

A brief review on Pharmacological, Morphological and Ecological investigation on *Swietenia macrophylla*

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Abstract

Swietenia macrophylla King, or Mahogany, is a Meliaceae medicinal plant of tropical and subtropical origin, which now originated in the Caribbean, Central America, and South America. Well known for its medicinal properties, its dark brown bark turns grayish from maturation and becomes smooth and flower after seven years. There are species found in area such as Indonesia and Malaysia with pharmacological potential which is interesting. This review consolidates its pharmacological, morphological, and ecological attributes, emphasizing its medicinal importance and the need for conservation of this valuable plant species.

Keywords: *Swietenia macrophylla*, morphological activity, ecological activity and pharmacological activity

Introduction

Swietenia macrophylla King (Meliaceae) is a slowly growing tropical tree, with a height of 35-40 m. It has a trunk that is straight, cylindrical form with a maximum trunk diameter of 120 cm covered with a gray broken bark, and top by a large, rounded crown. Apart from their involvement in photosynthesis, plants such as *Swietenia macrophylla* supply a wide array of phytochemicals that serve as the basis of herbal medicine and food supplements that are therapeutically effective. These phytochemicals contribute to human health maintenance, thus stressing the ecological and medicinal roles of this tree [1, 2]. With the development of pharmaceutical products, thorough investigation of medicinal plants is required to further reveal the biological activities and phytoconstituents they contain. Due to the small number of well proven medicinal plants available, there is an urgent need to explore extensively in this area. Ethnomedicine present a highly promising source of compounds to address chronic and viral ailments [3]. *Swietenia macrophylla*, also called the big-leaved mahogany tree, is not only a desirable timber tree in the wood industry due its high-quality timber, but also deserves attention as its potential therapeutic uses, and need for scientific explanation require further studies [3, 4]. Different methods have been developed to determine the geographical origins of *Swietenia macrophylla*, which is of great economic importance in many neotropical countries as the source of highly valued hardwood timber [4, 5]. These instruments are highly effective in preventing the illegal trade of species. However, extensive deforestation and land conversion have drastically reduced its native habitats, raising concerns about the future sustainability and commercial viability of *S. macrophylla*. Apart from its importance in the woodchip sector, studies point to its enormous potential in phytomedicine, emphasizing its multifarious biological activities and clinical effects for which further research is warranted and conservation measures are necessary [6, 7].

1. Morphological Investigation

Foliage: The leaves are asymmetrical and simple pinnately compound, comprising 4 to 6 leaflets. Fully matured leaves can reach a length of up to 20 cm, a consequence of the plant's strong leaf structure.

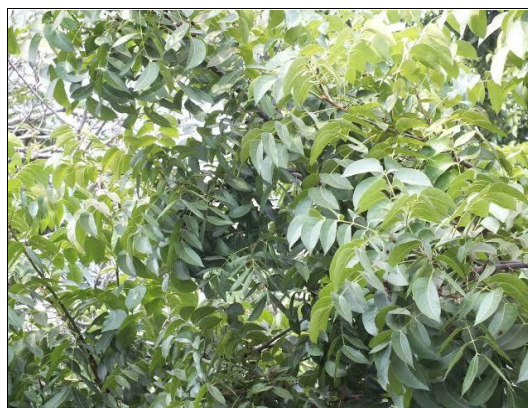


Fig 1: Foliage

Flowers: flowers are white, small, and fragrant, with inflorescences in the form of panicles. These blossoms contribute to the tree's distinctive reproductive characteristics.



Fig 2: Flower

Fruits: The desiccated mature fruits of *Swietenia macrophylla* are woody, rigid, elongated capsules reaching up to 40 cm in length. These capsules open from apex to base, expelling a multitude of stalked, brown winged seeds dispersed by wind.



Fig 1: Fruit

Propagation: Seedlings are propagated from the seeds obtained from mature fruits, which are collected from the tree and manually beaten to crack the fruit capsules. It is not necessary to pre-treat the seeds and fresh seeds are usually provided with a germination rate of more than 90% [8, 9].



Fig 2: Propagation

2. Ecological Investigation

Swietenia macrophylla grows in a variety of forest communities, from pine savannah edge to climax rainforest to mixed hardwood to riverbanks and fertile deep alluvial fans. It usually presents as random individuals or in small clusters and the density rarely goes beyond 4 to 8 trees/ha. In tropical America, it is surrounded by early colonizers of degraded agricultural lands. According to research *Swietenia macrophylla* could displace other species in mixed stands. In the Philippines, it shows a mild invasiveness and for a potential encroachment on native forests following disturbance. Therefore, cultivation adjacent to ecologically sensitive sites is avoided in an effort to minimize detrimental effects on terrestrial native ecosystems [10, 11]. The species is known to often regenerate in even-aged forests after severe disturbances (hurricane,

fire, flood) when disturbances are especially pronounced. Mature trees have survived such events by the strength of their buttresses and fire-resistance, which allows seed delivery into newly opened spaces or clearings. Whereas gap filling is not strictly necessary for seed germination in *S. macrophylla*, seed germination does occur in the presence of dense evergreen forest with limited light penetration which could hinder seedling establishment [12, 13].

Swietenia macrophylla can grow in several soil types in its natural environment. There, in the tropical American landscape, the species is typically found under the canopy of pioneer plants, returning to degraded agricultural lands. It is clear from research that in mixed stands, mahogany shows better performance than other species even those which are commonly grown to be used for furniture, revealing its high adaptability and growth properties [14].

3. Pharmacological Investigation

3.1. Anti-fungal activity

The increased antifungal activity of *Swietenia macrophylla* is mainly attributed to the presence of its chemical compounds, particularly triterpenoids, which contribute significantly to its constitutive defense. Extracts from *S. macrophylla* seeds, which contain high quantities of triterpenoidal compounds, have been demonstrated to effectively suppress plant pathogens fungi. Also, limonoids found in *S. macrophylla* have been reported to have potent antifungal activity against the groundnut rust fungus, by decreasing the number of rust pustules present on infected leaves [15, 16].

3.2. Anti-diarrhoeal activity

Acute diarrhea represents a significant public health challenge in many countries, ranking as one of the leading causes of illness, malnutrition, and mortality among children. This condition poses a substantial burden on healthcare systems and communities, emphasizing the urgent need for effective prevention and treatment strategies to mitigate its impact on vulnerable populations.

Diarrhea arises as a consequence of a derangement of homeostatic bowel function with increased bowel transit, hypersecretion of water and electrolytes. The disease is usually accompanied by such frequent, watery stools with abdominal pain and it is dehydrated. However, in certain cases secretory mechanism is often the leading force, in contrast to in other cases hypermotility of the intestines [17, 18].

Although several drugs have been created, none are standard for the treatment of diarrhea. Thus, the development of safer and more efficacious therapeutics is a key undertaking. Historically, Medicinal plants and their extracts have long been integral to traditional medicine for managing diarrhea. These natural remedies, often derived from indigenous knowledge, have provided effective and accessible solutions for alleviating symptoms, particularly in regions where conventional medical treatments may be limited. Their use underscores the importance of exploring plant-based compounds for therapeutic applications. In particular, seeds of *S. macrophylla* have long been used to treat diarrhea, and limited studies have revealed significant anti-diarrheal effects. Studies involving anti-diarrheal activity of *S. macrophylla* seed powder are based on the petroleum ether powder obtained from the Soxhlet extraction of *S. macrophylla* seeds powder [19, 20]. The study assessed the anti-diarrheal activity by examining several graded doses

and measuring the reduction in fecal frequency and consistency in rats induced with castor oil-induced diarrhea. Castor oil causes diarrhea through the ricinoleic acid, active metabolite of castor oil, which increases the motility of small intestinal by increasing the motility of small intestinal smooth muscle and changing the permeability of electrolyte in intestinal mucosa [21, 22].

The extract markedly attenuated the concentration and number of fecal matter discharged over a range of body weight doses, presenting compelling evidence about the anti-diarrhoeal activity. On the other hand, the extract effectively counteracted castor oil-induced intestinal fluid accumulation with similar effect to atropine sulfuric standard drug at both 0.1 and 3 mg/kg dosages body weight with intraperitoneal injection. Percent inhibition of wet feces and wet bulk build upon the anti-diarrheal characteristics of the extract and underscores its utility as a good candidate for the development of future anti-diarrheal drugs with the experimental data in hand [23, 24].

3.3. Hypoglycaemic activity

Diabetes is caused by inadequate amount of insulin secretion or reduced insulin action to control glucose homeostasis. Insulin is produced by islets of Langerhans in the pancreas and leads to the transformation of hyperglycemia to glycogen storage. Insulin that doesn't efficiently decrease blood glucose levels results in diabetes. *Swietenia macrophylla* is known to possess anti-diabetic properties and is a medicinal plant [25, 26]. In a study using streptozotocin-induced type II diabetic rats, the extract from *S. macrophylla* seeds at a dose of 300 mg/kg body weight showed significant efficacy in reducing fasting blood glucose levels (FBG), with statistically significant results observed on day 12. That dose also reduced serum total triglyceride, cholesterol levels by 10.41% and 18.56%, respectively and increased the liver glycogen. The underlying mechanism about anti-diabetic effect of *S. macrophylla* seed could be the increased glycogenesis and/or inhibition of glycogenolysis, resulting in high liver glycogen levels [27, 28]. Hyperglycemia as a result of diabetes is largely caused by the decreased tissue glucose uptake, which is usually associated with insulin resistance or insulin insufficiency, resulting in increased hepatic glycogenolysis and gluconeogenesis.

Supplementation with *S. macrophylla* extract in type II diabetic rats, caused significantly reduced values of triglyceride and total cholesterol. This effect could be attributed to a decrease in lipolysis regulated by insulin and/or a reduction in the activity of enzymes involved in cholesterol production. Furthermore, phytochemical and spectrometric tests showed the plant contains a multitude of bioactive molecules *S. macrophylla* through which swietenine, an insulin mimetic compound, improves external glucose uptake in diabetic rats [29, 30].

It is used in Malaysia to cure diabetes mellitus. Antihyperglycemic and hypoglycemic activity of its seed extracts have been shown in normoglycemic rats and rats with streptozotocin (STZ)-induced diabetes. Following the administration of various extracts (petroleum ether, chloroform, and methanol) derived from *S. macrophylla* seed, marked lowering of blood glucose levels were recorded. Moreover, glucose absorption in the colon and uptake by abdominal muscles were also assessed after

treatment. Subsequent gas chromatography-mass spectrometry (GC-MS) analysis revealed the hypoglycemic active compounds of *S. macrophylla* [31].

A study involving randomly selected normoglycaemic and diabetic rats assessed the effects of various extracts on blood glucose levels. Results indicated that none of the extracts significantly affected blood glucose levels in these rats. Only the petroleum ether (PE) extract significantly attenuated blood glucose levels in 50% of randomly chosen normoglycaemic rats in the IPGTT tests performed 30–120min after glucose administration. This indicates that physical exercise on its own did not seem to have a major effect on glucose uptake from the intestine, but rather, significantly increased glucose uptake in abdominal muscles, even without insulin stimulation.

S. macrophylla extracts, especially the PE extract, showed anti-hyperglycemic activity in these assays. According to the GC-MS analysis, many chemical compounds might play roles in the antihyperglycemic activity and glucose-lowering activity of the PE extracts [32].

3.4. Anti-bacterial activity

The pharmacological properties of *Swietenia macrophylla* are largely attributed to its terpenoids and limonoids. Two limonoids exhibit potent antibacterial activity against eight multidrug-resistant (MDR) bacterial strains. Another study investigated the antibacterial properties of extracts from various parts of the plant using different solvents and fractions [33].

The study aimed to explore the potential of a novel, natural, nontoxic, and effective antibiotic derived from *S. macrophylla* extracts.

The antibacterial activity of *Swietenia macrophylla* extracts was notably effective against both tested bacterial species. Among the extracts, the fruit cover displayed the strongest inhibitory effects. It exhibited superior antibacterial efficacy compared to other plant parts and solvent-based extracts. Although prior studies suggested methanol as more effective than acetone and ethanol for phytochemical extraction, the ethanol extracts in this study demonstrated greater inhibition zones against both bacteria, indicating a higher efficiency in extracting inhibitory compounds.

These findings highlight the effective recovery of antibacterial components through diverse extraction methods [34].

3.5. Cytotoxic activity

Cancer preventive compounds from plants which have been useful in the clinical treatment of cancer into the last 3 decades and continue to be an important source for cancer therapy as well as many diseases. Recently, plant-based drugs have attracted a lot of attentions due to their multi-faceted pharmacological properties.

The structural heterogeneity of phytochemicals contributes to improving the therapeutic efficacy of traditional plant-based therapies, thereby ensuring their role as an attractive area of drug discovery.

Specifically, research on *Swietenia macrophylla* has revealed its suitability as a source of new anticancer molecules. Current focus on the biological relevance of phytochemicals as well as plant-based drug discovery has led to a resurgence of interest in the use of botanicals for anticancer modalities [35].

3.6. Anti-inflammatory activity

Swietenia macrophylla exhibits significant anti-inflammatory properties. Its seed extract effectively reduces carrageenan-induced paw edema. The well-established link between inflammation and cancer underscores the therapeutic importance of anti-inflammatory agents.

Studies investigating the anti-inflammatory compounds of Formosan plants identified *S. macrophylla* as a potent species with inhibitory effects on neutrophil-mediated pro-inflammatory responses. Methanol-extracted fruit samples underwent chromatographic separation and purification using silica gel and preparative Thin Layer Chromatography (TLC). Compounds were further characterized via Nuclear Magnetic Resonance (NMR), isolating bioactive constituents responsible for anti-inflammatory effects. These findings highlight the potential of *S. macrophylla* in addressing inflammation-related conditions and its implications for cancer therapy [36].

3.7. Anti-hepatitis C activity

It is a growing global concern, affecting approximately 3% of the population and often progressing to chronic conditions. Current treatments, including Pegylated interferon alpha (INF- α) combined with ribavirin, show limited efficacy, with only about half of patients responding adequately. This underscores the urgent need for safer, more effective therapies, including plant-based pharmaceuticals [37].

Research on *Swietenia macrophylla* identified a bioactive compound, 3-hydroxy caruilignan C, through fractionation and separation guided by antiviral activity using a cell-based HCV replicon system. Extracted from the ethyl acetate fraction of *S. macrophylla* stems, 3-HCL-C demonstrated potent inhibition of HCV replication without cytotoxicity. Moreover, combining 3-HCL-C with IFN- α enhanced antiviral activity, highlighting its potential as a complementary or alternative treatment for HCV. These findings pave the way for further development of plant-derived anti-HCV therapeutics.

3.8. Anti-tumor and Anti-mutagenicity activity

Cancer is defined by the fast and unregulated proliferation of atypical cells, which can form tumors or spread throughout the body, potentially resulting in fatal outcomes if left untreated. Research has increasingly focused on medicinal plants rooted in traditional knowledge to identify natural compounds with therapeutic potential.

Plant-based extracts have been extensively studied for their ability to contribute to novel cancer treatments [38].

A study on *Swietenia macrophylla* seeds investigated the antimutagenic and antitumor-promoting properties of crude ethanol extract and its fractions, including hexane, carbon tetrachloride (CCl₄), and methanol.

These findings highlight the importance of *S. macrophylla* as a source of bioactive compounds for developing anticancer therapies, warranting further research to explore its mechanisms and clinical applications [39].

3.9. Anti-feedant activity

The antifeedant activity of *Swietenia macrophylla* has been studied for its potential as a natural pest control agent. Its triterpenoid-rich extracts were tested against the fall armyworm (*Spodoptera frugiperda*, FAW) and the striped cucumber beetle (*Acalymma vittatum*, SCB). Feeding trials

demonstrated that ethanol and hexane extracts reduced feeding significantly, with feeding ratios of 0.02 and 0.18, respectively, indicating strong deterrent effects, especially with the ethanol extract [40].

Although the extracts were non-lethal to FAW, they caused developmental disruption, with no pupation observed and larvae exhibiting stunted growth. The ethanol extract caused 20% mortality, whereas the hexane extract showed no lethal effects, highlighting the extracts' primary role as growth regulators rather than insecticides. Similarly, against SCB, the extracts demonstrated measurable antifeedant effects, though the efficacy was lower compared to other plants evaluated in the study.

These results suggest that *S. macrophylla* extracts can serve as a natural alternative to synthetic pesticides, primarily targeting larval development and feeding behavior. However, the relatively moderate effectiveness against SCB underscores the need for further optimization. The study highlights the potential of *S. macrophylla* in integrated pest management strategies, particularly where chemical-free solutions are desired [41, 42].

3.10. Anti-nociceptive activity

Pain, often induced by specific diseases or pathological conditions, is sensed by nociceptors in the skin's surface layers. These receptors detect pain stimuli and relay signals to the central nervous system, where they are processed as pain sensations. The use of natural materials for pain relief has a long history, exemplified by the discovery of morphine from poppy and salicylic acid from willow bark—both still integral to modern medicine. This longstanding tradition highlights the potential of plant-derived compounds as anesthetic agents [43, 44]. Recent research on *Swietenia macrophylla* extracts has uncovered active compounds with significant anti-nociceptive properties, which help reduce the sensation of pain. These findings align with a growing academic focus on higher plants as a source of bioactive chemicals, emphasizing their potential in addressing pain management challenges. The identification of such compounds in *S. macrophylla* underscores the plant's value as a candidate for the development of novel, natural pain-relief agents, offering a promising alternative to synthetic medications. This research supports the broader movement towards utilizing underexplored plant sources in modern pharmacology, potentially revolutionizing pain management through innovative and safer therapeutic options [45, 46].

Conclusion

The genus *Swietenia* is renowned for its diverse applications, with *Swietenia macrophylla* standing out as a prominent species cultivated extensively in China and various tropical regions worldwide. It has been documented for its broad therapeutic potential.

Beyond its medicinal uses, *S. macrophylla* has demonstrated significant pharmacological properties, including antimicrobial, anti-nociceptive, and anti-diarrheal activities. Despite these promising findings, the plant remains underexplored, with only a limited number of bioactive components isolated to date. This highlights the need for more comprehensive research to uncover its full potential and pave the way for novel therapeutic applications.

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