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SYZYGIUM SAMARANGENSE: A PLANT REVIEW

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ABSTRACT: Medicinal plants are the best source to obtain different drugs, about 80% of people in industrialized countries uses traditional medicines for their health benefit. Herbal medicines have been the basis of treatment, cure for various diseases and physiological conditions in traditional methods of practice such as Ayurveda, Unani and Siddha. Medicinal plants have therapeutic values for various ailments. Generally rural people prefer medicinal plants than synthetic drugs for the treatment of various diseases rather than urban areas. *Syzygium samarangense* (*S. samarangense*), commonly known as rose apple or java apple, is a plant in the family Myrtaceae is known to have medicinal importance. An ornamental plant stands for its numerous attributes such as Analgesic, Anti-inflammatory, Antidiarrheal, Anti-hyperglycaemic, Anti-diabetic activity, Anti-Cancer, Anti-trypaosomal, Hepatoprotective, Antimicrobial, cytotoxic, Anthelmintic, Anticholinesterase, Anti-ulcer, anti-Arthritic, Anti-inflammatory, Wound healing property, Antiviral, Immunopharmacological and Antioxidant activity. The present review is an attempt to highlight the various ethanobotanical and traditional uses as well as phytochemical and pharmacological reports on *Syzygium samarangense*.

INTRODUCTION: *Syzygium*, the largest woody genus of flowering plants, encompasses approximately 1,100-1,200 species distributed across tropical and subtropical regions, making it the 16th most diverse genus [1]. There are three species which will bear edible fruits, namely, the water apple (*Syzygium aqueum*), Malay apple (*Syzygium malaccense*) and wax apple (*Syzygium samarangense*). Among the three, wax apple enjoys the highest population in Southeast Asia.

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The *Syzygium samarangense (S. samarangense)* fruits are eaten raw with salt Natural products still contribute to drug developments now a days, where up to 50% of approved drugs in the last 30 years isolated from natural products. Natural products are well known to be used as food or spice, but some of them also have a significant effect as medicines. The family Myrtaceae, in which the genus of *Syzygium* is placed, is one of the largest plant families that consist of 3,800-5,800 species in 140 genera.

The fruits are eaten raw with saltor cooked as a sauce which has thirst-relieving properties. The fruit is oblong, pear shaped and 5-12 cm in length, with four fleshy calyx lobes [2]. Wax apple (*S. samarangense*) is a plant from the family Myrtaceae that is commonly found in Asia-Pacific,

especially in Indonesia. The leaf extract of this plant exhibits various bioactivities Leaf extract from the plant *S. samarangense* has some bioactivities, such as antioxidant, lipolytic, antityrosinase, and anti-cellulite [3].

This review is aimed at recapitulating the research established on the photochemistry, pharmaceutical and other applications of *S. samarangense*. Further, this review highlights the importance of *S. samarangense* and provides a baseline for future research studies. An examination of phytochemical compounds in *S. samarangense* bark extract revealed the presence of reducing sugars, tannins, flavonoids, saponins, gum, and alkaloids [4].

The flowers produce tannins, while the plant's fruits contain jasmonic acid and salicylic acid. During the post-harvesting process, the content of these components will be significantly reduced due to their roles in pathogenic resistance [5]. Leaf extracts of *S. samarangense* were reported to have antiulcer, anti-inflammatory, analgesic, antioxidant, antifungal, spasmolytic, cytotoxic, Antihyperglycaemic, antidepressant and Hepatoprotective effects. In addition, they were used for the treatment of fever, eczema and diarrhoea in southern China [6].

The fruits are utilized for treating mouth ulcers, promoting increased urine volume, stimulating blood flow to the pelvic and uterine areas, acting as an abortifacient and febrifuge. Additionally, a decoction made from the fruit's water is employed in fever management.

Root portion of *S. samarangense* induces the abortion and stop the menstrual cycle. Root is also used for edema; the powdered root is used for the treatment of itching the skin. The bark and stem serve as remedies for wounds, while in traditional medicine, crushed leaves are chewed to address cracked tongue, utilized for bathing, and incorporated into lotion formulations [7].

FIG. 1: *S. SAMARANGENSE* FRUITS

FIG. 2: *S. SAMARANGENSE* LEAVES

FIG. 3: *S. SAMARANGENSE* SEEDS

FIG. 4: *S. SAMARANGENSE* FLOWER

Taxonomy [8]:

Kingdom	Plantae
Sub kingdom	Tracheobionta
Super division	Spermatophyta
Division	Magnoliophyta
Class	Magnoliopsida
Order	Myrtales
Family	Myrtaceac
Genus	*Syzygium*
Species	*Syzygium samarangense*

Common Names [9]:

Language	Names
Thai	Wax apple, Love apple, chomphu
Vietnam	Man
Taiwan	Bell fruit
Jarnaica	Jamaican Apple, Otaheti Apple
Indonesian	Jambu air
Sri Lanka	Jumbu
Malay	Water apple, Mountain apple, cloud apple, Jambu air, and Water guava.
Philippines	Wax jambu, rose apple, bell offruit, makopa, and tambis.

Botanical Names [10]:

Other Scientific Names of *S. samarangense*: *Eugenia javanica Lam., Eugenia samarangensis (Blume) O. Berg, Jambosa javanica (Lam.) K. schum. & Lauterb., Jambosa samarangensis (Blume) DC., Myrtus javanica (Lam.) Blume* and *Myrtus samarangensis Blume*

Traditional Names [11]:

Location	Names
Filipino	Java apple, makopa
Indonesian	Jambu klampok (java)
Malay	Jambu air mawar
Hindi	Jamrul, amrool
Telugu	Gulaabijaamichettu
Thai	Chompu-khieo
Vietnamese	Roi
Malayalam	Chambekka
Jamaica	Otaheti apple
Bengali	Jamrul
Sri Lanka	Jumbo
French	Jamalac

Origin/Distribution: The Java apple is native to regions spanning from Bangladesh to the Solomon Islands. It has naturalized in the Philippines since prehistoric times.

It is commonly and widely cultivated in Malaysia, Indonesia, Thailand, Cambodia, Laos, Vietnam and Taiwan. It is frequently cultivated in India and in Africa and also in the Antilles, Suriname and northern Australia [12].

Edible Plant Parts and Uses: People enjoy ripe Java apple fruit either fresh, sliced for fruit cocktails, or dipped in salt, sweetened dark soy sauce, sambal, or mixed into a spicy peanut sauce for fruit salads like "rujak." In Indonesia the fruit are also preserved in pickles, “Asian”.

Java apple can also be stewed like apples. The fruit is commonly incorporated into salads and featured in lightly sautéed dishes within the cuisine of Indian Ocean islands.

The ripened fruit varies in hue and can be from yellowish-greenish white to light pink to red to a dark, maroon purple [12].

Phytochemical Constituents: Phytochemicals can be categorized into primary and secondary metabolites. Primary metabolites involved natural sugars, amino acids, proteins, purines and pyrimidines of nucleic acids and chlorophyll. Secondary metabolites encompass various plant chemicals including glycosides, alkaloids, terpenoids, flavonoids, lignans, steroids, curcuminoids, saponins, and phenolics [13].

The methanolic extracts consistently exhibited greater phenolic and flavonoid contents compared to the ethanolic extracts. The highest phenolic content was observed in methanolic fruit extracts followed by barks and leaves of three cultivars and it was highest in fruits of red cultivar [14].

Isolated Compounds:

Flower: Flowers of *S. samarangense* contains two anthocyanins- delphinidin-3- gentiobioside and malvidin-3-laminaribioside; petunidin-3-gentiobioside, malic acid, oxalic acid, tannins, cyanidindiglycosides, waxy component, triterpenhydroxy acid and oleanolic acid.

Leaves: The leaves contain compounds such as myricetin-3-L-arabinoside, dihydromyricetin, quercetin-3-D-galactoside, oleanolic acid, three triterpenoids, acetyl oleanolic acid, eugeniatriterpenoids A and B, ellagic acid, isoquercetin, and kaempferol. 5'-dimethyl-6'-methoxychalcone 1, 2', 4’- Dihydroxy-3', flavanone 5-O-methyl4'-desmethoxymatteucinol 2 and 2'4'- dihydroxy-6'-methoxy-3'- methylchalcone 3. Triterpenoidlupeol, betulin, epibetulinicacid.

Stem/Bark: The stem and bark Hepatocosane, nonacosane, triacontane, hentriacontane, octacosanol, triacosanol, dotriacosanol, betulinic acid and crotegolic acid.

Fruits: The fruits contains a gallic and ellagic acids, corilagin and related ellagitannis, 3, 6-hexahydroxydiphenoyl glucose and its isomer 4,6-hexahydroxydiphenoyl glucose, 1- galloylglucose, 3- galloylglucose, -di-0-′-tri-0-methylellagic, 3,4′,4′quercetin, 3,3 methylellagic, caffeic, ferulic, guaiacol, resorcinol dimethyl ether, veratrole, lignanglucoside, medioresinol 4''-0-beta-glucoside, (+)- pinoresinol-0- beta- glucoside, (+)-syringaresinol 0-beta-glucoside, dihydro-dehydrodiconiferyl -0- beta- glucoside and 5-′alcohol 4 (hydroxymethyl) furfural.

Seed: *S. samarangense* seeds contains methylxanthoxyline and 2, 6 dihydroxy 4-methoxyacetophenone (unsaponifiable fraction); -pineneβ- pinene and αbornyl acetate.

Essential Oil: Leaf oil is largely composed of monoterpenes (30% sesquiterpenes, 9 % caryophyllene).

It has been identified a total of 74 compounds of the essential oils from the leaves of five varieties of wax apple trees: 'An Phuoc', 'Hoa An', 'Hong Dao', 'Sua', and 'Xanh Duong' collected in Dong Thap Province, Vietnam.

The findings indicated that the concentrations of the primary constituents in the essential oils of the five varieties studied varied significantly from those reported in previous studies.

The main constitutes of essential oils were: o-cymene (13.47% - 'An Phuoc'), αcubebene (21.49% - 'Hoa An'), epizonarene (13.10% - 'Hong Dao'), β-gurjunene (10.73% - 'Sua'), and αselinene (20.11% - 'Xanh Duong').

In this study, essential oils extracted from the leaves of five varieties of wax apple trees exhibited antibacterial effects against four tested microorganisms: *B. cereus, E. coli, S. enteritidis,* and *S. aureus* [8].

Nutritive/Medicinal Properties: The nutrient composition of *S. samarangense* fruit per 100 g edible portion was reported as:

1.	Water	91.5 g
2.	Energy	30 kcal
3.	Protein	0.4 g
4.	Fat	0.1 g
5.	Carbohydrate	7.8 g
6.	Fibre	0.8 g
7.	Ash	0.2 g
8.	Calcium	17 mg
9.	Phosphate	9 mg
10.	Iron	0.3 mg
11.	Sodium	2 mg
12.	Potassium	105 mg
13.	b-carotene	0 mg
14.	Thiamin	0.03 mg
15.	Riboflavin	0.01 mg
16.	Niacin	0.3 mg
17.	Ascorbic acid	13 mg

Another analysis conducted in Australia reported that wax jambu had the following food value per 100 g edible portion:

Sl. no.	Composition	Quantity
1.	Water	90.3%
2.	Protein	0.7 g
3.	Fat	0.2 g
4.	Glucose	2.1 g
5.	Fructose	2.4 g
6.	Dietary fibre	1.9 g
7.	Malic acid	0.10 g
8.	Citric acid	0.12 g
9.	Oxalic acid	0.02 g
10.	Energy	94 kJ
11.	Vitamin C	8 mg
12.	Thiamin	0.02 mg
13.	Riboflavin	0.04 mg
14.	Niacin	0.5 mg
15.	Potassium	38 mg
16.	Sodium	1 mg
17.	Calcium	13 mg
18.	Magnesium	5 mg
19.	Iron	0.8 mg
20.	Zinc	0.1 mg

A total of 39 volatile constituents were identified in wax jambu (*S. samarangense*). The volatiles of wax jambu were distinguished by the abundance of C9 aldehydes and alcohols. Additionally, compounds such as methyl 3-epi-betulinate, 4,6-dihydroxy-2-methoxy-3,5-dimethyl chalcone, ursolic acid, jacoumaric acid, and arjunolic acid were isolated from the aerial parts of *S. samarangense*. Various parts of the plant have been reported to have bioactive compounds and to exhibit antioxidant, anticancer, antiviral, antimicrobial, spasmolytic, antihyperglycaemic, protease inhibition, anti-amnesiac and

immunomodulatory activities [11] presence of calcium antagonist activity explains the use of *S. samarangense* in diarrhoea [15].

Pharmacological Activities:

Analgesic, Anti-inflammatory and CNS Activities: The results of the experiments suggest that the methanolic extract of *S. samarangense* leave may be used as an alternative or supplementary herbal remedy for the treatment of analgesic, inflammatory and in depressant disease. Because of its analgesic, anti-inflammatory and antidepressant effects, the methanolic extract of *S. samarangense* leave have beneficial effects together with drugs known for a remarkable analgesic, moderate anti-inflammatory as well as antidepressant effects [9].

Antidiarrheal Activity: The research has shown that the use of wax apple These results indicate that the presence of compounds with spasmolytic and calcium antagonist activity may be responsible for the medicinal use of the plant in diarrhoea, The plant wax apple has rich amount of calcium antagonist, Hence it helps in case of diarrhoea [15].

Anti-hyperglycaemic Activity: The result obtained from the study indicate that the Methanol extract of the leaves of *S. samarangense* lowered serum glucose levels significantly when compared to control at nearly all doses examined in a dose-dependent manner [16].

Anti-diabetic Activity: The leaf extract of *S. samarangens*e contains plenty of previously characterized polyphenols. These compounds were categorized into different chemical classes and then subjected to docking studies within the active sites of two receptors known for their involvement in the management of type 2 diabetes mellitus (T2DM). Moreover, the studied extract at 100 mg/kg was able to improve the glycemic parameters, including serum glucose, insulin, and lipid peroxide levels in STZ-diabetic rats [17].

Anti-Cancer Activity: This study reports a simple, cost effective and efficient synthesis of silver nanoparticles from the leaves of *S. samarangense* (Java Apple) through the integration of green chemistry, Results from the *in-vitro* Total Antioxidant Capacity and Free Radical Scavenging by H2O2 method revealed the efficiency of AgNPs as a source of good antioxidant and to combat the free radicals that are the potent cause of oxidative stress. This investigation also explored the potential anticancer activity of green synthesized AgNPs against A549 tumour cell lines using MTT assay [18].

Anti-trypaosomal Activity: *S. samarangense* extracts exhibited moderate anti-trypanosomal activities *in-vitro* and *in-vivo* and were able to counteract the pathological anaemia and organ damage conditions accompanying *T. brucei* infection. The compounds that docked strongly to the target enzymes utilized in this study could be considered as potential leads for development of novel drugs of natural origin for the treatment of sleep sickness disorder and the plant could therefore serve as appealing sources to treat trypanosomes infections [19].

Hepatoprotective Activity: The induction of CAT and SOD activities, and reduction of nitrotyrosine and TNF-α levels in wax apple administration. Overall, these results provide evidence that the research the wax apple protects against STZ-induced pancreatic β-apoptosis and dysfunction in diabetic rats, possibly through inhibiting oxidative stress and pro-inflammatory cytokine, and activating anti-apoptotic proteins [20].

Antimicrobial and Cytotoxic Activities: The phytoconstituents present in the stem bark extract of S. *samarangense* may provide a potential candidate and have become an emerging research in future, the significant lethality of the MeOH soluble fractionate of *S. samarangense* stem bark to brine shrimps is an indicative of the presence of potent cytotoxic compounds which needs further investigation [21].

Anti-acne Activity: The observed potential antibacterial activity of the formulations may be due to the presence of active constituents in the ethanolic extract of *S. samarangense*. The antibacterial activity was well maintained when it was converted into cream formulation. This was good sign for further studies to make this product into commercial standards. We recommended that the formulated cream can be successfully used for skin infections which including acne vulgaris [22].

Anthelmintic Activity: From phytochemical screening we found that tannins were present in the

extract. Tannins may serve anthelmintic action by facilitating energy depletion in helminthes by uncoupling oxidative phosphorylation. In the present study the ethanolic extract of bark of *S. samarangense* showed dose dependent anthelmintic activities. However, these preliminary studies do not describe the actual mechanism of action of these activities. Further investigations are required to isolate the bioactive compounds responsible for the pharmacological activity of this plant [23].

Anticholinesterase Activity: In this study the rare C-methylated flavonoids from *S. samarangense* were identified from spectral data, only 7 showed an inhibitory activity against the acetyl-cholinesterase and butyrylcholinesterase enzymes with a 98.5% inhibition at a concentration of 0.25 mM and a 68% inhibition at a concentration of 0.20 mM, respectively. This finding adds to the number of bioactivities observed for dihydro-chalcones in particular and flavonoids in general. Further investigation may be done to establish the mechanism of inhibitory action of 7 and combined with molecular modeling studies may result in the development of a more potent compound [24].

Anti-ulcer and Anti-Arthritic Activity: Based on the results of the study, they conclude that aqueous root extract of *S. samarangense* possess significant anti-ulcer activity and anti-arthritic activity at examined concentrations. Further confirmational studies are required to identify the exact compounds which are responsible for the anti-ulcer activity and anti-arthritic activity of *S. samarangense* and also to elucidate the exact mechanisms involved [25].

Anti-inflammatory Activity: The dichloro-methane fraction identified pinocembrin as a potential compound for use as an anti-inflammatory agent by inhibiting COX-2 regulation according to the results. By the study they conclude that the Pinocembrin binds to COX-2 to prevent the production of prostaglandins, which are produced during inflammation. With a low binding energy (9.0 kcal/mol) and a high activity probability score, the pinocembrin molecule complex binds. So, it's possible that pinocembrin has anti-inflammatory properties [26].

Wound Healing Property: Based on the research and data analysis, they concluded that topical administration of Semarang guava leaf extract can speed up the healing process of burn wounds in mice. Further studies need to be carried out by testing Semarang water guava leaves at the fraction level [27].

Antiviral Activity: Oleanic acid has a reputation for being a powerful anti-HIV agent. In the leaves of *S. samarangense* several chemicals are also found. Oleanolic acid, known for its anti-HIV properties, and ursolic acid, another compound with potential health benefits, have both been extracted from leaves. Both oleanolic acid and ursolic acid were found effective in protecting against chemically induced liver injury in laboratory animals.

The Oleanolic acid has been marketed in China as an oral drug for human liver disorders. The oleanolic acid and ursolic acid have also been long recognized to have anti-inflammatory and Antihyperlipidemic properties in laboratory animals. Oleanolic acid and ursolic acid are relatively nontoxic and have been used in cosmetics and health products. Oleanolic acid also possessed anti-HIV activity. Studies showed that oleanolic acid inhibited the human immunodeficiency virus-1 (HIV-1) replication in all the cellular systems (cultures of human peripheral mononuclear cells (PBMC) and of monocyte/ macrophages) [28].

Immunopharmacological Activity: The Immuno-pharmacological action of the *S. samarangens*e flavonoids was examined. Human peripheral blood mononuclear cells (PBMCs) were used as the target cells, and 3H-thymidine uptake was used to evaluate cell growth. Stropopinin, myricetin, alpha-rhamnopyranoside, epigallocatechin, and myricetin alpharhamnopyranoside among the flavanoids demonstrated inhibitory effectiveness on PBMC proliferation induced by phytohemagglutinin (PHA). Compounds 1, 2, 3 and 4 had IC50 values of 36.3, 11.9, 28.9, and 75.6 µM on the proliferation of activated PBMCs, respectively. Since compounds 1, 2, 3, and 4 lowered the production of interleukin-2 (IL-2) and interferon-gamma (IFN-gamma), the inhibitory mechanisms may entail inhibiting these cytokines and IFN gamma production in PBMC in a dose-dependent manner [11].

Antioxidant Activity: Fruits were examined for *S. samarangense* antioxidant properties. For this, their fully developed fruits were first cut into little pieces, dried in the sun, and then ground into a powder using a grinder. Fruit powder ethanolic extracts were made using ethanol that was 99.99% ethanol. Using the extracts' capacity to scavenge the 1, 1- diphenyl-2-picrylhydrazyl (DPPH) free radical as a gauge, the antioxidative actions of the compounds were identified. Antioxidant activity was examined to be present in the ethanolic extracts of *S. samarangense*. The *S. samarangense* ethanolic extract had an IC50 of 200 /mL. This suggests that the fruit is healthy for people [29].

CONCLUSION: *S. samarangense* is an important medicinal plant having traditional importance and this is proven by various experiments and scientific studies. Medicinal plants becoming the most important aspect of global health care and formed the basis of health care throughout the world since the earliest days of humanity. This plant has numerous therapeutic applications like antioxidant, antimicrobial, anti-inflammatory, wound healing property, antiulcer activities, *etc*. as mentioned above. The major activities were reported using extracts of the plant; still the active principle involved behind these activities is needed to be worked on. This review has presented the general properties, medicinal properties along with the wide range of pharmacological activities of *S. samarangense* which will be helpful to the researchers for further study about the plant

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