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# PHARMACOGNOSTIC, PHYTOCHEMICAL AND PHARMACOLOGICAL ASPECTS OF *CAESALPINIA SAPPAN* PLANT

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**Keywords:**

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**ABSTRACT:** *Caesalpinia sappan* L. is a member of the Caesalpiniaceae family. It originated from India through Myanmar and Thailand to peninsular Malaysia to Indochina and south china. It is also called Brazilin. The heartwood of *Caesalpinia sappan* contains water soluble properties that color to transform into the red. When oxidation process occurred. The chemical constituents investigation of sappan wood resulted that it has phenolic components, including one xanthine, one coumarin, three chalcone, 2 flavones, three homoisoflavonoid and Brazilin. The traditional Chinese medicine brazilin is used to treat increased blood circulation, promote menstruation, and exhibit analgesic property. The article aims to review the pharmacognostic study of *Caesalpinia sappan* and explore its pharmacological properties such as antioxidant activity, antibacterial activity, antiacne activity, anti-inflammatory activity, hepatic-protective, anticancer activity, and larvicidal activity.

**INTRODUCTION:** Plants have been one of the important sources of many traditional medicines throughout the world. In India, around 3000 plants have been reported to have medicinal properties [1]. The medicinal value of the plant is due to the presence of a wide variety of secondary metabolites, such as alkaloids, glycosides, tannins, volatile oils and terpenoids. Medicinal herbs are the best attribute to various modern drugs [2]. *Caesalpinia sappan L.* is a medicinal and dye-yielding plant belonging to family Caesalpiniaceae. The plant is commonly known as Brazil wood, sappan wood or Indian redwood.

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Brazilian is one of the most important bioactive natural components from *Caesalpinia sappan* heartwood, having a wide variety of industrial applications. Since, proven medicinal properties and is used as dyeing agent, the wood has received both domestic and international markets and is being exported to USA and Europe from Southeast Asia. *Caesalpinia sappan is* considered to have come from India. It is found wild as in south India, west Bengal, Orissa and Sri Lanka [3]. The tree may be given pruning during the initial years to retain 3-4 straight branches per plant by removing uneconomic slender slide shoots.

*Caesalpinia sappan* known as Secang in Indonesia, is a flowering tree. Its heartwood is traditionally used for skin care. It is stated that in India, the wood of *Caesalpinia sappan* is used in toothpaste as a component due to its strong healing action to stop bleeding in gum [4]. This review mainly focuses on the pharmacognostic study of *Caesalpinia*

*sappan*, a medicinally promising plant, and explores its pharmacological activities. Brazilian is the main flavonoid found in sapwood [4]. The extract is not only non-toxic to humans but also environmentally friendly. It is used for making herbal drinking water in various regions. In Kerala, it is mixed with ginger, cinnamon and clove [5]. In traditional Chinese medicine, brazilin is used for treatment of increased blood circulation, promotes menstruation and exhibit analgesic property.

**TABLE 1: VERNACULAR NAMES [6]**

| S. no. | Language | Names |
|---|---|---|
| 1 | English | Sappan wood |
| 2 | Malayalam | Sappanam, Pathimukham |
| 3 | Tamil | Patungam |
| 4 | Telugu | Vakama |
| 5 | Hindi | Bakam |
| 6 | Guajarati | Patang |
| 7 | Kannada | Chappanga |
| 8 | Sanskrit | Patrangah, Patangah |

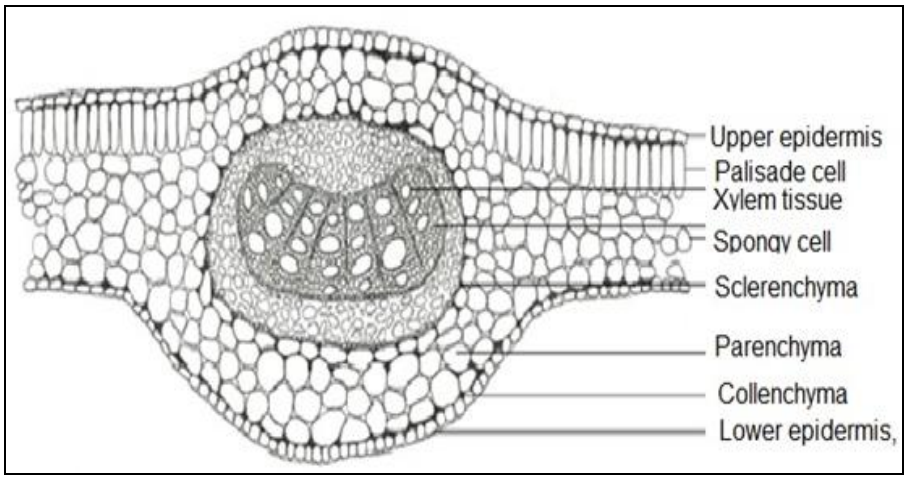
**TABLE 2: SCIENTIFIC CLASSIFICATION**

| S. no. | Kingdom | Plantae |
|---|---|---|
| 1 | Subkingdom | Tracheophytes |
| 2 | Unranked | Angiosperms |
| 3 | Unranked | Eudicots |
| 4 | Unranked | Rosids |
| 5 | Division | Magnoliophyte |
| 6 | Class | Magnoliopsida |
| 7 | Order | Fabales |
| 8 | Family | Fabaceae |
| 9 | Genus | *Caesalpinia* |
| 10 | Species | *sappan* |

**Plant Description:** It is a small thorny tree, 6-9 m in height and 15-25 cm in diameter with a few prickly branches. Leaves are compound, large and abruptly bi-pinnate with 8-12 pairs of oblong leaflets and small prickles. Its branches, when interlocked, make a strong barrier. Hence it is considered as a live fencing plant. Within a year's time, the plant reaches a height of 3-5 m sappan is cultivated as a horticulture plant for its large compound leaves and bright yellow flowers.

Flowers in terminal panicles, racemes pubescent, primary peduncles 30- 40 cm long, the flowering 9-15 cm long, bracts ovate-acuminate, about 6 mm long, flowers fragrant, 2-3 cm long, 5-merous; sepals glabrous, petals pubescent, the superior one smaller; calyx tube 3 mm long; corolla yellow, uppermost lobes cuneate, other obovate, all clawed and gland punctate; stamens 10, filaments densely tomentose in the lower half; ovary superior, pubescent. Fruit a dehiscent pod, globous, thick, flattened, obliquely oblong, prominently beaked, woody, polished-brown, 7-10 cm x 3-4 cm, 2-3 (-5) seeded. Seeds ellipsoid, flattened, 18-20 mm x 10-12 mm, brown [7, 8].

**Microscopy [9]:** The transverse section of the midrib of each Caesalpinia species was examined. The leaf samples were cleaned before use. The cross-sectioning of the midrib was done by hand with a razor as thin as possible, transferred onto a slide, two drops of water added, and the anatomical characteristics were observed and under a light microscope attached to a digital camera. All pictures were recorded by a digital camera and illustrated by hand drawing with dimensions of a specific ratio relative to the actual size.




**Phytoconstituents:** The heartwood contains water-soluble flavonoids namely Brazilin, protosappanin and haematoxylin. Brazilin is the main homoisoflavonoid constituent found in heartwood,

which is well known as the natural red color dye for staining. Heartwood of *Caesalpinia sappan* L. indicated the presence of homoisoflavonoids and phenolic such as 4-O-methylsappanol, protosappanin A, protosappanin B, protosappanin E, Brazilin, brazilein, caesalpin, brazilide A, neosappanone A, caesalpin P, sappanchalcone, 3-deoxysappanone, 10 7,3′,4′-trihydroxy-3- benzyl-2H-chromene, and others [5,6,7] caesalsappanins A–L, two new cassane diterpenes, designated caesalsappanin R and caesalsappanin S 8,9], 3-deoxysappanchalcone, rhamnetin. [(6aS, 11bR)-7, 11b-dihydro-6H-indeno [2,1-c] chromene-3, 6a, 9, 10-tetrol]. *Caesalpinia sappan* L. boiled with 70ºC water for 20 minutes yielded the finest quality of Brazilin. Redness produced by Brazilin was correlated with pH level [10].

**TABLE 3: PHYTOCONSTITUENTS OF *CAESALPINIA SAPPAN***

| Part | Compound/group |
|---|---|
| Bark | Alkaloids, steroids, flavonoids, terpenoids, tannins |
| Stem | Alkaloids, flavonoids, tannins, terpenoids, alkaloids, sterols |
| Heartwood | Flavonoids, glycosides, phytosterol, tannins, saponins, terpenoids |
| Heartwood | Protosappanins E-1 and E-2 |
| Heartwood | Brazilin, sappanchalcone, protosappanin A, protosappanin B, protosappanin C, protosappanin D, and protosappanin E |
| Heartwood | (+)-(8S,8'S)-bisdihydrosiringenin, sappanchalcone, 3'-Deoxy-4-O-methylepisappanol, protosappanin A, sappanone B, palmitic acid, brazilein, Brazilin, 3-deoxysappanchalcone, (+)-lyoniresinol, 3-deoxysappanone B, protosappanin B, isoprotosappanin B, 3'-O-methylbrazilin |
| Heartwood | Brazilin, lupeol, linoleic acid, vanillin, friedelin, campesterol, β-sitosterol and stigmasterol |
| Heartwood | Flavonoids, triterpenoids, tannins, and sterols |
| Leaves | Glycosides, phenols, saponins, flavonoids, tannins |
| Leaves | Flavonoids, saponin, phenol, steroid, tannins |
| Heartwood | Episappanol, protosappanin C, brazilin, (iso-protosappanin B and sappanol |
| Wood | Brazilin, protosappanin A and sappanone B |
| Leaves | Flavonoids, phenolic compounds, tannins, saponins |
| Seed | Caesalsappanin R and caesalsappanin S |
| Heartwood | Brazilein |
| Leaves | Phenols, saponins, flavonoids, tannins, glycosides |
| Heartwood | Caesalpiniaphenols A–D |
| Heartwood | Sappanchalcone, caesalpiniaphenol G, and quercetin |

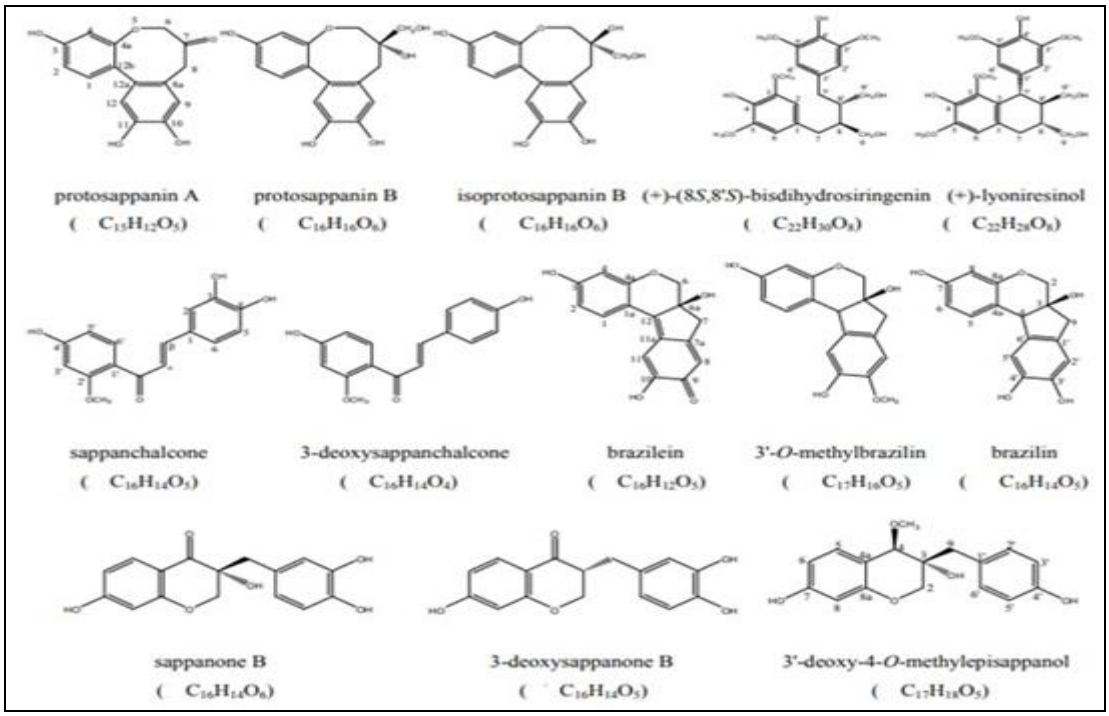



**FIG. 1: PHYTOCONSTITUENTS OF *CAESALPINIA SAPPAN***

**Phytochemical Screening and Other Studies [11]:** The HPTLC studies were also performed for the Successive petroleum ether, chloroform, methanol, and crude 50% methanol and distilled water extracts on precoated silica gel GF254 plates and the suitable solvent system, Rf values, and the percentage of the constituents in each extract were found out and the results.(Shrishailappa Badami *et al.,* 2003).

**TABLE 4: THE HPTLC PROFILE OF VARIOUS EXTRACTS OF *CAESALPINIA SAPPAN* HEARTWOOD**

| S. no. | Extract | Solvent System | Number of peaks | Rf values | Percentage peak area |
|---|---|---|---|---|---|
| 1 | Petroleum ether | Pet. Ether 80: Ethyl acetate 20 | 10 | 0.11, 0.13, 0.19, 0.24, 0.30, 0.57, 0.65, 0.67, 0.72, 0.80 | 0.11, 1.36, 1.75, 0.41, 4.02, 38.98, 0.38, 0.24, 1.46, 51.28 |
| 2 | Chloroform | Chloroform 40: Ethyl Acetate 60 | 5 | 0.20, 0.30, 0.56, 0.78, 0.94 | 0.64, 8.13, 21.64, 58.41, 11.18 |
| 3 | Methanol | Chloroform 90: Methanol 10 | 8 | 0.08, 0.13, 0.18, 0.25, 0.32, 0.44, 0.76, 0.84 | 9.51, 4.24, 3.95, 28.95, 42.68, 9.01, 1.01, 0.65 |
| 4 | 50% Methanol | Chloroform 90: Methanol 10 | 8 | 0.07, 0.14, 0.16, 0.23, 0.31, 0.42, 0.79, 0.84 | 29.33, 3.60, 3.14, 15.05, 40.29, 6.87, 1.01, 0.70 |

**Traditional use [5]:** Traditionally it is used for the treatment of blood pressure, burning sensations, cancer, cataract, digestion, dysmenorrhea, ear diseases, gonorrhea, heart diseases, jaundice, nervous disorders, obesity, ophthalmic diseases, spermatorrhoea, stomach aches, syphilis, urinary diseases and vascular diseases.

**Pharmacological Action:**

**Anthelmintic Activity [12, 13]:** Brazilein recovered from heartwood showed cestocidal activities against Hymenolepis nana, and reduction of spontaneous movement in Anisakis simplex. Petroleum ether and methanol extracts from leaves showed anthelmintic activity in earthworms in terms of causing paralysis and death of worms. Ethanol and aqueous extracts of bark from *Caesalpinia sappan* against *Pheritima posthuma* showed anthelmintic activity causing death of worms.( Rasheed Ahmed *et al*.,). Petroleum ether extract of leaves of *Caesalpinia sappan Eisenia foetida* exhibited marked anthelmintic activity causing paralysis and death of worms (Suttee A *et al.,* 2016).

**Wound Healing Activity [14, 15]:** Ethanol extract and Brazilin from *C. sappan* displayed wound healing activity through Fibroblast proliferation, fibroblast migration, and collagen production (Tewtrakul *et al.,* 2015). Similarly, Brazilin-rich extract from heartwood was shown to be effective in terms of its wound healing activity as studied by scratch wound assay (Nirmal *et al.,* 2014).

**Hepatoprotective Activity [16, 17]:** Methanol and aqueous extracts from heartwood showed hepatoprotective activity in $CCl_4$ induced toxicity in animals (Srilakshmi *et al.,* 2010). *Caesalpinia sappan* extract from heartwood showed PASS-Predicted hepatoprotective activity in Thioacetamide-Induced Liver Fibrosis in Rats (Normadiah M. Kassim *et al.,* 2014).

**Anti-inflammatory Activity [18, 19, 20, 21]:** Brazilin, sappanchalcone, protosappanin A, protosappanin B, protosappanin C, protosappanin D, and protosappanin E recovered from heartwood showed anti-inflammatory activity through inhibition of the chemical mediators of inflammation in J774.1 cell line (Washiyama *et al.,* 2009). Ethanolic extract from heartwood displayed anti-inflammatory potential through suppression of the expression of inflammatory mediators in human macrophages and OA chondrocytes (Wu *et al.,* 2011). Brazilin rich extract and Brazilin isolated from the heartwood of *C. sappan* were shown to exhibit anti-inflammatory activity as evaluated by anti-denaturation assay (Nirmal and Panichayupakaranant, 2015). Ethanol extract and Brazilin from *C. sappan* displayed anti-inflammatory activity through inhibition of the production of NO, PGE2 and TNF-α (Tewtrakul *et al.,* 2015). Compounds *viz.* Episappanol, protosappanin C, Brazilin, iso-protosappanin B and sappanol isolated from heartwood exhibited anti-inflammatory potential in macrophages and chondrocytes (Mueller *et al.,* 2016).

**Insecticidal Activity [22]:** Two cassane-type diterpenoids, Caesalsappanin R and Caesalsappanin S, isolated from seeds of *C. sappan* were evaluated

for insecticidal activity against *Culex quinquefasciatus.* The isolated diterpenoids were effective but with low toxicity (Zhu *et al.,* 2017). Ethanol extract from seeds of *C. sappan* was shown to control cockroaches by causing mortality f cockroaches (Acero 2019).

**Termiticidal Activity [23]:** The ethanol extract of seeds was shown to exhibit termiticidal activity as screened by assessment of termite mortality in the presence of extract (Acero *et al.,* 2018).

**Anti-cerebral Ischemic Activity [24]:** Ethanolic extract from heartwood of *C. sappan* displayed anti-cerebral ischemic activity as studied by middle cerebral artery occlusion rat model (Wan *et al.,* 2019).

**2.8 Anti-plasmodial Activity [25]:** Through microculture radioisotope technique, (Zhu *et al.* 2017) showed antiplasmodial activity of Caesalsappanin R and Caesalsappanin S isolated from seeds of *C. sappan*.

**Hypoglycemic Activity [26, 27]:** Ethanol extract from wood revealed hypoglycemic activity as indicated by glucose tolerance test (Saefudin *et al.,* 2014). In a recent study, (Ahmad *et al.* 2020) revealed antidiabetic activity of Brazilin through the inhibition of Dipeptidyl peptidase IV.

**Melanogenesis Inhibitory Activity [28]:** Butyl alcohol extract (Chun *et al.,* 2012) and Sappanone A from heartwood (Chang *et al.,* 2012) were shown to display melanogenesis inhibitory activity through the inhibition of tyrosinase activity

**Cytotoxic Activity [29]:** Methanolic extract of heartwood of *Caesalpinia sappan* inhibit the growth of oral cancer cells via a pathway involving MAP kinase (Tran Manh Hung *et al.,* 2013).

**Anti-viral Activity [30]:** *In-vitro* antiviral activity against PRRSV of a semi-purified fraction of ethanoliccrude extract of *Caesalpinia sappan* showed marked anti-viral activity (Korawan Sringarm *et al.,* 2021.

**Gastro Protective Activity [31]:** *In-vitro* studies showed that the hydroalcoholic extract of *Caesalpinia sappan* heartwood showed a dosedependent cytoprotective effect against indomethacin-induced cytotoxicity and exhibited maximal cytoprotective effect with 76.82% reduction against indomethacin-induced cytotoxicity at 25 µg/ml of dose. *Caesalpinia sappan* showed 63.91% inhibition in H+/K+ ATPase inhibitory assay at the concentration 500 µg/ml.

*In-vivo* studies using the Wistar albino model were also reported. Before induced by necrotizing agents, the hydroalcoholic extract of *Caesalpinia sappan* heartwood at the dose level 250 and 500 mg/kg body weight was selected and administered orally to fasting overnight Wistar albino model. Rats that received treatment with *Caesalpinia sappan* at the dose level 500 mg/kg showed a reduction in ulcer area, supporting better mucosal architecture. This observation and no signs of hemorrhage were also observed.

*Caesalpinia sappan* heartwood possesses gastroprotective activity, possibly mediated through cytoprotection and antioxidant mechanisms (Afifah K. Vardhani 2020).

**Anti-oxidant Activity [32]:** Antioxidant activity of *C. sappan* heartwood was studied both by *in-vitro* and *in-vivo* models. The ethyl acetate, methanol, and water extracts exhibited strong antioxidant activity, as evidenced by the low $IC_{50}$ values in both 1,1-diphenyl-2-picryl hydrazyl (DPPH) and nitric oxide methods.

**CONCLUSION:** *Caesalpinia sappan* is a traditionally more potent medicinal plant. The review article confirms that Caesalpinia sappan plant has high therapeutic value and colourant. It is being used in Kerala, India and several parts of the world for its medicinal properties. The reported activities confirmed its antitumor, antimicrobial, antiviral, anti-inflammatory, hepatoprotective, and several other properties. As a colouring agent in wines, meat and fabricit's used already well established. It can be used as a colouring agent for food products and for pharmaceuticals. It can potentially enter the market as herbal antioxidant mineral water, as used commonly in Kerala. In the future more basic research is needed to elucidate the mechanism of action and isolation of its active ingredients.

*Caesalpinia sappan*, with highly interesting biological effects and vast, folklore uses, is worth studying more, and that might provide rich natural resources of lead compounds for drug development. Brazilin, responsible for most of the biological effects of wood, has the potential to become a drug to enter the market.

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**CONFLICT OF INTEREST:** The authors hereby declare that this manuscript has no conflict of interest.

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