OPEN ACCESS
World Journal of Applied Medical Sciences
ISSN (Online): 3049-0200 | Vol. 2, No. 12, 2025
Website: https://wasrpublication.com/index.php/wjams

DESIGN AND CHARACTERIZATION OF SWIETENIA MAHAGONI Jacq. MEDIATED SILVER NANOPARTICLES FOR HYPERGLYCEMIC AND HYPERLIPIDEMIC CONTROL

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Received: 17/08/2025 | Accepted: 27/10/2025 | Published: 03/12/2025

Abstract: The present study was designed to evaluate the design and characterization of swietenia mahagoni jacq. mediated silver nanoparticles for hyperglycemic and hyperlipidemic control. Using the extraction methods like soxhlet extraction, benzene extraction, Ethanolic Extraction, Ethyl acetate extraction, petroleum ether extraction. Animals were randomly divided into 5 groups. Group 1- normal control, Group 2- diabetic control, Group3 –treatment control Swietenia mahagoni 100mg/kg, Group 4 – Swietenia mahagoni 200mg/kg treated group, Group 5 – Glibenclamide 5mg/kg. The levels of biochemical parameter, body weight, serum lipid profile, serum total cholesterol, serum glycerides, VLDL AND & HDL cholesterol, HDL cholesterol, Hemoglobin & glycated hemoglobin were examined in each of these groups. Chronic administration of swietenia mahagoni at a dose of 100mg/kg & 200mg/kg, p.o. for a period of 21 days markedly decreased the level of blood glucose level & lipid level. Phamacological studies were assessed for bio assessment, clinical trials, and toxicological studies. Quantitative estimation of total phenolic and flavonoid like estimation of total phenolic content, total flavonoid content, HPTLC investigation of ethanol extract. Taken together, the results suggested that treatment reduced hyperglycemic and hyperlipidemic control. This study demonstrates the swietenia mahagoni jacq. Mediated silver nanoparticles for hyperglycemic and hyperlipidemic control.

Keywords: Swietenia mahagoni Jacq.; Silver nanoparticles; Hyperglycemia; Hyperlipidemia; Antidiabetic activity.

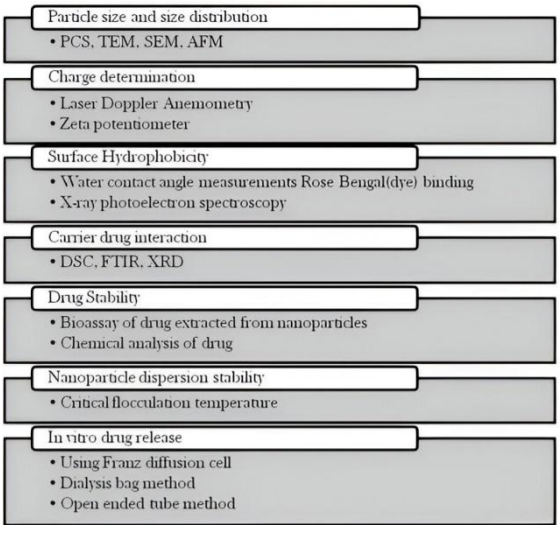
Cite this article:

Vigneshwaran, L.V., (2025). DESIGN AND CHARACTERIZATION OF SWIETENIA MAHAGONI Jacq. MEDIATED SILVER NANOPARTICLES FOR HYPERGLYCEMIC AND HYPERLIPIDEMIC CONTROL. *World Journal of Applied Medical Sciences*, *2*(12), 1-5.

Introduction:

One of the fields that has advanced the fastest in recent years is nanotechnology. The understanding of chemistry, physics, engineering, and material science are all connected in this multidisciplinary field.[1, 2].The Greek word "nanos" is where the term "nano" originates," which means "dwarf." In mathematics, a nano is one billionth of a number or period, which is represented as 1 x 10-9 or basically as 10-9.It is the study of extremely minute things, including almost any science that deals with altering materials at the atomic and molecular scales and comprehending the universe at the atomic level.3.Nanoparticles, which range in extent from 10 to 1000 nm (1.0 µm), are small solid colloidal particles that contain the vigorous component or organically active substance melted, tricked, adsorbed, or connected. Using a controlled and targeted medication delivery technique, nanotechnology aims to identify as correctly and early as possible and treat as successfully feasible exclusive of causing any unfavorable effect, just like medicine does. Drug delivery and related pharmaceutical development should be understood as the science in the perspective of nano medicine, and the technology of multifaceted systems at the nanoscale, having as a minimum two components, one of which is a pharmaceutically lively element.

Characterization of Nanoparticles



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Preparation of Nanoparticles

The three processes for creating nanoparticles are

- Dispersing premade polymers
- Polymerizing monomers
- Co-acervation of hydrophilic polymers or ionic gelation.

The literature has documented various methods for creating nano particles making particles with supercritical fluid methods and non-stick molds. It was claimed that the latter had total control over the particles' size, shape, and makeup, and that this may be used as a model for future industrial mass production of NPs.

Drug Profile:

It's Known as "Mahogany," Swietenia mahagoni Jacq. The Meliaceae family includes the economically significant, deciduous timber tree, Puerto Rican mahogany, also known as Spanish mahogany, Cuban mahogany, or Jamaican mahogany, native to Central America. One of the most widely used traditional remedies in Africa comes from this important plant, which is closely linked to the African genus Khay.

Figure :1. Habitat of *S. mahogini* jacq

History

At first, only the British-controlled islands in the West Indies were referred to by the term mahogany. The origin of the name is uncertain, though it may be a distorted form of "Moganwo." The Yoruba and Igbo people of West Africa use this name for trees in the *Khaya* group, which are closely related to *Swietenia* trees. According to the aforementioned interpretations[3], the tree's exact origin is still up for debate. The term "mahogany" was first used in print in John Ogilby's America in 1671. Although the quality and character of mahogany varied depending on the soil and environment, it was considered a single species until the 19th century.[4] In 1795, mahogany was introduced to India.

Phenology

Soon after the new leaves develop, in April or May, the unassuming flowers appear. October through December[6] is when the fruits ripen. It blooms in South India between February and May[5]. Insects are the creatures that pollinate. Hybridization occurs often wherever the species coexist, particularly with S. macrophylla. Typically, only one flower in a cluster develops into a fruit after fertilization, while the others do not. It takes 8–10 months for a bloom to develop into a fully ripe fruit[6]. Fruits ripen between December and January. Since the fruit takes a long time to develop, crop evaluation can typically be done many months prior to harvest. Flowering typically occurs just before the rainy season, though it varies according on the climate, or geographic location. In the Caribbean Islands, the fruits of S. mahagoni Jacq.take eight to ten months to ripen, from January to March, after flowers bloom from April to July. Mahoganies typically flower and fruit every year between the ages of 10 and 15.[110].

Figure: 2. Fruit capsules of *Swietenia mahagoni* Jacq.

Growth & Reproduction: Swietenia mahagoni Jacq.is typically cultivated from seed because it is challenging to start from cuttings. The wind disperses the tiny, winged seeds of mahogany, which can produce a large number of seedlings close to mature trees[5]. Direct sowing, transplanting, and stump planting are all methods of artificially propagating the tree; however, transplantation yields the best results and is the most widely used technique1. Although pretreatment is usually not required, Immersing in water for 12 hours may improve the germination of seeds with low moisture content that have been kept. The seeds' ability to germinate is roughly 40%.[5]. The seeds are planted directly in containers or in holes or furrows that are 3–7 cm deep in a bed of light sand. One could say that seedlings fall somewhere in the middle of the light-demanding and shade-bearer[108] spectrums in terms of their light requirements. Seeds that are germinating should be kept wet and under shade. It will take 10 to 21 days for seeds to sprout. Hypogenous germination occurs. Until they are out planted, the seedlings are maintained in shadow. When the seedlings are between 50 and 100 cm tall, they can be planted in the field[5].

Plant Collection Techniques

The capsules are harvested from the ground after the seeds fall or directly from trees between October and December, ideally just before they open. Site and year[5] have an impact on seed output. The seeds are removed and kept once the capsules open after being sun-dried. In India, seeds are stored for up to eight or even twelve months in a covered container. After six months, the feasibility of an open basket drops to a negligible level. The weight of the seeds varies. The seeds in Puerto Rico are said to weigh 7,040 seeds per kilogram, while the seeds in India weigh 3,350 to 3,500 seeds per kilogram.[5].

Materials and method:

Silver nitrate, swietenia mahagoni jacq

Sodium pottasium tartrate, starch, α-amylase enzyme, NaoH, $Nacl_2$, Sodium phosphate monophasic.

Methodology

Using the extraction methods like soxhlet extraction, benzene extraction, Ethanolic Extraction, Ethyl acetate extraction, petroleum ether extraction.[6] Identification test of plant constituents parameters like flavonoids, terpenoids, saponins, carbohydrate and glycosidic compounds, proteins and aminoacids, protein test, lignin. Biological assays, including in vitro and in vivo models, can be employed to identify novel compounds for the treatment of various diseases. Animals were randomly divided into 5 groups. Group 1- normal control, Group 2- diabetic control, Group3 – treatment control Swietenia mahagoni 100mg/kg, Group 4 – Swietenia mahagoni 200mg/kg treated group, Group 5 – Glibenclamide 5mg/kg. The levels of biochemical parameter, body weight, serum lipid profile, serum total cholesterol, serum glycerides, VLDL AND & HDL cholesterol, HDL cholesterol, Hemoglobin & glycated hemoglobin were examined in each of these groups. Chronic administration of swietenia mahagoni at a dose of 100mg/kg & 200mg/kg, p.o. for a period of 21 days markedly decreased the level of blood glucose level & lipid level. Pharmacological studies were assessed for bio assessment, clinical trials, and toxicological studies.[7]And finally investigated quantitative estimation of total phenolic and flavonoid like estimation of total phenolic content, total flavonoid content, HPTLC investigation of ethanol extract. [8] The following metrics were used to characterise Swietenia mahagoni Jacq. silver nanoparticles. (1) Visual examination, (2). UV- spectroscopy, (3) Fourier Transform Infrared Spectroscopy, (4). Drug Entrapment, (5). Determination of particle size & zeta potential, Scanning electron microscopy, & In-vitro studys for first order kinetics, zero order kinetics, Higuchi's model, korsmayer peppas.

Results and Discussion

A subset of the broader phrase "complementary and alternative medicine" (CAM) was another name for herbal medicine. Herbs were the standard treatment for almost all illnesses long before modern medicine was developed. Due to the negative consequences of contemporary medicine, more and more individuals are using herbal therapy as a supplement to and alternative to contemporary medications. The chemical components found in different plant tissues, referred to as secondary metabolites, and were what give medicinal plants their value. These compounds include alkaloids, glycosides, fatty and essential oils, gums, resins, mucilage, tannins, and more. The plant's storage organs, such as its roots, seeds, leaves, wood, etc., may contain these active ingredients.

Diabetes disrupts essential biochemical processes in nearly every cell and raises the chance of serious complications including atherosclerosis, neuropathy, cardiac infarction, and nephropathy, making it a major global health challenge. Therefore, one of the main areas of research has been the hunt for safer and more effective hypoglycemic medicines. The active plant components that were found to be a natural hypoglycemic medication due to traditional knowledge are used in many medical systems. Compared to synthetic medications, herbal ones were thought to have fewer negative effects.

They were more widely used, less harmful, and reasonably priced. The current study aims to determine which plant-based medication based on herbs may be utilized to treat diabetes mellitus, with a particular focus on assessing Swietenia Mahagoni Jacq. Ag nanoparticles that were mediated.

Phytochemical Screening

Table 9.2 displays Preliminary screening tests on solvent extracts of S. mahagoni Jacq. Seeds revealed petroleum ether and benzene extracts contain alkaloids, carbohydrates, flavonoids, and proteins, while ethyl ethanoate extract lacks fixed oils and fats. All phytochemicals were found in the ethanolic fraction.

Determination of Phenolic and Flavonoid Levels

Using the standard curve, the phenolic content of *S. mahagoni* Jacq. seed extracts was quantified as µg gallic acid equivalents (GAE) per mg of sample.Table9.3 & 9.4 provides absorbance value of gallic acid &Quercetin. The benchmark for flavonoid content was quercetin.

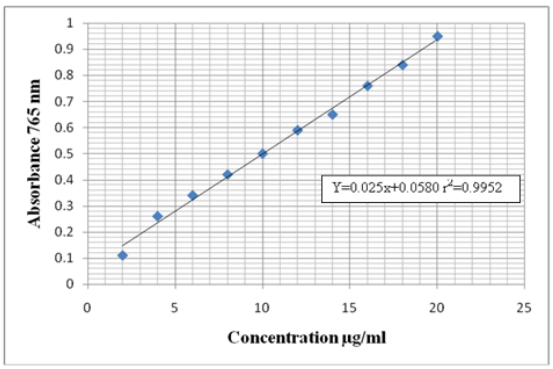

Figure 9.1. Calibration curve of Gallic acid

Table 9.5 Total Phenolic and Flavonoid content of extracts of *S.mahagoni* Jacq

S. No	Name of the extract	Total phenolic content (mE Ga/mg of dry extract)	Total flavonoidal content (mE quercetin / mg of dry extract)
1.	Pet ether extract	1.8 ± 0.14	3.55 ± 0.13
2.	Benzene extract	1.8 ± 0.07	1.3 ± 0.14
3.	Ethylacetate extract	2.86 ± 0.10	2.2 ± 0.21
4.	Ethanol	2.96 ± 0.04	0.61 ± 0.03

*(Mean + SD) (n=3)

Pharmacological Studies

Pharmacological research was conducted in two distinct areas. The initial step was to use the α-amylase inhibitor test for in-vitro screening in arrange to conclude how effective the plant extracts were. The research's second component involved screening diabetic rats, OGGT, and in vivo.

In-vivo study

Acute oral toxicity studies

Oral Acute Toxicity of Ethanolic Extract of *S. mahagoni* **Jacq. Seed** was assessed according to OECD 425 guidelines. No mortality or toxic symptoms were observed within 14 days after administering a 2g/kg dose, indicating an LD_{50} greater than 2 g/kg.

Table 9.8. Effect of ethanol extract of *S. mahagoni*jacq seed on the body weight of rats at 2,000 mg/kg dose after 14 days

Group	Treatment	Body weights (g)		Calculated 't' value	remarks
		Before treatment M1±SD1	After treatment M2±SD2		
Control	Gum acacia suspension	160.63 ± 1.87	165.06 ± 2.08	t=2.7412	NS
Treated	2,000 mg/kg of EESM	163.03 ± 3.40	167.50 ± 2.52	t=1.8264	NS

N = 3; M1, SD1 and M2, SD2 are mean weights and standard deviations before and after treatment respectively; NS = Not significant.

Oral Glucose Tolerance Test

Table 9.10. Effect of Ethanol extract of *S. Mahagoni* Jacq seed on oral glucose tolerance test (OGTT) in normal healthy rats

Group	Treatment	Dose (mg/kg)	Fasting blood glucose level (mg/dL)					Reduction after 60min (%)
			0 min	30 min	60 min	90 min	120 min	
I	Normal Control	----	72.33 ±1.14	106.00 ± 1.03	92.16 ± 1.70	83.33 ± 1.58	75.50 ± 2.43	----
II	Animal 1	100	82.00 ±1.20	112.00 ± 1.70	90.67. ± 1.83	89.00 ± 1.14 (2.36%)	83.24 ± 1.18 (8.08%)	8.08
III	Animal 2	100	81.54 ±1.70	110.00 ± 1.16	94.00 ± 1.32	90.14 ± 1.22 (3.96%)	88.00 ±1.06 (6.26%)	6.26
IV	Animal 3	100	78.00 ±1.40	107.22 ±1.83[a]	96.00 ±1.15[a]	94.25 ±1.29[a] (1.61%)	81.66 ±1.68[b] (13.81%)	13.81
VIII	Glibenclamide	5	79.50 ±1.87	106.33 ±1.70[a]	101.50 ±1.99[a]	91.83 ±1.70[a] (9.96%)	83.33 ±1.66[a] (18.50%)	18.50

Data are presented as mean ± SEM, (n=6). [a]p< 0.01, [b]p< 0.05 when compared with corresponding values of the control group,one way ANOVA followed by Dunnett's test.

The study showed that *S. mahagoni* Jacq. seed extract enhanced glucose tolerance in rats, with 100 mg/kg being most effective. Consequently, the research evaluated its ethanol extract (0.1 and 0.2g/kg) for antioxidant, antidiabetic, and anti hyperlipidemic effects in STZ-NC-induced diabetic rats.

Anti hyperlipidemic activity

Serum Lipid Profile Analysis

Table 9.14. Effect of ethanolic seed extract of *S.mahagoni Jacq.* on HDL, LDL, TC, TG of control and experimental groups of rats

GROUP	HDL	LDL	TC	TG
Normal control	52.83±1.014	23.33±0.88	129.0±1.065	63.5±1.66
Diabetic control	13.33±1.909$^{###}$	145.7±2.04$^{###}$	280.2±7.05$^{###}$	201.8±3.911$^{###}$
STZ+G	42.17±0.7032***	39.67±1.22***	156.5±2.232***	90.50±1.33***
STZ SM 100mg	26.00±1.06**	74.83±0.70**	217.5±2.045**	182.0±29.55**
STZ SM 200mg	37.17±0.70***	53.17±0.60***	177.5±3.00***	134.3±3.148***

The data are expressed as mean ±SEM, n=6.

One way ANOVA followed by Dunnett's test

ns=non-significant

Compared with normal control; # p<0.05, ## p<0.01, ### p<0.001

Compared with disease control;* p<0.05,** p<0.01, *** p<0.001

Pre formulation study Solubility Test

Table 9.26 showed the solubility test results for powdered *Swietenia mahagoni* Jacq seed extract in various solvents.

Table9.26. Solubility of *S.Mahagoni Jacq.* in different solvents

Solvent	Soluble	Sparingly soluble	Insoluble
Ethanol	+	-	-
Water	+	-	-
Chloroform	-	+	-
Diethylether	-	+	-

Findings revealed that the powdered SMSE was readily soluble in ethanol and water, whereas it showed limited solubility in chloroform and diethyl ether. Consequently, the extract demonstrated greater solubility in polar solvents compared to non-polar ones.

UV-visible spectral analysis of *S.Mahagoni Jacq.* seed extract

A 0.05 mg sample of S. mahagoni Jacq. seed powder was dissolved in 10 mL purified water, and its UV–Vis spectrum (200–800 nm) is shown in Figure 9.26."

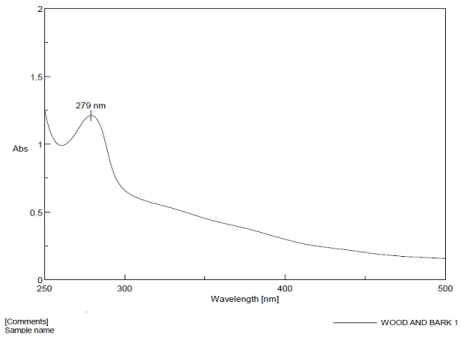

Figure 9.26. Uv-Visible absorption spectra of *S.Mahagoni Jacq.* seed extract

The greatest absorption of *S.Mahagoni* Jacq. wood and bark extract was discovered at 279nm, which was chosen as the wavelength for future investigation.

Calibration curve for UV-Visible Spectral Analysis of *S. mahagoni* Jacq Seed Extract at 279 nm

An R2 value of 0.999 indicated that the standard curve was linear between dosages ranging from 4 to 20 µg/ml. The sample S. Mahagoni Jacq. bark and wood aqueous extract, following Beer's law, has a concentration of 4-20µg/ml.

Green Synthesis of Ag Nano Particles

Bark and wood extract from S. Mahagoni Jacq. were mixed with an Ag nitrate solution dropwise, and The Mixture was magnetically Processed at 120 rpm using hot plate to promote Ag nanoparticle synthesis. When Ag nanoparticles form, they turn brown instead of yellow.

Characterization of Agnano particles contain *S. Mahagoni JACQ.* Extract

Visual Examination

When the Ag nitrate solution was added, the *S. Mahagoni Jacq.* extract's original yellow hue changed to a dark brown. The absence of a discernible color shift after ninety minutes indicated that the reduction process had finished. With a size in the nanometric range, This change suggested that the reaction medium's Ag ions had changed into elemental Ag.[9]

UV Visible Spectral Analysis

The figure 9.30 showed periodic sampling that was done at 30-, 90-, 210-, and 24-hour intervals: 12.The study found that active biomolecules in the bark and wood extract of Pterocarpus marsupium Roxb. reduced Ag^{+} to Ag^{0}, resulting in a color change from yellow to brown. The formation of silver nanoparticles, which display a surface plasm on resonance (SPR) absorption band in the visible spectrum, is linked to this transformation.

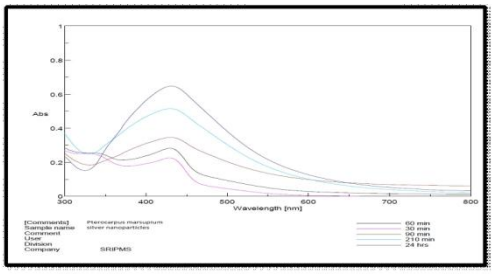

Figure 9.30. Uv-visible absorption spectra of *S.Mahagoni Jacq.* silver nanoparticles at different time intervals

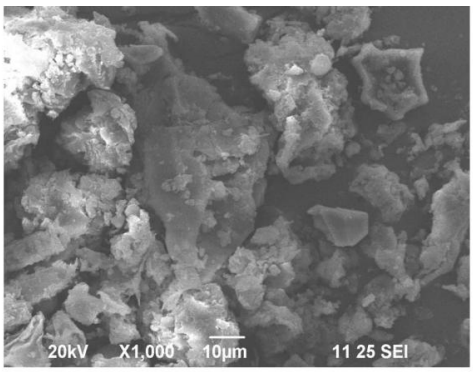

Figure 9.35. SEM analysis of *S.Mahagoni Jacq*. Seed Extract nanoparticles at 1000X magnification

Electrostatic interactions including hydrogen bonds, bio-organic connections, and capping molecules are what lead to the biogenesis of Ag nanoparticles. Additional information on morphology can be obtained by scanning electron microscopy. It was discovered from the SEM examination of S. Mahagoni Jacq. Ag nanoparticles are spherical in form and assemble on the surface.[10]

Histopathological studies

At the conclusion of the investigation, the pancreatic histology of the experimental rats was assessed.[9,10] Diabetes-induced pancreas exhibited severe necrotic alterations, reduced β cell size, and diminished Langerhans Islets. However, rats treated with STZ-NC showed normal β cell size, acini, and Islets of Langerhans, restoring normal structures.

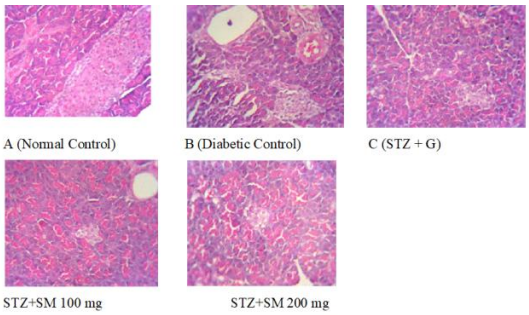

Figure 9.21. Effect of ethanolic seed extract of *S.Mahagoni*Jacq. on cellular damage in pancreas of control and experimental groups of rats (400x).

B = Diabetic control group (showing atrophic acini, reduced β-cell size, and decreased islet size);

C = STZ + Glibenclamide group (demonstrating well-regenerated and preserved cells with significant β-cell proliferation and regeneration);

E = STZ + SM 200 mg

group (exhibiting Functional, regenerated, and conserved cells with notable β-cell proliferation and regeneration);

A and D = STZ + SM 100 mg

group (displaying Pancreas exhibiting atrophy with acinar atrophy, reduced β-cell size, and presence of hyperplastic cells).

Statistical Analysis

The study used Graph Pad Prism 5 for statistical analysis of differences and linear regression, expressing all values as mean ± SD.

Conclusion

Since the beginning of the world civilization humans are depended on herbal medicine because of its health care and various disease treatment properties. Over 300 limonoids have been extracted from this family, including seven from the extract of S. mahagoni seeds. Different species of Swietenia contain in their various parts phenolic compounds, triterpenoids (limonoids), flavonoids, swiemahogins A and BC, and alkaloids. The chemical entities of this plant have been proved for their Anti-bacterial activity, Antimicrobial Activity, Anti-oxidant activity, Antiulcer activity, Anti-fungal activity, Anti-inflammatory, Analgesic activity, Hypoglcemic activity, Platelet Aggregation Inhibitors activity etc. These scientifically proved activities can be related with the traditional usage of the plant. Thus S. mahagoni Jacq. is one of the most important plants that has a tremendous scope for research in future. The novelty and applicability of this valuable species are hidden. Such things should be overcome through extensive scientific research. The drug may be a good candidate for developing a safe, tolerable, and promising nutraceutical treatment for the management of many diseases.

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