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A narrative review on Sappan wood (*Caesalpinia sappan* L.)

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Abstract
The plant *Caesalpinia sappan* is a small leguminous tree that may grow up to 10 meters tall and is a member of the Caesalpiniaceae family. It has an orange-red hard Heartwood with a spiky trunk that is ideal for turning and also produces a red dye. It comes from tropical Asia and is also cultivated as a hedge plant. It is also known as Brazil or Sappan wood. The plant is used all over the world for a variety of traditional medical uses, including anti-tumor, anti-inflammatory, immunosuppressive, anti-diabetic, anti-allergic, cardioactive, anti-bacterial, anti-acne, anemia, and other things. Brazilin, the primary active component, is included along with flavonoids, lipids, steroids, amino acids, etc. The volatile oil produced by the leaves ranges from 0.16 to 0.25 percent, the pods contain 40 percent tannin, the seeds produce 32.1% and 34.4% mucilage, and the roots contain sitosterol and caesalpin-type diterpenoids.

Keywords: Sappan wood, *Caesalpinia sappan* L., anti-inflammatory

Introduction
Plants have always been a common source of medications due to their bioactive components. More than 75% of people on the planet primarily use plants and plant extracts for their health. One of the world's 12 biodiversity hotspots is India, which is home to more than 45,000 different plant species. Of these, 1500–20,000 have promising therapeutic potential. Herbal medicines have long been a part of traditional medical practises in India, including Unani and Ayurveda. About 700 species are used in the Ayurvedic system of medicine, 700 in Unani, 600 in Siddha, 600 in Amchi, and 30 in modern medicine. The medications can be made from the entire plant or from distinct parts of it, such as the leaves, stem, bark, roots, flowers, and seeds, among others a few drugs are prepared from exudates of plant product such as gums, resins and latex. (Joy *et al.*, 1998) [11].

Small leguminous tree *Caesalpinia sappan* belongs to the Caesalpiniaceae family. Plant-shaped tiny tree, 5–10m high, 15–25cm in diameter, with rufous-pubescent branches and a spherical, brownish-green stem. The wood is hard, heavy, prickly, hefty, and orange-red, and in addition to being good for turning, it also produces a crimson dye. After a year of growth, flowering can take place, usually during the rainy season, and fruits follows approximately six months later. It is frequently referred to as Sappan or Brazil wood. Brazilin is the primary active component, while other substances such as triterpenoids, flavanoids, lipids, steroids, amino acids, etc. are also present. It is grown all throughout the tropical regions of Asia, including Kerala, Andhra Pradesh, Orissa, West Bengal, Tamil Nadu, and Sri Lanka. In addition to being used to dye textiles, it also produces red paint and ink. Traditional medicines employ heartwood as a component. The wood is being shipped from India to the United States and Europe due to its extensive and well-established therapeutic benefits. (Badami *et al.*, 2004; Mekala *et al.*, 2015) [4, 16].

Fig 1: Diagrammatically representation of sappan wood

Traditional Chinese medicine has used the dried heartwood of *C. sappan* to treat a variety of illnesses, including traumatic injury, fractures, muscle injuries, blood stasis stagnation pain, dysmenorrhea, amenorrhea, postpartum blood stasis, and carbuncle swelling. Leaves yield volatile oil, 0.16 to 0.25%; pods contain 40% tannin; seeds yield 32.1% and 34.4% mucilage and straw –yellow, edible oil (7.5%) having a characteristic smell. Pharmacological studies showed that *C. sappan* had a wide range of bioactivities, including the suppression of melanin synthesis, anti-inflammatory, antioxidant, and antibacterial effects (Niu *et al.*, 2020).

Table 1: According to United State Department of Agriculture. *Caesalpinia sappan* L classification. (Vardhani *et al.*, 2019) [27].

Kingdom	Plants – Plantae
Subkingdom	Tracheobionta – vascular plants
Super division	Spermatophyte – seed plants
Division	Magnoliophyte – flowering plants
Class	Magnoliopsida – dicotyledons
Subclass	Rosidae
Order	Fabales
Family	Fabaceace / Leguminosae Pea family
Genus	Caesalpinia L – nicker
Species	*Caesalpinia sappan* L – Sappanwood

Biochemical composition of sappan wood

Chemical constituents of sappan wood resulted in the isolation of various structural types of phenolic components including one xanthone, one coumarin, three chalcones, two flavones, three homoisoflavonoids and brazilin (Nirmal *et al.*, 2015; Shan *et al.*, 2011) [21, 24].

Table 2: Biochemical composition of sappan wood

Xanthone	A wide range of pharmacologic properties, including antioxidant, anti-tumor, anti-allergic, anti-inflammatory, anti-bacterial, anti-fungal, and anti-viral activities, are known to be present in the xanthones found in the pericarp, whole fruit, heartwood.
Coumarin	a substance with a vanilla fragrance that is present in many plants and was previously used to flavour food.
Chalcones	Today, a variety of chalcones are employed as food additives and ingredients in cosmetic formulations as well as for the treatment of viral illnesses, cardiovascular diseases, pain, gastritis, and stomach cancer.
Flavones	A colourless crystalline compound which is the basis of a number of white or yellow plant pigments.
Homoiso flavonoids	Rare compound distributed within few families of plants. The genus Caesalpinia is a prolific source of these natural products. Homoisoflavonoids have been reported with borad range of bioactivities including anti- microbial, anti- mutagenic, anti- diabetic and vasorelaxant.
Brazilin	White or pale phenolic compound $C_{16}H_{14}O_5$ obtained from brazilwoods of genus Caesalpinia especially used for dyeing purpose

The heartwood of *Caesalpinia sappan*

The important part of CS is the heartwood which is pale red, hard, and heavy with an even and fine structure. Chinese folk medicine and Indian Ayurveda both traditionally use heartwood. It is mostly utilized in Thailand as a coloring agent in beverages, foods, clothing, and cosmetics. The Namya-utai solution, which has anti-thirst and cardiotonic qualities, is made from a decoction of heartwood. CS heartwood decoction is utilized as an anti-inflammatory medicine for the treatment of traumatic disease and arthritis in Northern Thailand, particularly in the provinces of Chiang Mai, Nan, and Lampang. The Northern Thai population has a long tradition of using CS heartwood decoction for domestic use, including the promotion of health and the treatment of sickness. Heartwood is utilized in Ayurveda to treat vitiated pitta problems, which include skin issues. rashes, scorching feelings, peptic ulcers, increased body heat, heartburn, and indigestion. Additionally, it is utilized as a blood purifier and for the treatment of wounds, diarrhea, diabetes, etc. CS heartwood is also used to improve complexion and lessen discomfort and swelling brought on by exterior injuries. It is mostly utilized in Chinese folk medicine as an emmenagogue, hemostatic, analgesic, anti-inflammatory, and blood flow-promoting medication for traumatic sickness. Additionally, CS heartwood decoction is used to treat conditions like high 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. (Min *et al*., 2012) [17].

The water-soluble flavonoids brazilin, protosappanin, and hematoxylin are present in the heartwood. The primary homoiso flavonoid component of the CS heartwood, known as the natural red color dye for staining, is brazilin. Brazilin also displays a variety of commercial uses. (Batubara *et al.*, 2010) [7].

Active Compound present in Sappan wood i.e. Brazilin

Brazilin, a white phenolic compound with two aromatic rings, one pyrone, and one five-membered ring, is the main active component of sappan. Scientific research have supported the majority of brazilin's traditional uses, including its antioxidant, antibacterial, anti-inflammatory, anti-photoaging, hypoglycemic, vasorelaxant, hepatoprotective, and anti-acne properties. Brazilin is a natural substance that is safe and has the potential to be developed into a medication with applications in the food, beverage, cosmetics, and pharmaceutical industries to test its clinical use in contemporary medicine. Brazilin is classified as a bioflavonoid based on its molecular composition. The hydroxyl group in the brazilin structure, however, is easily oxidized and can transition into a carbonyl group, leading to

the structural transformation and creation of brazilein, a colorful substance. Brazilein has in fact been used extensively as a natural colorant; sappan extract containing brazilein has long been employed in book painting as well as in the dying of silk and wool. Since an aqueous extract of sappan has numerous advantages over other red-color pigments, such as no distinctive flavour, no taste, and low cost of the plant source, it has also been employed as a colourant to produce red colour in traditional meals and beverages in many Asian nations. (Ngamwonglumlert *et al.*, 2020) [19].

As shown in Figure 2. The chemical substances known as brazilein are responsible for the red dyes that are produced from Caesalpinia wood. Brazil or brazilin is known to be yellow in the meanwhile. Both compounds have two aromatic rings, one pyrone and five carbons, making them tetracyclic. The inclusion of a carbonyl group results in an increase in the delocalization of electrons, which causes the yellowish brazilin to transform into a reddish brazilein. (Dapson *et al*., 2015) [8].

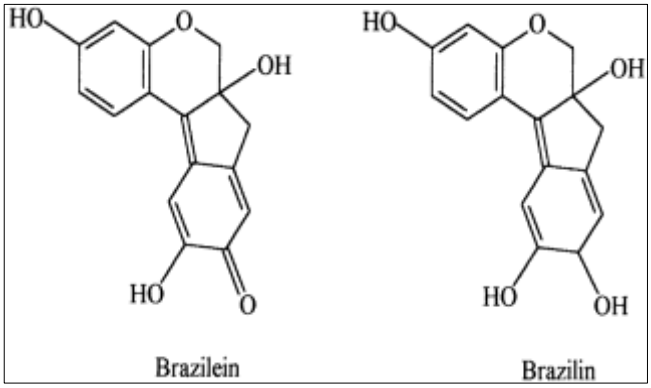

Fig 2: Functional groups of Brazilein and Brazilin

Pharmacological activity

Anti-inflammatory

Heat, redness, discomfort, swelling, and altered physiological processes are all signs of inflammation, which is a defensive pathophysiological reaction to tissue injury brought on by physical trauma, dangerous chemicals, or infectious agents. A variety of mediators, including as the enzymes cyclooxygenase, nitric oxide synthase, and protease, as well as their intermediate and final products, are all involved in the intricate process of inflammation. Arachidonic acid is converted by the cyclooxygenase enzymes COX-1 and COX-2 into the unstable prostaglandin intermediates PGG2 and PGH2, which play a role in inflammation. Numerous disorders, including atherosclerosis, inflammation, and carcinogenesis, have been linked to nitric oxide (NO), a hazardous gas. In some cell types, such as macrophages, the activation of bacterial lipo-polysaccharide (LPS) might result in the excessive formation of NO. (Jeong *et al.*, 2008) [30]. Nitric oxide (NO) is produced by an enzyme called nitric oxide synthases (NOS), which has three distinct isoforms: endothelial (eNOS), neuronal (nNOS), and inducible (iNOS). iNOS is one of them and is the primary driver of NO generation at an inflammatory location. (Bae *et al.*, 2005) [5] (Batubara *et al.*, 2009) [6].

The most significant transcription factor in inflammatory disorders, which is triggered by LPS, is nuclear factor kappa B (NF-B). The expression of iNOS and the production of several pro-inflammatory cytokines, including TNF-, IL-6, IL-1, and IL-8, are both induced when NF-B is activated (Tak *et al*., 2001) [26]. In some inflammatory illnesses, such as type III hypersensitivity reaction, protein denaturation is one of the factors that contribute to inflammation and the formation of auto-antigens (Mallikadevi *et al*., 2012) [15]. To avoid unneeded tissue damage and persistent inflammation, the inflammatory response must be stopped when it is no longer required. The majority of researchers focused on NO production inhibition and iNOS suppression when studying the anti-inflammatory properties of brazilin (Sasaki *et al.*, 2007) [23].

Anti- oxidantant

In recent years, people have been more interested in using natural antioxidants that they can get from medicinal plants. They have positive effects on human health and can be used as food preservatives (Aguiar *et al*., 2016) [3]. *Caesalpinia sappan* L. has recently become more widely used as an antioxidant. The secondary metabolites brazilin and sappan chalcone, which were effectively identified, were responsible for the antioxidative effects of *C. sappan* wood. *C. sappan* mostly utilizes its wood in that area. (Mu'nisa *et al.*, 2016) [18].

1.74–4.4 g/mL of brazilin were present in the 20 g/mL *Caesalpinia sappan* L extract. Brazilin demonstrated a dose-dependent ability to scavenge DPPH free radicals. Brazilin, the main constituent of *Caesalpinia sappan* L, scavenged UVA-induced H_2O_2 secretions and promoted the production of antioxidant enzymes. Additionally, *Caesalpinia sappan* L extract and brazilin had protective activities against oxidative stress; hence, this natural chemical derived from *Caesalpinia sappan* L represented a potential cure for oxidative stress-related skin photoaging. (Vardhani *et al.*, 2019) [27].

Brazilin has a significant reducing power because it contains an ortho-substituted diphenol group. During incubation at 50 °C for 250 hours, brazilin also demonstrated dose-dependent suppression of peroxide generation in the linoleic acid emulsion. Brazilin, which was isolated from Indonesian CS heartwood (IC50 = 8.8 M), showed nearly comparable DPPH radical scavenging efficacy to conventional (+) catechin (IC50 = 10.2 M). (Batubara *et al.*, 2009) [6]. Brazilin showed an IC_{50} value of 28.8 µg as determined by ABTS radical scavenging activity. (Wetwitayaklung *et al.*, 2013) [28].

Anti-bacteria

Research has focused heavily on bacterial infections in living things for decades. Bacteria are present in the soil, water, and air, among other places. Most of the bacteria in nature are pathogenic and can create a serious threat to a human being. Antibiotics are available commercially to combat pathogenic bacteria. CS extract has been tested against different microorganisms for its potential antimicrobial activity. The maximum zone of inhibition was observed in ethanolic extract against Pseudomonas aeruginosa (34 mm) followed by Staphylococcus aureus (31 mm), Salmonella typhi (24 mm), Enterobacter aerogens (21 mm), Candida albicans (20 mm), Escherichia coli (15 mm) and minimum zone of inhibition was observed against Aspergillus niger (14 mm). Methanol extract of CS heartwood extract showed higher inhibitory activity against methicillin-sensitive Staphylococcus aureus (MSSA) as well as methicillin-resistant Staphylococcus aureus (MRSA) (14 mm) than n-butanol, chloroform and aqueous extracts (8 mm) (Kim *et al.*, 2004) [13].

Hepatoprotective activity

The best-characterized system of xenobiotic-induced hepatotoxicity is liver damage caused by CCl4, and medication hepatoprotective properties are frequently based on this system. The alterations brought on by CCl4-induced liver damage are comparable to those brought on by acute viral hepatitis. Since most hepatic damage are caused by free radicals, medicinal plant extracts with strong antioxidant activity may also have strong hepatoprotective effects. (Srilakshmi *et al.*, 2010) [25].

At doses between 1000 and 800 g/ml, the anti-hepatotoxic effect of methanolic extract was found to be comparable to that of the common medication silymarin in newly separated rat hepatocytes. In newly isolated rat hepatocytes as well as in animals, both extracts were able to return the biochemical levels to normal that had been changed as a result of CCl4 intoxication. (Kadir *et al.*, 2014) [12].

Anti–acne activity

The wood of *C. sappan* is used to produce pink pigment for beverages such Bir Pletok, a Batavian spice drink, and is traditionally used for skin care in Indonesia, particularly on Sumbawa Island. *Caesalpinia sappan* has already been identified as a promising source of ingredients for skin care, particularly in the fight against skin photocarcinogenesis, and it has the potential to be developed as a skin-whitening cosmetic ingredient. (Hwang *et al.*, 2002) [10]. The pigment of *C. sappan* has reportedly already been used as an antioxidant in cosmetics by a Japanese cosmetics company, according to the patent.

Utilisation as natural colorant

Boiling the wood pieces of secang (*Caesalpinia sappan*) produces natural coloration. Demand for color variation is driven by the textile industry's increasing expansion. Color is one of the reasons why textile items are appealing. Dyes are colorful organic compounds that are used to provide color to objects or fabrics. Technology has allowed for the production of synthetic dyes in a variety of colors, but the trash they produce is detrimental to the environment. Due to the dangerous chemical procedures, they use to produce nearly all synthetic colorants, petrochemicals present a threat to their environmental friendliness. Natural dyes are attractive and practical substitutes for synthetic colors because of their positive effects on the environment. (Abu *et al.*, 2019) [1]. The dye can be made used for coloring foods such as hard cheese, butter, other dairy products, fish products, salad dressing, confectionery, bakery, ice creams, beverages, snack foods, floor polishes, etc. It can also be used in the preparation of shoe polish, hair nails, and red ink and for coloring leather, furs, silk, and toys. It has the potential to enter the market as herbal antioxidant mineral water being used commonly in Kerala. (Herawati *et al.*, 2021) [9].

Conclusion

Based on the literature it can be concluded that *Caesalpinia sappan* on heartwood has a high potential for therapeutic and coloring use. It is being used in Kerala, India, and several parts of the world for its medicinal properties. It can be used in skin care products in cosmetics. Apart from its coloring aesthetic effects, the consumers shall get the beneficial medicinal effects of this wood on their bodies and such colorants are in demand now. Medicinally the wood is recommended as a substitute for logwood. It has vast uses in Ayurveda and Yunani. Brazilin has potential pharmacological activity such as anti-tumor, anti-inflammatory, anti-diabetic, and immunostimulant properties and also anti-thirst, blood purifying action, and healing properties in Ayurveda and Unani beneficial to develop into a drug, nutraceuticals and in cosmetics. Further studies should be conducted to determine other active ingredients and benefits from *Caesalpinia sappan*, including formulations to be administered as a modern drug.

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