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DALBERGIA SISSOO LINN. AN OVERVIEW MORPHOLOGY, PHYTOCHEMISTRY AND PHARMACOLOGY

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ABSTRACT: The present review is, therefore, an effort to give a detailed survey of the literature on its pharamacognosy, phytochemistry, traditional uses and pharmacological studies of the plant *Dalbergia sissoo*. The genus consists of 300 species among which 25 species occur in India. The generic name *Dalbergia* honors the Swedish brothers Nils and Carl Dalberg, who lived in the 18th century. *Dalbergia sissoo* is an important timber species around the world. Besides this, it has been utilized as medicines for thousands of years and now there is a growing demand for plant based medicines, health products, pharmaceuticals and cosmetics. *Dalbergia sissoo* is a widely growing plant which is used traditionally as anti-inflammatory, antipyretic, analgesic, anti-oxidant, anti-diabetic and antimicrobial agent. Several phytoconstituents have been isolated and identified from different parts of the plant belonging to the category of alkaloids, glycosides, flavanols, tannins, saponins, sterols and terpenoids. A review of plant description, phytochemical constituents present and their pharmacological activities are given in the present article.

INTRODUCTION: Medicinal plants have been the part and parcel of human society to combat diseases since the dawn of human society to combat diseases since the dawn of human civilization. The earliest description of curative properties of medicinal plants were described in the Rigveda (2500-1800 BC), Charak Samhita and Sushruta Samhita. Herbal medicine remains one of the most common forms of therapy widely available throughout the world population. [1-3] *Dalbergia sissoo* Roxb. belongs to Leguminoseae plant family which is native to India and had been long cultivated in Egypt has shade tree on the banks of irrigation canals. [4]

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Dalbergia sissoo is the state tree of Punjab state (India) and the provincial tree of Punjab province (Pakistan). It is found growing along river banks below 900 metres (3,000 ft) elevation, but can range naturally up to 1,300 m (4,300 ft). It can withstand average annual rainfall up to 2,000 millimetres (79 in) and droughts of 3–4 months. It prefers soils from pure sand and gravel to rich alluvium of river banks. Shisham can grow in slightly saline soils. Seedlings are intolerant of shade. [5]

2. Synonyms: *Amerimnon sissoo* (Roxb.) Kuntze, Coroya Pierre, *Amerimnon* P. Browne, *Ecastaphyllum* P. Browne, *Miscolobium* Vogel, *Triptolemea* Mart. [6]

3. Common names: Sanskrit (Shinshapa, aguru), English (Indian Rosewood, Bombay blackwood), Hindi (Shisham, sissu, sisam), Tamil (Sisso, gette), Bengali (Shishu), French (Ébénier juane), Arabic (Arabic). [6]

4. Scientific Classification: [7]

Kingdom - Plantae

Unranked - Angiosperma

Unraked - Ecidicots

Unranked - Rosids

Order - Fabales

Family - Fabaceae

Sub Family - Faboideae

Tribe - Dalbergia

Genus - *Dalbergia*

Species – *Sissoo*

5. Taxonomical Classification: [8]

Domain - Eukaryota

Kingdom - Plantae

Division - Magnoliophyta

Phylum - Tracheophyta

Tribe - Dalbergieae

Genus - *Dalbergia*

Species - *Sissoo*

Binomial name - *Dalbergia Sissoo* DC.

6. Botanical Discription: *Dalbergia sissoo* is a medium to large tree of about 25 meters high with grey yellow trunk, 2-3 meters in diameter. [9]

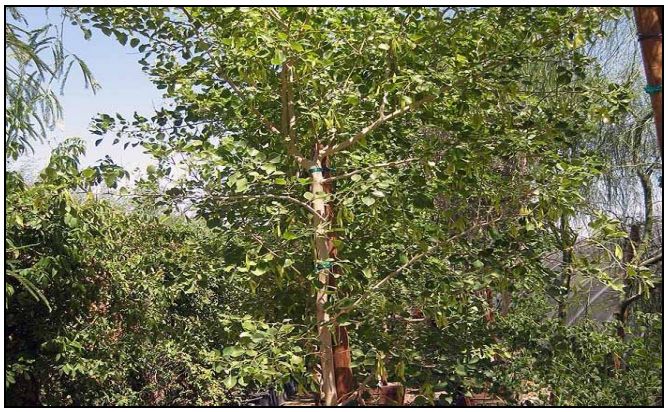


FIG. 1: *DALBERGIA SISSOO* TREE

6.1 Leaves are leathery, pinnately compound, alternate leaflets, petiolated leaf stalk, measures about 15 cm long, each leaflet widest at the base, to 6 cm long with a fine pointed tip. [9]

FIG. 2: *DALBERGIA SISSOO* LEAVES

6.2 Flowers are whitish to pink, fragrant, nearly sessile, and in dense clusters. [9]

FIG. 3: *DALBERGIA SISSOO* FLOWERS

6.3 Pods are oblong, flat, thin, strap-like 4–8 cm long, 1 cm wide and light brown. They contain 1–5 flat bean-shaped seeds 8–10 mm long. It has a long taproot and numerous surface roots which produce suckers. Young shoots are downy and drooping, stems have light brown to dark grey bark up to 2.5 cm (0.98 in) thick, shed in narrow strips, large upper branches support a spreading crown. [10]

FIG. 4: *DALBERGIA SISSOO* PODS

6.4 Seeds are 6-8 x 4-5 mm, kidney shaped, thin and flat, light brown. The fruit is dry and hard. The sapwood is white to pale brown in colour and the

heartwood is golden to dark brown in colour. It develops a long taproot from an early age, and numerous lateral ramifying roots.[11-12]

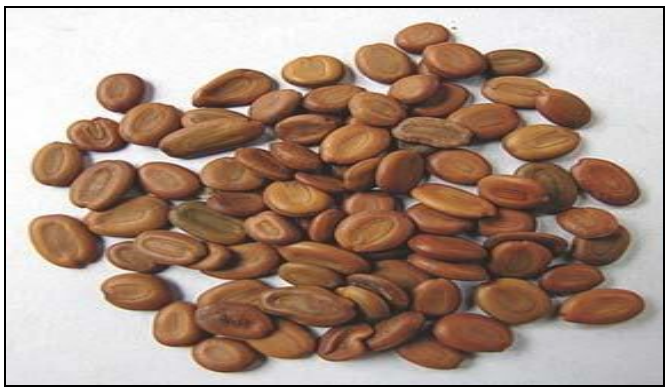


FIG. 5: *DALBERGIA SISSOO* SEEDS

7. List of species of in dalbergia genus: [13-14]

TABLE 1: SPECIES OF IN *DALBERGIA* GENUS

S.no.	Species name
1	**(**Rosewood) D. *Abrahamii*
2	**(**Burmese Rosewood) D. *Bariensis*
3	(Palisander) *D. Baronii*
4	(Caroba-Brava) D. *Brasiliensis*
5	Brown's Indian Rosewood) D. *brownei*
6	**(**Granadillo) D. *Calycina*
7	**(**Dalbergia) D. *Candenatensis*
8	**(**Jacarand) D. *Catingicola*
9	**(**Brazilian Kingwood) D. *Cearensis*
10	**(**Rose Wood) D. *Cochinchinensis*
11	(Granadillo) D. *Cubilquitzensis*
12	(Burma Blackwood) D. *Cultrate*
13	**(**Burma Blackwood) D. *cultrata* var. cultrata
14	(Bejuco De Peseta) D. *Ecastaphyllum*
15	(Bastiao-De-Arruda) D. *Decipularis*
16	(Mussuta) D. *Elegans*
17	(Jacarand -Rosa) D. *Foliolosa*
18	(Jacarandá-Rosa) D. *Frutescens*
19	(Pau-De-Estribo) D. *frutescens* var. frutescens
20	(Jacarand -Rosa) D. *frutescens* var. tomentosa
21	(Ebano) D. *Funera*
22	(Tripa-De-Galinha) D. *Gracilis*
23	(Sebastiao-De-Arruda) D. *Hortensis*
24	(Jacaranda) D. *Inundata*
25	(Shisham) D. *Lanceolaria*
26	(Bombay Blackwood) D. *Latifolia*
27	(Bois de Rose) D. *Maritime*
28	**(**African Blackwood) D. *Melanoxylon*
29	(Canela-De-Burro) D. *Miscolobium*
30	(Rosewood) D. *Mollis*
31	**(**Bejuco De Peseta) D. *Monetaria*
32	(Bahia Rosewood) D. *Nigra*
33	(Fragrant Rosewood) D. *Odorifera*
34	(Burma Rosewood) D. *Oliveri*
35	(*Dalbergia*) D. *Palauensis*
36	(*Dalbergia*) D. *Palauensis*
37	(Akar Laka) D. *Parviflora*
38	(Nambar) D. *retusa* var. Retusa
39	(Rabo-De-Guariba) D. *Riparia*
40	(Malabar Blackwood) D. *Sissoides*
41	(Indian Rosewood) D. *Sissoo*
42	(Sabuarana) D. *Spruceana*
43	(Rosewood) D. *Stevensonii*
44	(Ver"nica) D. *Subcymosa*
45	(Rosewood) D. *Trichocarpa*
46	(Dalbergia) D. *Tucurensis*
47	(Heliotropio) D. *Villosa*
48	(Heliotropio) D. *villosa* var. Barretoana
49	(Rosewood) D. *Xerophila*
50	(Yucatan Rosewood) D.*yucatensis*

8. Geographical Distribution:

8.1 Exotic range: Afghanistna, Bangladesh Bhutan, India, Malaysia, Pakistan. [15]

8.2 Native Range: Cameroon, Cyprus, Ethiopia, Indonesia, Iraq, Israel, Kenya, Mauritius Nigeria, Sudan, Tanzania, Thailand, Togo, US, Zimbabwe.[15]

9. Traditional Uses: Various parts of *Dalbergia sissoo* are traditionally used in treating different diseases and are mentioned below.[16]

9.1 Seeds: *Sissoo* oil is used to treat blue itching, burning on the skin, and scabies.[16]

9.2 Leaves: Finely ground paste of 8-10 leaves of *sissoo* and 25gm of palm candy taken in the morning alleviates profuse menstruation. 50-100ml decoction of the leaves taken thrice in a day is useful in Painful micturition and to cure boils and pimples. 10-15 ml juice (leaves) taken thrice in a day helps in eliminating pus in urine and in treating jaundice. The leaves warmed and tied on breast, and consuming the decoction of the leaves removes swelling of the breast.[16]

9.3 Bark: 3-6gm powdered bark or decoction of the leaves is helpful in gonorrhea. Decoction of the bark and leaf is given in leprosy. Make a decoction of 10gm *sissoo* bark with 500gm of water and it should be boiled till the liquid reduces to half. Mix the juice of the bark and consume for forty days every morning which helps in leprosy.[16]

9.4 Sissoo nectar: Take 20gm of *sissoo* nectar, 320gm water, and 160 gm milk. Boil it till only milk remains. Consume 3 times a day. This milk cures any type of fever.[16]

10. Chemical constituents:

10.1 Leaves: Sissotrin and Isoflavone-O-Glycoside. [17]

10.2 Flowers: Biochanin A, Tectorigenin, 7, 4-Dimethyl Tectorigenin and 7-O-Methyl tectorigenin.[17]

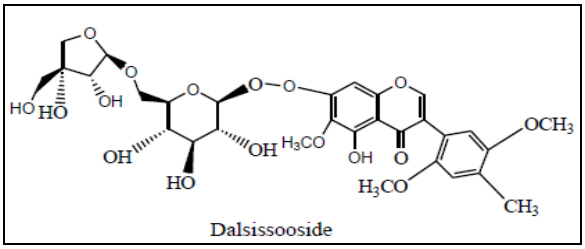
10.3 Green pods: Meso-Inisitol, 7-O-Methyltectorigenin and 4´-Rhamnoglucoside. [17]

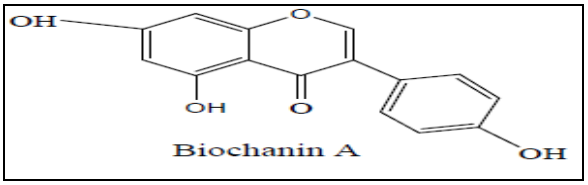
10.4 Mature pods: Isocaviumin, Tectorigenin, Dalbergin, Biochanin A, 7-Hydroxy-4-Methyl Coumarin, 7-O-Glucosides of Tectorigenin, Caviunin and Tannins.[17]

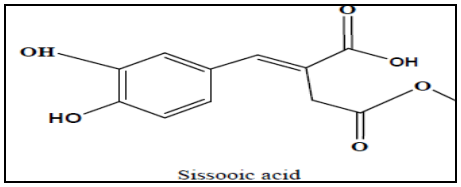
10.5 Stem bark: Dalberginone, Dalbergin, Methyldalbergin, 4-Phenylchromene, Dalbergi chromene and Isotectorigenin. [17]

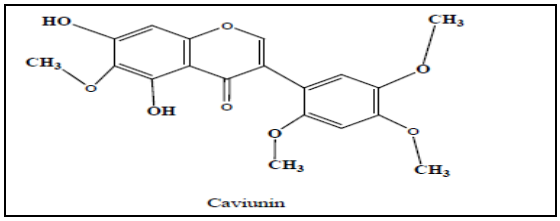
10.6 Heartwood: Dalbergin, Nordalbergenones, Dalbergichromene 3, 5-Dihydorxytrans- Stilbene, Biochanin A, Allylphenol of Latifolin Type – Dalbergiphenol and Fixed Oil. [17]

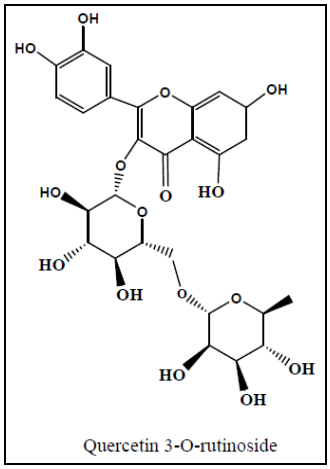
11. Chemical Structure: [18]











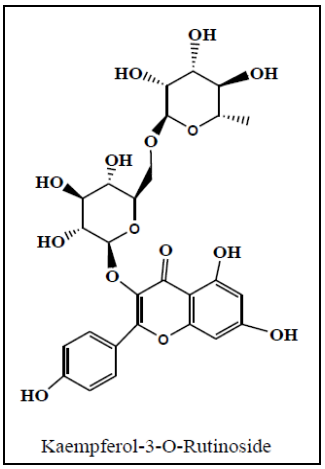


FIG. 6: CHEMICAL STRUCTURES OF IMPORTANT CONSTITUENTS IN GREEN LEAVES OF *DALBERGIA SISSOO*

TABLE 2: CHEMICAL CONSTITUENTS OF VARIOUS PART OF PLANT *DALBERGIA SISSOO* [19-38]

Plant parts	Chemical constituents	Reference
Leaves	Trisacchrides	19
Leaves	Oligosacchrides	20
Tree Trunk	Flavanoids	21
Flower	Tectorigeninbiochanin	22
Leaf	Phenols	23-24
Stem Bark, Heart Wood	Neoflavenes (Dalbergichromene**),** 4-phenyl chromene	25-26
Pods	Tannin	25-27
Barks	Flavanoid	28
Pods	Caviunin 7-O-gentiobioside	29
Stem Bark	Cinnamylphenols	30
Heart Wood	Chalcones [Isoliquiritigenin], Isosalipurposide	31
Trunk exudates	Flavanones [Naringenin]	32
Heart Wood	Amino acids [Glycin, Alanine, Threonine, Isolucine, Phenylalanine]	33
Heart Wood	Myristic acid, Palmitic acid, Stearic acid, Arachidic acid, Linoleic acid, Oleic acid	34
Heart Wood	Dalbergin	35
Root Bark	Chalcone(2,3-dimethoxy-4'-ϒ,ϒ-dimethyl allyloxy-2'hydroxy chalcone)	36
Root Bark	Isoflavone(7-ϒ,ϒ-dimethylallyloxy-5-hydroxy-4'methoxy isoflavone), biochanin A	36
Root Bark	Flavone, 7-hydroxy-6-methoxy flavone	36
Root Bark	Rotenoid, Dehydroamorphigenin	36
Root	Cardiac Glycoside, Anthraquinone, Saponin	37
Heart Wood	Dalbergenone	38

12. Phytochemistry of *Dalbergia sissoo*: [39-50]

By using Silica gel column chromatography and Spectral analysis isoflavones, biochanin-A, muningin, sissotrin, amyrin, stigmasterol were isolated from aerial parts of *Dalbergia sissoo* Roxb, 13 fatty acids were identified. The alcoholic leaf extract showed inhibitory effect on motility of rabbit duodenum, analgesic, antipyretic activity. [39] Farag and his co-authors isolated isoflavone glycoside, biochanin A, tectorigenin from methanolic extract of leaves of *Dalbergia sissoo* using Reverse phase liquid chromatography on ODS. Two isoflavone glycosides, biochanin A 7-O-[b-d-apiofuranosyl-(1-5)-b-dapiofuranosyl-(1-6)-b-d-glucopyranoside] and tectorigenin 7-O-[b-d-apiofuranosyl-(1-6)-bd- glucopyranoside], were isolated from *Dalbergia sissoo* using reverse phase liquid chromatography using ODS column. Their structures were elucidated on the basis of UV and NMR spectral and chemical evidence. [40] From the methyl acetate extract of root bark of *Dalbergia sissoo*, Reddy *et al.*, have reported to isolate new chalcone, hydroxyl chalcone, isoflavone, methyl isoflavone, biochanin A, dehydroamorphigenin. [41] Several water soluble polysaccharides were reported to isolated leaves of *Dalbergia sissoo* by Gel permeation chromatography, Paper chromatography, Gas liquid chromatography which further revealed the presence of Rhamnose, galactose, glucuronic acid in leaf extract. [42] The extract of heartwood of *Dalbergia odorifera* of same genus found to contain sesquiterpenes 1 & 2 which are having strong antiplatelet and poor antithrombic activity.[43]

The stem-bark of *Dalbergio sissoo* has yielded the known compounds dalbergenone, dalbergin and methyl dalbergin and a new 4-phenyl chromenedalbergichromene. Its structure has been determined as 7-mahoxy-6-hydroxy-4-phenyl chrom-3-ene by spectral and degradative experiments. Reinvestigation of the heartwood shows that in addition to the known compounds the plant also contains dalbergichromenenordalbergin and isodalbergin as minor constituents.[44]

Dalbergia sissoo is most valued not only for the durability of its timber but also for its resistance to attack by insects and micro-organisms. They have provided a large number of neoflavonoid and isoflavonoid derivatives. The neoflavonoids can be placed under 5 major groups as follows: 4-phenylcoumarins, dalbergiquinols, dalbergi quinones and brazilins. Largest group among neoflavonoids and contains a number of complex derivatives. There are only a few compounds with substituents in the 4-phenyl ring. The presence of isoprene units and their incorporation into new rings leads to the complexity of products; such compounds are present in oil seed in *Dalbergia* woods species. [45]

A new isoflavoneglucoside from the mature pods of *Dalbergia sissoo* has been isolated and identified as caviunin 7-0-gentiobioside, i.e. the 7-gentiobioside of 5, 7-dihydroxy-6, 2', 4', 5'-tetramethoxyisoflavone. The ethanolic extract was column chromatographed (Si gel). The EtOAc-MeOH (4: 1) eluate contained, in addition to the polymeric impurities, a compound which gave dim red fluorescence. It was obtained in pure form by precipitation with in ethanol and methanol (1: l). [46]

A new isoflavonediglucoside, isocaviunin 7-0-gentiobioside has been isolated from *Dalbergia sissoo*. On Silica gel TLC with solvent systems $CHCl_3$,-MeOH (7:3); and EtOAc-MeOH (1: 1) it showed on exposure to iodine vapours a single yellow colour spot which on keeping changed to green. Hydrolysis with sulphuric acid yielded glucose and an aglycone. The molecules were characterized by UV and NMR spectroscopy. [47]

Thirteen rosewood *(Dalbergia)* species produced a purple quinonemethide pigment in the callus that was apparently identical between the species. The pigment was first purified from D. *retusa* cell culture and its structure was elucidated by mass, infrared, and detailed 1H and 13C NMR and NOE spectroscopic studies including 2D experiments (COSY, NOESY, HMQC, and HMBC). [48]

From the methyl acetate of root bark of *Dalbergia sissoo* extract a chalcone, 2,3- dimethoxy-40-g,g-dimethylallyloxy-20-hydroxychalcone (1) and an isoflavone, 7-g,g-dimethylallyloxy- 5-hydroxy-40-methoxyisoflavone (2) together with a known flavone, 7-hydroxy-6-methoxyflavone (3), a known isoflavone, biochanin A (4) and a known rotenoid, dehydroamorphigenin (5) were isolated by silica gel as stationary phase with solvents like n-hexane and ethyl acetate in gradient step method. The

structures of compounds 1–5 were elucidated on the basis of spectral and chemical studies. [49] Several water soluble polysaccharides were reported to isolate from leaves of *Dalbergia sissoo* by gel permeation chromatography, paper chromatography, gas liquid chromatography which further revealed the presence of rhamnose, galactose, glucuronic acid in leaf extract. [50]

13. Phytochemical Screening of ethanolic extract of stem bark of plant *Dalbergia sissoo*: [51-52] Qualitative phytochemical analysis of the ethanolic extract of *Dalbergia sissoo* was carried out using standard procedures to assess the different types of phytochemical constituents present in the bark of *D. sissoo* using different chemical tests. Screenings were carried out for carbohydrates, glycosides, proteins, amino acids, phytosterols, saponins, flavonoids, alkaloids and tannins.

13.1 Test for Reducing Sugars (Fehling's test): The ethanol extract (0.5 g in 5 mL of water) was added to boiling Fehling's solution (A and B) in a test tube. The solution was observed for a colour reaction (a purple ring at the junction of two liquids).

13.2 Test for Anthraquinones: 0.5 g of the extract was boiled with 10 mL of sulphuric acid (H_2SO_4) and filtered while hot. The filtrate was shaken in 5 mL of chloroform. The chloroform layer was pipetted into another test tube, and 1 mL of dilute ammonia was added. The resulting solution was observed for colour changes.

13.3 Test for Terpenoids (Salkowski's test): 2 mL of chloroform was added to 0.5 g of the extract. Concentrated H_2SO_4 (3 mL) was carefully added to form a layer, and the solution was observed for a reddish brown colouration at the interface, which indicated the presence of terpenoids.

13.4 Test for Flavonoids: Three methods were used to test for flavonoids. (i) Dilute ammonia (5 mL) was added to a portion of an aqueous filtrate of the extract. Concentrated sulphuric acid (1 mL) was then added. A yellow colouration that disappeared on standing indicated the presence of flavonoids. (ii) A few drops of 1% aluminium solution was added to a portion of the filtrate. A yellow colouration indicated the presence of flavonoids. (iii) A portion of the extract was heated with 10 mL of ethyl acetate over a steam bath for 3 min. The mixture was filtered, and 4 mL of the filtrate was shaken with 1 mL of dilute ammonia solution. A yellow colouration indicated the presence of flavonoids.

13.5 Test for Saponins: 5 mL of distilled water was added to 0.5 g of extract in a test tube. The solution was shaken vigorously and observed for a stable persistent froth. The froth was mixed with three drops of olive oil and shaken vigorously, after which it was observed for the formation of an emulsion.

13.6 Test for Phenolic Compounds: 50 mg of extract was dissolved in distilled water and to this; 3 mL of 10% lead acetate solution was added. Formation of a bulky white precipitate indicated the presence of phenolic compounds (lead acetate test). 50 mg of extract dissolved in 5 mL of distilled water and to this; 2 mL of a 1% solution of gelatin containing 10% sodium chloride was added. The appearance of white precipitates indicated the presence of phenolic compounds (gelatin test).

13.7 Test for Tannins: About 0.5 g of the extract was boiled in 10 mL of water in a test tube and then filtered. A few drops of 0.1% ferric chloride was added, and the solution was observed for brownish green or a blue-black colouration.

13.8 Test for Alkaloids: 0.5 g of the extract was diluted to 10 mL with acid alcohol, boiled and filtered. 2 mL of dilute ammonia was added to 5 mL of the filtrate, followed by the addition of 5 mL of chloroform. The mixture was shaken gently to extract the alkaloidal base, and the chloroform layer was extracted with 10 mL of acetic acid. The chloroform layer was divided into two portions. Mayer's reagent was added to one portion and Draggendorff's reagent to the other. The formation of a cream (with Mayer's reagent) or reddish brown precipitate (with Draggendorff's reagent) was regarded as positive for the presence of alkaloids.

13.9 Test for Cardiac Glycosides (Keller-Killiani test): 0.5 g of extract was diluted to 5 mL in water, and 2 mL of glacial acetic acid containing one drop of ferric chloride solution was added to it. 1 mL of concentrated sulphuric acid was added to form a layer, and the colour at the inter phase was recorded. A brown ring at the interface indicated

the presence of a deoxy sugar characteristic of cardenolides. A violet ring may appear below the brown ring, while in the acetic acid layer, a greenish ring may form just above the brown ring and gradually spread throughout this layer.

14. Pharmacology activity:

TABLE 3: PHARMACOLOGICAL ACTIVITY OF VARIOUS PART OF PLANT *DALBERGIA SISSOO* [53-74]

Plant part	Extract	Pharmacology activity	Author & Year
Leaf	Alcoholic extract	Antipyretic & analgesic	Hajare *et al.*, 2000
Oil	Oil	Anti-larvicidal	Ansari *et al.*, 2000
Leaf	Ethanolic extract	Anti-inflammatory	Hajare *et al.*, 2001
Different Parts	Decoction of dried leaves	Anti-diarrhoeal	Brijezh *et al.*, 2006
Leaf	Aqueous extract	Use as cosmetic	Sazia *et al.*, 2006
Different parts	Aqueous & Ethanolic extract	Anti-mollusicidal	Adenusia *et al.*, 2008
Leaf	Ethanolic extract	Anti-diabetic	Pankaj *et al.*, 2010
Seed	Ethanolic extract	Antipyretic & analgesic	Mallinath *et al.*, 2010
Stem bark	Methanolic extract	Antioxidant	Nayan *et al.* 2011
Root bark	Ethanolic extract	Antispermato-genic	Vasudeva *et al.*, 2011
Different parts	Pet. Ether, Carbon tetrachlorid, Benzene, Ethanolic extract	Anthelmintic	Hood *et al.*, 2011
Bark	Ethanolic extract	Antinociceptive	Asif *et al.*, 2011
Leaf	Ethanolic extract	Anti-osteogenic	Preety *et al.*, 2012
Bark	Ethanolic extract	Anti-diabetic	Pund *et al.*, 2012
Leaf & Pods	Butanol-soluble standardized fraction	Anti-osteopenia	Khedgikar *et al.*, 2012
Stem bark	Methanolic extract	Gastro protective	Muhammad *et al.*, 2013
Leaf	Ethanolic extract	Neuro protective	Swaroop *et al.*, 2014

14.1 Anthelmintic activity: The ethanolic extract of bark of *Dalbergia sissoo* Roxb. was investigated for its activity against Indian earthworms *Pheretima posthuma* and nematode *Ascardi galli*. Various concentrations (10, 20, 50 mg/ml) of ethanolic extract were tested, which involved determination of time of paralysis and time of death of the worms. It was compared with Piperazine citrate (15 mg/ml) and Albendazole (20 mg/ml) as standard reference and normal saline as control. The study indicated the potential usefulness of *Dalbergia sissoo* Roxb. against helminthic infections.[53]

14.2 Antimicrobial property: In a study, a herbal preparation containing *Dalbergia sissoo* and *Datura stramoium* with cow urine (DSDS), was evaluated for its antibacterial potential against pathogenic strains of grampositive (*Staphylococcus aureus* and *Streptococcus pneumoniae*) and gram-negative (*Escherichia coli, Pseudomonas aeruginosa* and *Klebsiella pneumoniae*) bacteria. Antibacterial activity was compared to standard antibiotic drugs *i.e.* Chloramphenicol (30 mcg), Ampicillin (10 mcg), Nalidixic acid (10 mcg) and Rifampicin (30 mcg). Cow urine extract was found to be most active against both gram-positive as well as gram-negative bacteria. Clinical isolate of *S. aureus* showed higher sensitivity towards cow urine extract of DSDS than standard strains, and inhibited growth on most regulatory levels such as inhibition of protein, DNA, RNA and peptide glycan synthesis. The results of the present study shows that the cow urine extract of DSDS may be used as a potent antiseptic preparation for prevention and treatment of chronic bacterial infections.[54]

14.3 Anti-inflammatory activity: The methanolic extract of *Dalbergia sissoo* Roxb was investigated for anti-inflammatory activity in experimental animal models. Treatment with 70% methanolic extracts of *Dalbergia sissoo* demonstrate a diminished inflammation in rat hind paw when challenged with carrageenan induced paw edema. The methanolic extract of *Dalbergia sissoo* root at 1000 mg/kg showed the most potent anti-inflammatory activity compared to the other groups (100 and 500 mg/kg) throughout the observation period. *Dalbergia sissoo* Roxb. was devoid of ulcerogenic effect on the gastric mucosa of rats in acute and chronic tests. It was concluded that the *Dalbergia sissoo* root extract possessed significant anti-inflammatory activity without any side effect on gastric mucosa. [55]

The possible anti-inflammatory activity of a 90% ethanolic extract of *Dalbergia sissoo* bark was also studied in a model of inflammation using a right hind paw oedema method in Wistar rats. One percent carrageenan in 0.5% sodium carboxy methyl cellulose (CMC) was administered through the sub-plantar region of the right hind paw of the animals. CMC was used as a suspending agent because it does not produce evident changes in activity response. Phyto-chemical investigation of bark extract showed that it contained carbohydrates, proteins, amino acids, tannins and flavonoids. After oral administration of ethanolic extract at different doses (300, 500 and 1000 mg/kg), inhibition of right hind paw oedema was observed at 30, 60, and 120 min time intervals. The anti-inflammatory effects of the extract were compared with a standard dose of indomethacin (10 mg/kg). In acute toxicity studies, the extract was found to be safe up to 3000 mg/kg, p.o. in the rats. The biological effects increased with increasing doses. The ethanolic extract of *Dalbergia sissoo* bark at 1000 mg/kg showed the most potent anti-inflammatory activity compared to the other groups (300 and 500 mg/kg) throughout the observation period.[56]

14.4 Analgesic and Antipyretic: The peripheral analgesic activity of Shisam seed extract (SSE) was studied using acetic acid-induced writhing in mice and by Randall-Selitto assay in rats. Further, the central analgesic activity of SSE was studied by tail-clip test and hot plate method in mice. The antipyretic activity of SSE was studied in Brewer's yeast-induced pyrexia in rats. Results showed significant decreased writhing movements in mice by acetic acid-induced writhing test and significant increased in the pain threshold capacity in rats in Randall-Selitto assay and the reaction time in hot-plate test but not in tail-clip test for analgesic activity. Moreover, it also showed significant antipyretic activity in Brewer's yeast-induced pyrexia in rats throughout the observation period of 6 h. Thus, SSE has moderate analgesic and remarkable antipyretic activities.[57-58]

14.5 Antinociceptive activity: The antinociceptive activity of ethanolic extract of the plant bark of *Dalbergia sissoo* was evaluated using tail flick method on Wistar rats. Three different dose levels (300, 500, and 1000 mg/kg) in 0.5% carboxyl methyl cellulose were administered. The antinociceptive extract activities of the all doses were compared with that of the standard drug asprin (300 mg/kg). The results were found to be significant ($P<0.01$). At the above doses, the extract possesses significant dose-dependent anti nociceptive activity. Phyto-chemical investigation of the ethanolic extract showed the presence of carbohydrates, proteins, amino acids, phenolic compounds, and flavanoids. The antinociceptive activity of the bark extract may be due to the presence of phytochemical constituents such as flavanoids.[59]

14.6 Osteogenic activity: One new isoflavone glucoside, caviunin 7-O-[β-D- apiofuranosyl-(1→6)-β-D-glucopyranoside] and a new itaconic derivative, (E)-4-methoxy-2-(3, 4- dihydroxy benzylidene)-4-oxobutanoic acid along with series of isoflavones and flavonols with their glucosides and a lignan glucoside were isolated from the ethanolic extract of *Dalbergia sissoo* leaves and were assessed for osteogenic activity in primary calvarial osteoblast cultures. Result showed that compounds exhibited significant osteogenic activity.[60]

14.7 Antioxidant potential: Stem bark of *Dalbegia sissoo* were evaluated for its antioxidant potential. Finally results shown, among the different extracts of stem bark of the plant, chloroform extract exhibited marked antioxidant activity, whereas methanolic extract shown moderate activity in different *in vitro* anti-oxidant assays.[61, 62]

14.8 Antidiarroheal activity: Antibacterial, anti-protozoal, and antiviral activities of the plant *Dalbergia sissoo* were checked by agar dilution method, tube dilution method, and neutral red uptake assay, respectively. Cholera toxin (CT) and *Escherichia coli* labile toxin (LT) were assayed by ganglioside monosialic acid receptor ELISA. Suckling mouse assay was used to assess E. coli stable toxin (ST). As a measure of colonisation, the effect against adherence of *E. coli* and invasion of *E. coli* and *Shigella flexneri* to HEp-2 cells were studied. It reduced the production and the binding of CT and bacterial adherence and invasion. This study showed that *D. sissoo* is anti-diarrhoeal as it affects bacterial virulence.[63-64]

14.9 Anti-spermatogenic activity: A study was undertaken to evaluate the anti-spermatogenic efficacy of ethanol extract of stem bark of *Dalbergia sissoo* Roxb. For the *in vitro* study, semen samples were obtained from 15 healthy fertile men aged 25–35 years. Sperm motility was examined by the Sander-Cramer method. A dose-dependent and time-dependent effect of ethanol extract on sperm motility and sperm viability were observed. Various concentrations affected the motility of sperm. Ethanol extract at a concentration of 20 mg/mL caused complete immobilization within 3 minutes. Sperm viability and hypo-osmotic swelling was significantly reduced at this concentration. The *in vivo* studies were carried out on Swiss male albino mice. Ethanol extract at a dose of 200 mg/kg body weight resulted in a significant decrease ($p<0.001$) in weight of the testis and epididymis. A significant decrease ($p<0.01$) in sperm motility and sperm count in the epididymis were observed. Histological changes in the epididymis and testis were also investigated.[65]

14.10 Anti-diabetic potential: Pankaj singh niranjan et al conducted a study in 2010 to evaluate the anti-diabetic activity of ethanolic extract of *Dalbergia sissoo* leaves in alloxan induced diabetic rats. They concluded that the ethanolic extract of the leaves are 12% more effective in reducing the blood glucose level compared to standard Glibenclamide.[66, 67]

14.11 Molluscicidal activities: In the search for molluscicidal compounds from plants, crude aqueous and ethanolic extracts from different parts of *Dalbergia sissoo* Roxb. were evaluated against egg masses and adults of *Biomphalaria pfeifferi* and the snail intermediate host of *Schistosoma manson* in Nigeria. Laboratory-bred adult *B. pfeifferi* and their viable 0–24 h old egg masses were separately exposed to five different concentrations (7.81–2000 mg l−1) each, of the crude aqueous and ethanolic extracts of the fruits, leaves, roots and stem bark of *D. sissoo*, for 24 h. The LC_{50} and LC_{90} values of each extract for the target organisms were calculated using probit analysis. Only the ethanolic extracts of the fruits and roots showed significant activities against the adult snails (24 h LC_{90}<100 mg l−1: 74.33 and 93.93 mg l−1, respectively) and their egg masses (LC_{90}: 89.29 and 114.29 mg l−1, respectively) while all other extracts demonstrated weak molluscicidal and ovicidal activities (24 h LC_{90} > 100 mg l−1). There were concentration-dependent behavioural changes in snails exposed to test extracts, while egg mortalities, manifested at the gastrula/exogastrula stage and or the prehatch snail stage of development, were similarly concentration-dependent. The crude ethanolic extracts of *D. sissoo* fruits and roots exhibited promising molluscicidal activities (LC_{90} values<100 mg l−1) against adult *B. pfeifferi* with additional toxicities towards its 0–24 h-old egg masses. [68-69]

14.12 Anti-termite activity: Anti-termite activity of heartwood of *Dalbergia sissoo* was evaluated. It was concluded that the plant extracts can be used as an alternative for synthetic pesticides for the control of termite in buildings. [70]

14.13 Anti-larvicidal activity: Studies were carried out to evaluate the growth inhibitor, repellent action & anti larvicidal action of *D. sissoo* oil against *Aedes aegypti*, *Anopheles stephensi* and *Culex quinquefasciatus* under laboratory conditions. The oil also showed strong repellent action when oil was applied on exposed parts of human volunteers. They were protected from mosquito bites for 8±11 h. The protection obtained with *sissoo* oil was comparable to that with commercial Mylol oil consisting of di-butyl and di-methyl phthalates. [71]

14.14 Anti-mollusicicidal activity: The crude aqueous and ethanolic extracts from different parts of *Dalbergia sissoo* were evaluated against egg masses and adults of *Biomphalaria* pfeifferi the snail intermediate host of *Schistosoma mansoni* in Nigeria. Only the ethanolic extracts of the fruits and roots showed significant activities against the adult snails and their egg masses while all other extracts demonstrated weak molluscicidal and ovicidal activities. [72]

14.15 Neuroprotective action: This research was performedin 3- Nitropropionic acid induced neurotoxic rats to characterize the neuroprotective effect of ethanolic extract of *Dalbergia sissoo* leaves. The ethanolic extract of *Dalbergia sissoo* leaves was administered 300 and 600mg/kg orally

to neurotoxic rats. These results suggest that ethanolic extract of *Dalbergia sissoo* leaves may have potential therapeutic value in various neurological disorders, probably by its antioxidant, anti-inflammatory and estrogenic properties.[73]

14.16 Gastro protective action: This study was conducted to evaluate the antiulcer effects of *D.sissoo* stem bark methanol extract (DSME) against the diclofenac sodium-induced ulceration in rats. The results of this study showed that DSME exhibits a potential gastro protective activity probably due to its antioxidant and cytoprotection ability.[74]

CONCLUSION: The multiple benefits of *Dalbergia sissoo* it a true miracle of nature. Numerous studies have been conducted on different parts of *Dalbergia sissoo*, this plant has yet developed as a drug by pharmaceutical industries. These drug so few side effects with the higher doses administartion. A detailed and systematic study is required for identification, cataloguing and documentation of plants, which may provide a meaningful way for the promotion of the traditional knowledge of the herbal medicinal plant.

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