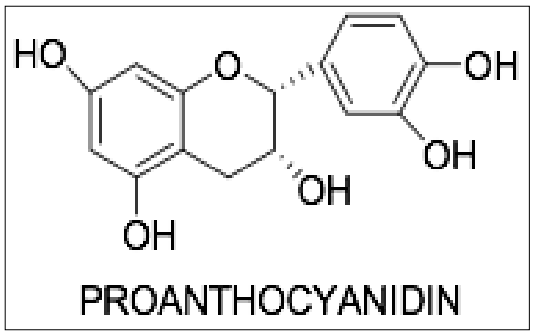


Fig 21

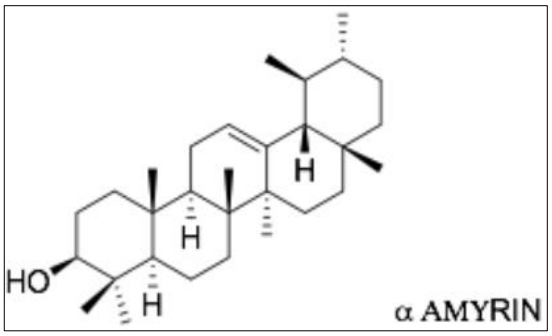
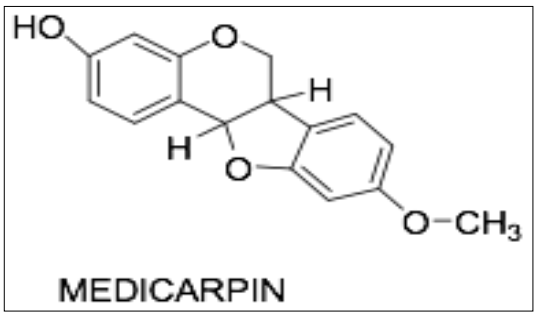


Fig 22



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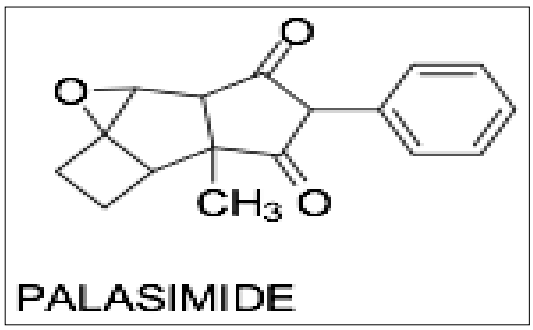

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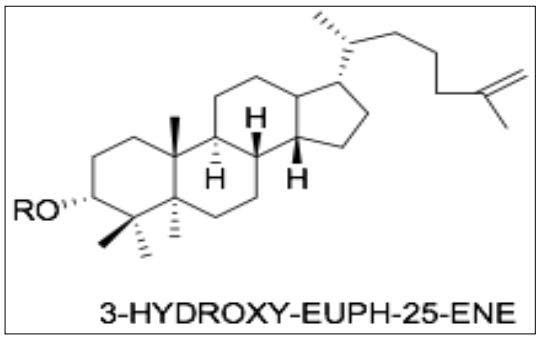

Fig 25

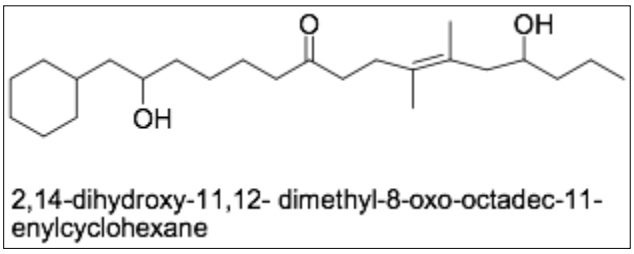

Fig 26

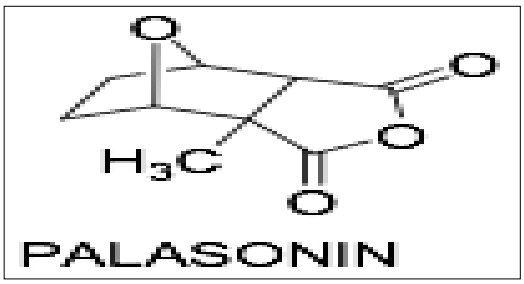

Fig 27

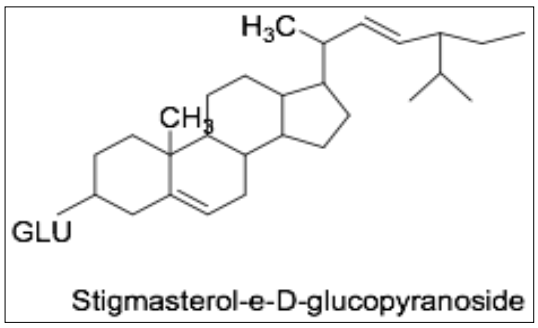

Fig 28

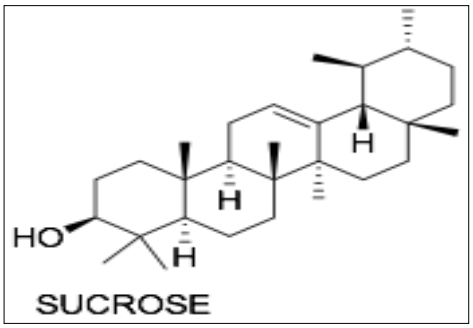

Fig 29

2. HPTLC

Chromatographic conditions:-a camagmicrolitre sample syringe was used for sample application on pre-coated silica gel aluminum plate 60F-254, (10cm x 10 cm with 0.2 mm thickness) the HPTLC was then performed by using the solvent system Toluene: ethyl acetate(9:1) this will cause the separation of constituent. Densitometric scanning was performed on Camag TLC scanner III in the reflectance-absorbance mode for all measurements and operated by CATS software. The plate was scanned at 254 and 366 nm.

Table 1: Result

HPTLC result of palash			
Spot. No	**Rf value at 254 nm**	**Spot. No**	**Rf value at 366 nm**
1	0.02	1	0.02
2	0.05	2	0.07
3	0.19	3	0.1
4	0.21	4	0.25
5	0.33	5	0.33
6	0.4	6	0.39
7	0.49	7	0.49
8	0.59	8	0.72
9	0.72	9	0.85
10	0.85	10	---
11	0.93	11	---

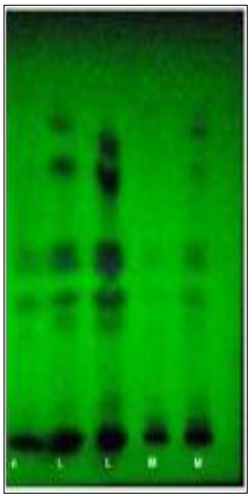

Fig 30

1.14 HPTLC fingerprinting profile of methanol extract of crude drug of plash at 254 nm [38-41]

1. Spectroscopic Data of Some Important Compounds

Spectroscopic methods are very useful in the structure elucidation of various natural and synthetic compounds. The various synthetic compounds can be derived from modification in the structure and functional group of the chemical structure of natural compound to improve its therapeutic effect and to minimise the side effect of drugs. the spectroscopic data of some compound from Butea monosperma are listed be

2. Butin [45]:

2.1 White amorphous solid,

IR (KBr) cm^{-1}: 3481, 3366, 3119,1664, 1607, 1584, 1508, 1361, 1326, 1287, 1266, 1232, 1170, 1113, 994,819.

1H-NMR (400 MHz, DMSO-d_6) δ: 2.62 (1H, dd, *J*=16.7, 2.9 Hz, H-3eq), 3.03 (1H, dd, *J*=16.7, 12.5 Hz, H-3ax), 5.36 (1H, dd, *J*=12.5, 2.9 Hz,H-2), 6.32 (1H, d, *J*=2.1 Hz, H-8), 6.47 (1H, dd, *J*=8.7, 2.1 Hz, H-6), 6.72 (2H, s-like, H-5′, H-6′), 6.86 (1H, s, H-2′), 7.61 (1H, d, *J*=8.7 Hz, H-5),9.02 (2H, brs, OH);

1H-NMR (400 MHz, $CDCl_3$ +5 drops CD_3 OD) δ : 2.67 (1H, dd, *J*=16.9, 2.9 Hz, H-3eq), 2.93 (1H, dd, *J*=16.9, 12.9 Hz, H-3ax),5.23 (1H, dd, *J*=12.9, 2.9 Hz, H-2), 6.31 (1H, d, *J*=2.1 Hz, H-8), 6.44 (1H, dd, *J*=8.7, 2.1 Hz, H-6), 6.73 (1H, dd, *J*=8.1, 1.6 Hz, H-6′), 6.78 (1H, d,*J*=8.1 Hz, H-5′), 6.87 (1H, d, *J*=1.6 Hz, H-2′), 7.70 (1H, d, *J*=8.7 Hz, H-5);

ES-MS *m/z*: 271 $[M-H]^-$.

3. Butein [45]:

3.1 Orange solid;

IR (KBr) cm^{-1}: 3301, 2928, 1638, 1558, 1457, 1352, 1235, 1175, 859.

1H-NMR (400 MHz, CD_3OD) δ : 6.28 (1H, d, *J*=2.4 Hz, H-3′), 6.40 (1H, dd, *J* =8.8, 2.4 Hz, H-5), 6.81 (1H, d, *J*=8.4 Hz,H-3), 7.10 (1H, dd, *J*=8.4, 1.6 Hz, H-2), 7.17 (1H, d, *J*=1.6 Hz, H-6), 7.52 (1H, d, *J*=15.4 Hz, H-a), 7.71 (1H, d, *J*=15.4 Hz, H-b), 7.92 (1H, d, *J*=8.8 Hz, H-6′).

ES-MS *m/z*: 567 $[2M+Na]^+$.

4. (-)-Butrin [45]:

4.1 White solid,

M.P 193—194 °C from MeOH-CH_2CH_2 (lit.27) 190—191 °C);

IR (KBr) cm^{-1}: 3367, 2921, 2873, 1669, 1612, 1575, 1520, 1442, 1279, 1252, 1191, 1170, 1109, 1073, 1038, 1014;

1H-NMR (400 MHz, DMSO-d_6) δ : 2.67 (1H, dd, *J*=16.8, 2.6 Hz, H-3eq), 3.20 (1H, obscured signal,H-3ax), 3.15 (2H, m, H-5″, H-5‴), 3.25 (2H, obscured signal, H-2″, H-2‴), 3.40 (4H, obscured signal, H-3″, H-4‴, H-3‴, H-4‴), 3.43 and 3.68 (each 2H, each m, H-6″, H-6‴), 4.54 and 4.59 (each 1H, each dd, *J*=5.5, 5.4 Hz, OH-6″, OH-6‴), 4.71 (1H, d, *J*=7.1 Hz, H-1‴), 4.97 (1H, d, *J*=7.2 Hz, H-1″), 5.02 (2H, d, *J*=4.6 Hz, OH-2″, OH-2‴), 5.09 (2H, br d, *J*=4.6 Hz, OH-4″, OH-4‴), 5.35 (1H, br d, *J*=4.1 Hz, OH-3″), 5.45 (1H, obscured signal,OH-3‴), 5.45 (1H, dd, *J*=12.8, 2.6 Hz, H-2), 6.60 (1H, d, *J*=2.2 Hz, H-8), 6.70 (1H, dd, *J*=8.7, 2.2 Hz, H-6), 6.83 (1H, d, *J*=8.2 Hz, H-5′), 7.02 (1H, dd, *J*=8.2, 1.5 Hz, H-6′), 7.30 (1H, d, *J*=1.5 Hz, H-2′), 7.70 (1H, d, *J*=8.7 Hz, H-5), 8.78 (1H, br s, OH-4′);

13C-NMR (100 MHz, DMSO-*d*6) δ :

42.9 (C-3), 60.4 and 60.7 (C-6″ and C-6‴), 69.4 and 69.8 (C-5″ and C-5‴),73.0 and 73.2 (C-2″ and C-2‴), 75.9 and 76.3 (C-3‴ and C-3‴), 76.9 and 77.1 (C-4″ and C-4‴), 79.2 (C-2), 99.6 (C-1′), 101.9 (C-1‴), 103.4 (C-8), 110.9 (C-6), 115.3 and 115.6 (C-2′ and C-5′), 115.7 (C-10), 121.6 (C-6′),127.8 (C-5), 129.7 (C-1′), 145.0 (C-3′), 147.1 (C-4′), 162.8 (C-7), 163.4 (C-9), 190.4 (C-4);

ES-MS *m/z*: 595 $[M-H]^-$.

5. β- Sitosterol [44]

5.1 White shining crystals

M.P.:134.5°C.

IR νmax (KBr): 3420, 2924, 1463, and 884 cm^{-1}.

1H NMR (CDCl3, 400 MHz, δ ppm): 0.63, 0.77, 0.81, 0.83, 0.88, 0.92 (each 3H, s, Me-18, Me-29, Me-27, Me-26, Me-21, Me-19), 3.36 (1H, H-3), 5.32 (1H, H-6).

MS m/z (rel. int. %): 414, (C29H50O, M+) (15), 399 (M-Me)+ (10), 396 (M-H2O)+ (12), 381 (M-Me-H2O)+ (79),329 (M-H2O-C5H7)+ (25), 303 (M-H2O-C7H9)+ (23), 275 (M-H2O-

C2H13)+ (12), 273 (M-C10H21)+ (17) and 255 (M-C10H20O-H2O)+ (30).
13C NMR (CDCl3, 400 MHz, δ ppm): 140.9 (C-5), 121.9 (C-6), 71.9 (C-3), 56.8 (C-14), 56.2 (C-17), 50.8 (C-9),50.4 (C-24), 42.6 (C-13), 42.4 (C-4), 40.3 (C-12), 39.5 (C-20), 37.3 (C-1), 36.6 (C-10), 36.3 (C-20), 35.6 (C-8),34.0 (C-22), 33.0 (C-6), 32.1 (C-7), 32.0 (C-8), 31.8 (C-2), 29.3 (C-23), 28.2 (C-16), 26.2 (C-25), 24.3 (C-15),23.1 (C-28), 21.1 (C-21), 21.1(C-11), 19.8 (C-27), 19.4 (C-19), 19.1 (C-21), 18.8 (C-26), 11.9 (C-29), 11.9 (C-18).

6. Lupeol [44]:

6.1 White crystalline compound

M.P.: 210-212°C.
IR νmax (KBr): 3449, 2961, 2926, 2849, 1452, 1254 and 1024 cm^{-1}.
1H NMR (CDCl3, 400 MHz, *δ* ppm): 0.74, 0.79, 0.85, 0.94, 0.97, 1.05 (each 3H, s,
Me-28, Me-23, Me-24, Me-25, Me-26, Me-27), 1.66 (3H, s, Me-30), 3.18 (1H, H-3), 4.57
(1H,H-29), 4.67 (1H, H-29).
EIMS m/z(rel. int. %) :
426 (C30H50O, M+) (20), 411 (M-Me)+ (25), 408 (M-H2O)+ (30), 393 (M-Me-H2O)+ (35), 385 (M-41)+ (15), 220 (M-C15H26)+ (80), 218 (M-C14H24O)+ (55), 207 (M- C16H27)+ (25), 189 (M-C16H29O)+ (100) and 139 (M-C21H35)+(70).
13C NMR (CDCl3, 400 MHz, δ ppm):
38.0 (C-1), 27.4(C-2), 78.0 (C-3), 38.7 (C-4), 55.3 (C-5), 55.3 (C-5), 18.3 (C-5), 18.3 (C-6), 34.0 (C-7), 40.1 (C-8), 50 4 (C-9), 37.7 (C-10), 20.9 (C-11), 25.1 (C-12), 38.0 (C-13), 42.8 (C-14), 27.4 (C-15), 35.6 (C-16), 42.8 (C-17), 48.2 (C-18), 48.0 (C-19), 150.8 (C-20), 28.5 (C-21), 40.0 (C-22), 28.1 (C-23), 15.4 (C-24), 16.1 (C-25), 15.9 (C-26), 14.6 (C-27), 18.0 (C-28), 109.3 (C-29), 19.4 (C-30).

7. Quercetin [44]

7.1 Pale yellow powder

M.P. 322-324°C.
IR νmax (KBr): 3436, 2925, 1715, 1463, 1378, and 1028 cm^{-1}.
1H NMR ($CDCl_3$, 400 MHz, δ ppm): 6.17 (1H, s, H-6), 6.37 (1H, s, H-8), 6.86 (1H, d, H-5), 7.62 (1H, d, H-6), 7.72 (1H, s, H-2)
MS m/z (rel. int. %): 302 (100), 273 (10), 153 (10), 137 (18), ($C_{16}H_{10}O_7$)
13C NMR ($CDCl_3$, 400 MHz, δ ppm): 94.58 (C-8), 99.41 (C-6), 104.69 (C-10), 116.18 (C-2), 116.39 (C-5),121.85 (C-6), 124.32 (C-1), 137.37 (C-3),146.38 (C-3), 148.19 (C-4), 148.93 (C-2), 158.41 (C-9), 162.67 (C-5),165.72 (C-7), 177.50 (C-4)

8. Monospermoside [54]

8.1 Yellowish red amorphous solid

UV (MeOH): 370 and 310nm;

IR (KBr): 3395 (chelated-OH group), 2925 and 760 (phenol-OH group), 1645 cm^{-1}
(>C=o group);
1H NMR showed glycosidic 6 protons between 3.3-3.92 ppm H-1 glycosyl proton at 4.8 to 5.3 ppm. The aromatic proton appears at d 6.16-7.68 (H-6). MS(low intensity molecular ion peak) at m/z 432 due to rapid loss of sugar from the parent molecule. This was followed by strong peak to m/z 415 (M-OH), 368 {M-(OH+CH2OH}, 256 (M-hexose).

9. Lupenone [55]

9.1 Colorless needles,

MP: 168-170ºC;
EIMS for $C_{30}H_{48}O$ m/z: 424 [M+];
1H NMR ($CDCl_3$): δ 0.74, 0.78, 0.83, 0.91, 0.94, 1.06, 1.72 (each 3H, s, Me × 7), 4.56 (1H, s, H-29a), 4.74 (1H, s, H-29b);
13C NMR ($CDCl_3$): δ 212.8 (C- 3), 150.4 (C-20), 108.8 (C-29), 59.3 (C-5), 58.0 (C-9), 53.1 (C-18), 42.6 (C-19), 42.2 (C-17), 41.6 (C-4), 41.4 (C-14, 8), 40.4 (C-22), 39.7 (C-1), 36.0 (C-10, 16), 35.6 (C-13), 35.1 (C-2), 33.1(C-7), 32.3 (C-23), 32.0 (C-24), 30.2 (C-15), 29.7 (C-21), 29.4 (C-12), 22.5 (C-11), 21.0 (C-30), 20.2 (C-28), 18.9(C-25), 18.5 (C-6), 18.0 (C-26), 15.1 (C-27)

10. (+)- Isomonospermoside [45]:

10.1 White amorphous solid

IR (KBr) cm^{-1}: 3346, 2914, 2866, 1656, 1609, 1523, 1466, 1335, 1284, 1162, 1119, 1071, 1034, 990, 799;
1H-NMR (400 MHz, DMSO d_6) d : 2.63 (1H, dd, *J*=16.8, 2.6 Hz, H-3eq), 3.10 (1H, dd, *J*=16.8, 12.8 Hz,H-3ax), 3.13 (1H, m, H-5″), 3.26—3.34 (3H, m, H-2″–H-4″), 3.46 (1H, m, H-6″a), 3.68 (1H, br d, *J*=11.1 Hz, H-6″b), 4.69 (1H, d, *J*=7.2 Hz, H-1″), 5.40 (1H, dd, *J*=12.8, 2.6 Hz, H-2), 6.33 (1H, d, *J*=2.0 Hz, H-8), 6.48 (1H,dd, *J*=8.6, 2.0 Hz, H-6), 6.82 (1H, d, *J*=8.2 Hz, H-5′), 7.01 (1H, dd, *J*=8.2, 1.6 Hz, H-6′), 7.26 (1H, d, *J*=1.6 Hz, H-2′), 7.62 (1H, d, *J*=8.6 Hz, H-5);
ES-MS *m/z*: 457 $[M+Na]^+$.

1.15 Pharmacological review

1. Anthelmintic activity

Crude powder of seeds of *Butea monosperma* administered at doses of 1, 2 and 3 g/kg to sheep naturally infected with mixed species of gastrointestinal nematodes exhibited a dose and a time dependent Anthelmintic effect. The Anthelmintic activity of different species of *Butea* has been reported against *ascaridiagalli*, *ascarislumbricoides*, earthworms, *toxocaracanis*, *oxyurids*, *dipylidiumcaninum* and *taenia*. [7, 8]
The aqueous extracts of Butea monosperma seeds exhibited anthelmintic efficacy against Haemonchus contortus of sheep and goats [46].

2. Anti-diabetic activity

Ethanolic extract of *Butea monosperma* in dose of (200 mg/kg,) significantly improved glucose tolerance and caused reduction in blood glucose level in alloxan-induced diabetic rats. Repeated oral treatment for 2 weeks significantly reduced blood glucose, serum cholesterol and improved HDL-cholesterol and albumin as compared to diabetic control group Ethanolic extract of seeds in dose 300mg/kg Exhibited significant hypolipemic anti-peroxidative and anti-diabetic, effects in non-insulin dependent diabetes mellitus rats [9, 10, 11].
Ethanolic extract of Butea monosperma flowers significantly reduced blood glucose, serum cholesterol, improved HDL-cholesterol and increased the activities of antioxidant enzymes [47].
The ethanolic extract of Butea monosperma leaves elevated blood insulin level in Type 2 diabetic rats, stimulated insulin secretion in isolated rat islets, and enhanced hepatic glycogen formation [48].
The leaves and stem bark of Butea monosperma showed significant anti-diabetic activity using various *in vitro* techniques viz. glucose adsorption, diffusion, amylolysis

kinetics, enteric enzymes and glucose transport across yeast cells [49].

3. Anti-diarrhoeal activity

Ethanolic extract of stem bark of *Butea monosperma* at 400 mg/kg and 800mg/kg inhibited castor oil induced diarrhoea due to inhibiting gastrointestinal motility and PGE2 induced enteropooling and it also reduced gastrointestinal motility in Wistar albino rats after charcoal meal administration. It decreases bilirubin level and also use in chronic diarrhea [12].

4. Anti-inflammatory activity

The leaves of *Butea monosperma* exhibit ocular anti-inflammatory activity in rabbits.The methanolic extract of *Butea monosperma* show anti-inflammatory activity that evaluated by carrageenin induced paw edema and cotten pellet granuloma [13].

Antimicrobial, Antifungal activity, anti-bacterial Activity

Antifungal compound (-)-3-hydroxy-9-methoxypterocarpan [(-)-medicarpin (20) isolated from petroleum and ethyl acetate extract of stem bark from *Butea monosperma*. Both (-)-medicarpin and its acetate were active against *cladosporium cladosporioides*. The low polarityactive constituent was isolated by bioassay monitored chromatographic fractionation, and identified as (-)-medicarpin (20) by comparison of physical data. The antifungal activity of (-)-medicarpin (20) was found to be greater than a standard fungicide i.e Benlate, while (-)-medicarpin acetate also exhibited significant activity against *C. cladosporiodes*. The seed oil of *Butea monosperma* shows significant bactericidal and fungicidal effect in in-vitro testing studied by the filter paper disk method against several human pathogenic bacteria and fungi. Gum of *Butea monosperma* is used to treat microbial and fungal infections in folk medicine. To validate this use, the in- vitro antimicrobial activity of petroleum ether and alcoholic extract of gum was evaluated against various microbial strains such as *Staphylococcus aureus*, *Bacillus subtilis*, *Bacillus cereus*, *Salmonella typhimurium*, *Pseudomonas aeuriogenosa*, *Escherichiacoli*, *Candida albicans* and *Saccharomyces cerevisiae* by using disc diffusion method [14, 15, 16].

5. Anti-conceptive activity

Seeds of Butea contain Butin (3) which is active at doses of 5, 10 and 20 mg/rat from day 1 to day 5 of pregnancy showed anti-implantation activity in 40%,70% and 90% of the treated animals respectively. There was a dose-dependent termination of pregnancy at lower doses and reduction in the number of implantation sites. In ovary ectomized young female rats, the butin (3) exhibited estrogenic activity at comparable anti-conceptive doses, but was devoid of anti-estrogenic activity. Butin (3) is a weak estrogen in that a significant uterotrophic effect was discerned evens at 1/20th the Anti-conceptive dose. It was reported that seed oil use as traditional sexual toner and contraceptive [17, 18].

6. Anti-convulsive activity

The n-hexane:ethylacetate (1:1) fraction of the petroleum ether extract of dried flowers of *Butea monosperma* contains a triterpene which shows anti convulsive activity. it exhibited anti-convulsant activity against seizures induced by maximum electroshock and its LD(50)was found to be 34.2+/-18.1 mg/kg. triterpene also inhibited seizures induced by pentylenetetrazol (ptz), electrical kindling, and the combination of lithium sulfate and pilocarpine nitrate (li-pilo). Triterpene exhibited depressant effect on the central nervous system. The petroleum ether extract of flowers of *Butea monosperma* exhibited anticonvulsant activity. The acetone soluble part of petroleum ether extract of *Butea monosperma* flowers showed anticonvulsant activity. The fractions protected animals from maximum electro shock, electrical kindling pentylenetetrazole and lithium–pilocarpine induced convulsion but failed to protect animals from strychnine-induced convulsions. The fractions raised brain contents of gamma-amino butyric acid (GABA) and serotonin [19, 20].

The ethanolic extract of Butea monosperma bark and leaf exhibited anticonvulsant effect in pentylene tetrazole and maximal electro shock seizure models [50].

7. Anti-estrogenic and anti-fertility activity

Methanolic extracts of *Butea monosperma* exhibited effect on uterotropic and uterine peroxidase activities in ovariectomized rats & determine estrogenic/anti-estrogenic potential of anti-fertility substances using rat uterine peroxidase assay. Alcoholic extract of flowers of the title plant has also been reported to exhibit anti-estrogenic and anti-fertility activities. Butin (3) isolated from its flowers show both male and female contraceptive properties [21, 22, 23].

Anti-stress activity

Water soluble part of Ethanolic extracts of flower attenuated water immersion stress, induced elevation of brain serotonin and plasma corticosterone levels. The ulcer index also decreased in dose dependent manner. Observed effects may be attributed to its nonspecific anti-stress activity [24].

Thyroid inhibitory, anti-per oxidative and hypoglycaemic effects

Stigma sterol isolated from the bark of *Butea monosperma* was evaluated for its thyroid hormone and glucose regulatory efficacy in mice by administrating 2.6 mg/kg/d for 20 days which reduced serum tri-iodothyronine (T3), thyroxin (T4) and glucose concentrations as well as the activity of hepaticglucose-6-phophatase (G-6-Pase) with a concomitant increase in insulin indicating its thyroid inhibiting and hypoglycaemic properties. A decrease in the hepatic lipid per oxidation (LPO) and an increase in the activities of catalase (CAT), superoxide dismutase (SOD) and glutathione (GSH) suggested its anti-oxidative potential. The highest concentration tested (5.2 mg/kg) evoked pro-oxidative activity [25].

8. Wound healing

8.1 Topical administration of an alcoholic bark extract of *Butea monosperma* on coetaneous wound healing in rats increased cellular proliferation and collagen synthesis at the wound site, by increase in DNA, total protein and total collagen content of granulation tissues, the tensile strength also increased significantly & histo-pathological examinations also provide favourable result So, it possesses antioxidant properties, by its ability to reduce lipid per oxidation [26].

9. Anti-filarial

The aqueous extract of Butea monosperma leave and roots showed significant inhibition of motility of brugia malayi microfilariae as compare to control suggesting anti-filarial effects (Sahare *et al.,* 2012). The methanolic and hexane-ethanolic extracts of Butea monosperma plant leaves showed

significant antifilarial activity in terms of motility inhibition assay and MTTreduction assay [51].

10 Antioxidant and free radical scavenging activity

The ethyl acetate, butanol and aqueous fractions from total methanolic extract of Butea monosperma flowers possess free radical scavenging activity (Lavhale *et al.*, 2007). The aqueous and ethanolic leaf extracts of Butea monosperma do contain compounds capable of inhibiting the cyclophosphamide induced oxidative stress and subsequent DNA damage in both the peripheral blood and bone marrow cells in mice [52,46].

11. Anti-cancer

The aqueous extract of Butea monosperma flowers inhibited cell proliferation and accumulation of hepatoma cell in G1 phase with significance induction of apoptotic cell death suggesting chemopreventive and anti-cancer property[53].

1.16 Markted Preprations

Krimimudgrasa, Krmighna churn, Krmikutharras, Plashbeejj churn, palshghrit, CrushLukol, Hairzone, palash capsules [36].

Fig 31: Marketed preparations of palash

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