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SYZIGIUM AQUEUM: A COMPREHENSIVE PLANT REVIEW

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ABSTRACT: Since ancient times, natural plants have been a key source of pharmaceuticals. The therapeutic elements found in plants are crucial in the management of a wide range of illnesses. They provided a plentiful supply of the active phytochemical components needed to produce a range of biological activities. One of the valuable therapeutic plants belonging to the Myrtaceae family is the watery rose apple, scientifically known as *Syzigium aqueum*. The plant is indigenous to Malaysia and Indonesia. Because the fruit of the plant has a high water content, it is also known as water cherry, water apple, and water jamboo, among other names. The phytochemical elements found in abundance in the plant's parts are primarily responsible for producing a range of biological activities. The herb is commonly used in traditional medicine to treat a range of illnesses. Therefore, the primary goal of this review is to highlight the many sections of the *Syzigium aqueum* plant and its origin, distribution, phytochemical ingredients, nutritional value, traditional uses, health advantages and pharmacological qualities.

INTRODUCTION: Humans have been used medicinal plants from a very long time to treat various diseases. Currently, various medicinal plants have been scientifically reported to be able to help humans in overcoming various health problems [1]. Medicinal components from plants plays an important role in the treatment of various health diseases. They were the sole source of active constituents capable of curing the various disease and helps in maintaining the physiological condition. Medicinal plants not only important for the treatment of diseases but also as potential material for maintaining good health and conditions [2].

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The field of herbal medicine has grown exponentially in the last several decades. Many diseases and physiological abnormalities have been treated and cured with herbal medicines. Thus, the natural products have been a major source of drugs for centuries [3]. Myrtaceae is the eighth-largest family of medicinal plants, with approximately 140 genera and 3,800–5,800 species. *Syzygium* is the 16th biggest flowering plant genus in the Myrtaceae family. It is widely cultivated for its colourful, delicious, and fleshy fruits [4].

Syzigium aqueum (S. aqueum), commonly referred to as water apple, one among the foremost valuable medicinal plant species under the Myrtaceae [5]. *S. aqueum* is a plant in which its fruits are favoured by many. It is simple to grow and is commonly planted in residential yards not only for its fruits but also for protection. Native to Indonesia and Malaysia, the fruit of this plant is widely known as the water jamboo, although other common names

include water apple, bell fruit, water cherry, or watery rose apple [6]. *S. aqueum* is rich in various bioactive components distributed all plant parts. These includes phenolic compounds, flavonoids, tannins, terpenoids and essential oils [7]. The plant has been widely employed as traditional medicine and has been mentioned to have a various biological activity. The fruit is used to treat liver diseases and the fresh leaves have been used to relieve childbirth pain and their dried powdered form is to treat mouth ulcers. The root preparation has been used to reduce itching and swelling, while decoction of its bark is used for thrush[8]. Different parts of the plant have been reported for their various biological activities like antioxidant, anti-inflammatory, hepatoprotective, antinociceptic-activity [9]. This review aims to comprehensively detail the phytochemistry, nutritional composition, traditional uses and pharmacological properties of *S. aqueum* while emphasizing its significance as a potential subject for further study.

FIG. 1: *S. AQUEUM* TREE

FIG. 2: *S. AQUEUM* LEAVES

FIG. 3: *S. AQUEUM* FLOWERS

FIG. 4: *S. AQUEUM* FRUITS

TABLE 1: TAXONOMICAL CLASSIFICATION [10]:

Kingdom	Plantae
Clade	Tracheophytes
Clade	Angiosperms
Clade	Eudicots
Clade	Rosids
Order	Myrtales
Family	Myrtaceae
Genus	Syzigium
Species	*S. aqueum*

Synonyms: *Cerocarpus aqueous* Hassk., *Eugenia alba* Roxb., *Eugenia aquea* Burm. f., *Eugenia callophylla* (Miq.) Reinw. ex de Vriese, *Eugenia malaccensis* Lour. nom. illeg., *Eugenia mindanaensis* C.B. Robinson, *Eugenia nodiflora* Aubl., *Eugenia observa* Miq., *Eugenia stipularis* (Blume) Miq., *Gelpkea stipularis* Blume, *Jambosa alba* (Roxb.) G. Don, *Jambosa ambigua* Blume, *Jambosa aquea* (Burm. f.) DC., *Jambosa calophylla* Miq., *Jambosama dagascariensis* Blume, *Jambosa obtusissima* (Blume) DC., *Jambosa subsessilis* Miq., *Jambosa timorensis* Blume, *Malidra aquea* Raf., *Myrtusob tusissima*

Blume, *Myrtus timorensis* Zipp. ex Span., *Syzygium obversum* (Miq.) Masam [11].

TABLE 2: VERNACULAR NAMES [12]:

Hindi	Gulabjamun
Gujarati	Gulabjamun
Malayalam	Malakkacampa
Kannada	Pannerale
Telugu	Jambuneredu
Marathi	Jamb
Assamese	Golapi-jamuk
Tamil	Champai
English	Rose apple, Malabar plum

Botonical Description: Watery rose apple is a tropical fruit tree 25-32 °C temperature range is desirable for better growth rate, higher yield and quality produce. While deep, loamy soil is often considered optimal for the rose apple, it demonstrates versatility by thriving in various conditions, including sandy and limestone soils with minimal organic content. Constant water supply is needed to maintain soil moisture content which is essential for this crop. Depending upon the variety tree start bearing fruits after 2-5 years of plantation [13].

The tree of *S. aqueum* is cultivated well in heavy and fertile soils and insensitive to frost. It grows up toa height of 8–10m with branching near the base. Leaves are 4.5–23cm long, 1.5–11cm wide and oblong to elliptic. The leafstalk is 1–5mm long. Flowers are yellowish-white or pinkish and are 2–3cm long.

Terminal or axillary cymes characterize their flowering, typically appearing in February to March, while fruit maturation takes place from May to June. The fruits, which are pale rose or white, are small, bell-shaped, and watery, with glossy skin, a spongy texture, and a subtle fragrance. Typically measuring about 1 inch in length and ½ inch in width [14]. There are two types, one white-fruited and the other bearing red or pale-rose coloured fruits. Propagation of *S. aqueum* is achieved through various methods including seeds, budding, and air-layering. Fruit pulp is crispy and watery. The wood is hard and is often used to produce handicrafts. The leaves are eaten raw or dried. The unripe green fruits are eaten raw as well as used to make pickles, jelly, syrup and sauces. In Malaysia and Indonesia, Watery Rose Apple fruits are eaten in fruit salad [15].

Geographical Distribution: The species has its origin in tropical Asia to north Queensland. It is commonly cultivated in India, southeast Asia and in the Pacific Islands. In the Philippines, *S. aqueum* thrives abundantly in the provinces of Mindanao, Basilan, Dinagat, and Samar, appearing almost as if it were growing wild. It is occasionally grown in Trinidad and Hawaii [11]. *S. aqueum* particularly distributed in Sri Lanka, Pakistan and Malaysia. In India, it is most likely to occur in moist deciduous forests up to an altitude of 1500 m. It generally grows in the warmer parts like Andhra Pradesh, Assam, Karnataka, Kerala, Orissa, Maharashtra, West Bengal, Punjab, Rajasthan and Tamilnadu. It also grown in southern and south-eastern Asia including Philippines, Myanmar, and Afghanistan [12].

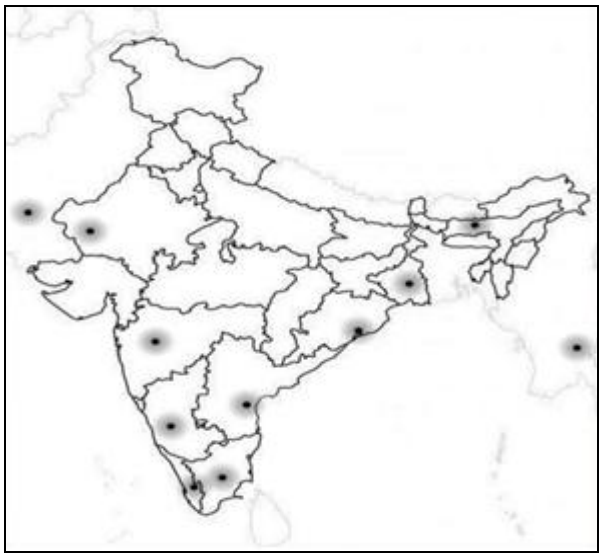

FIG. 5: GEOGRAPHICAL DISTRIBUTION OF *SYZIGIUM AQUEUM* SEVERAL PLACES OF INDIAN SUBCONTINENT

Phytochemical Constituents of *S. aqueum*: Given its diverse pharmacological effects, *S. aqueum* is recognized for containing numerous nutraceuticals, prompting investigations into its chemical constituents, with a particular focus on the leaves as the most exploited part. In general, the plant is rich in phenolic compounds belonging to different classes such as phenolic acids, flavonoids, anthocyanin, tannins, and lignans. Terpenoids and volatile oils are also present in *S. aqueum*. Although research has primarily concentrated on isolating and identifying bioactive compounds from the leaves, limited studies have explored the fruits and stem bark. Similar to the leaves, the fruits have

been found to contain phenolic compounds and flavonoids, suggesting their potential as a source of volatile compounds and oils for industrial, nutritional, and pharmaceutical applications [7].

TABLE 3: DIFFERENT PHYTOCHEMICAL CONSTITUENTS PRESENT IN *S. AQUEUM*:

Sl. no.	Plant Part	Phyto Constituents	Reference
1.	Leaf	Phenolic compounds, Flavonoids myricetin and quercetin3-O-βD-xylopyranosyl (1→2) α L rhamnopyranosides, Ursolic acid and myricitrin.	Palanisamy, 201122, Islam et al., 201224, Bonfanti et al., 2013[25], Aggrarwatti and Ramadhania (2016)26
2.	Bark	Tannin, Riedelin, beta-amyrin acetate, betulinic acid and lupeol	Djipa et al., (2000)27,Kuiate et al., (2007)28
3.	Fruit	Alkaloids, glycosides, formic acid, tartaric acid flavonoids, phenolic content and steroids	Levitah, (2014) 29

Isolated Compounds [9]:

Leaves:

Flavonoids: Methanol extract of *S. aqueum* leaves contained a number of 87 different compounds rich in flavonoids, for example, myricetin rhamnoside, myrigalone G pentoside, quercetin galloyl-pentoside, cryptostrobin, in which myrigalone- B and myrigalone- G were the major flavonoid compounds. Six flavonoids (e.g., 4-hydroxybenzaldehyde, myricetin- 3- O-rhamnoside, europetin- 3- O- rhamnoside, phloretin, myrigalone- G, and myrigalone- B) were isolated from the ethanol leaf extracts of *S. aqueum*. Among them, myricetin- 3- O-rhamnoside and europetin- 3- O- rhamnoside showed antihyperglycemic activity.

Phenols: Methanol extract of *S. aqueum* leaves contained a few phenolic compounds (e.g. caffeic acid) [9].

Tannins: Methanol extract of *S. aqueum* leaves contained few number of tannin compounds (e.g. galloylquinic acid).

Proantrocyanins: Methanol extract of *S. aqueum* leaves contained 87 different compounds which were determined through high- resolution LC- ESI-MS/MS analysis; among them, major proanthocyanins were samarangenin A; (epi)-gallocatechin gallate; (epi)- catechin- (epi)-gallocatechin.

Nutrional Value: The Watery Rose Apple fruit is rich in fibres, calcium, magnesium, potassium, and Vitamin C though very low in proteins. It has high antioxidant activity and beta-carotene content. It is very low calorie fruit due to high water content and very low fat content [15]. Nutrient composition of water-apple fruit per 100 g of edible portion was reported by Dignan *et al.* (1994) [16].

Sl. no.	Constituents	Range
1.	Moisture	95%
2.	Protein	0.8gm
3.	Fat	0.1gm
4.	Carbohydrate	3gm
5.	Fibre	1.3gm
6.	Ash	0.7gm
7.	Calcium	2mg
8.	Phosphorous	13mg
9.	Ferrous	0.2mg
10.	Sodium	1mg
11.	Potassium	48mg
12.	Vitamin A	1mg
13.	Beta carotene	7mg
14.	Thiamine	0.044mg
15.	Vitamin C	16.7mg
16.	Vitamin E	Traces

Another analysis of water-apple fruit reported per 100 g of edible portion conducted in Malaysia by Tee *et al.* (1997) [17] is reported as:

Sl. no.	Constituents	Range
1.	Energy	17Kcal
2.	Protein	0.8gm
3.	Fat	0.1gm
4.	Carbohydrate	3.1gm
5.	Fibre	0.8gm
6.	Ash	0.2gm
7.	Calcium	2mg
8.	Phosphorous	5mg
9.	Iron	0.2mg
10.	Sodium	1mg
11.	Potassium	48mg
12.	Carotenes	7mg
13.	Vitamin B_1	0.04mg
14.	Vitamin C	16.7mg

A total of 42 volatile constituents were identified in water apple fruit, the largest number and proportion (41.4%) were terpenoids, among which gamma – terpinene was dominant [18].

Traditional Uses: *S. aqueum* is viewed as a great potential in traditional medicine as a source of natural antioxidants [6]. The fruits, leaves, and bark of the Watery Rose Apple are utilized in traditional medicine for various purposes, including treating fever, detoxifying the liver, alleviating headaches, addressing digestive issues, managing diabetes, lowering cholesterol, treating skin conditions, and potentially aiding in the prevention of certain types of cancers. A decoction of the astringent bark of Watery Rose Apple is a local application on thrush [15]. Literature review regarding medicinal use of this plant revealed that in Malaysia, various parts of this plant has been used in traditional medicine. *S. aqueum* leaves possess antibiotic activity and the tribal people in Malaysia often ate raw leaves to get relief from birth pain. The tribal people also used powdered dried leaves of this plant for the treatment of mouth ulcers, and preparation from its root has been used to relieve itching and swelling.

A decoction made from the bark of *S. aqueum* act as an effective astringent. A recent report regarding the cosmeceutical potential of leaf extract of this species proved its utility as a cosmetic ingredient due to its antityrosinase, lipolytic, and anticellulite activities. Literature review of this species also revealed that its leaves possess anticancer and antidiabetic activity [19]. According to Chinese medical science water rose apple leaves, fruits and seeds are reported to be antipyretic while roots are diuretic. Use of wax apple fruit, in sultry summer, is an excellent choice for quenching thirst, even effective at releasing the sunstroke and removing harmful effects of dehydration proving its usefulness in dispelling summer heat. Salted fruit can help to release the discomfort in the intestine and stomach. The flowers of watery apple are astringent and known for their use in the treatment of fever and diarrhea [20].

Pharmacological Properties:

Antioxidant Activity: Antioxidants play a crucial role in scavenging free radicals, bolstering protection against oxidative damage, and mitigating oxidative stress. Numerous compounds derived from plants serve as natural reservoirs of antioxidants. Consumption of foods rich in flavonoid and phenolic compounds can impart beneficial antioxidant effects on health. *In-vitro* studies have demonstrated that *S. aqueum* leaf extract exhibits robust antioxidant properties and confers protection against UVA damage to human keratinocytes (HaCaT cells) [21].

Antiinflammatory Activity: Anti- inflammatory is an action of a substance, which affects the CNS to block the pain signalling to the brain and helps to reduce inflammation and pain.

The polyphenol- enriched leaf extract of *S. aqueum* exhibited promising anti- inflammatory activities where it inhibited LOX, COX- 1, and COX- 2 with a higher COX- 2 selectivity than that of standards indomethacin and diclofenac and reduced the extent of lysis of erythrocytes upon incubation with hypotonic buffer solution [21].

Cosmeceutical Activity: *S. aqueum* leaf extracts may be used as a skin treatment ingredient because it is not only an antioxidant but has tyrosinase inhibition activity and may also possess UVB-blocking ability [22].

Antidiabetic Activity: Substances employed to manage diabetes mellitus by modulating blood glucose levels are referred to as antidiabetic, hypoglycemic, or antihyperglycemic agents. The bioactive compounds found in the leaf extract of *S. aqueum* have demonstrated efficacy in enhancing adipogenesis, stimulating glucose uptake, and augmenting adiponectin secretion, thereby showcasing promising potential as antidiabetic agents [21].

Hepatoprotective Activity: The capacity of a substance to shield the liver from damage or injury is termed as antihepatotoxicity or hepatoprotective activity. *S. aqueum* leaf extract exhibited hepatoprotective effects by lowering elevated levels of ALT, AST, total bilirubin (TB), total cholesterol (TC), and triglycerides (TG).

Antimicrobial Activity: Antimicrobial agents are crucial substances employed primarily to combat pathogenic microbes, either by killing or inhibiting their growth to safeguard cells. The ethanolic extract derived from three varieties of *S. aqueum* exhibited effectiveness against the growth of *S. aureus, B. subtilis, E. coli* and *P. aeruginosa*, while no inhibition was observed against *Aspergillus flavus* and *Saccharomyces cerevisiae* [23].

Anticancer Activity: *S. aqueum* leaves underwent methanol extraction to assess cytotoxicity via the sulforhodamine B (SRB) assay. The study evaluated its effects on human breast cancer cells (MDA-MB-231) in comparison to doxorubicin, a standard cytotoxic drug. The extract demonstrated lower toxicity towards the cancer cell line, with an IC50 value exceeding 100 µg/mL.

Antiproliferative Property: The antiproliferative properties of *Syzygium* fruit, namely water apple (*S. aqueum*) against two types of cancer-origin cells, namely MCF-7 (hormone dependent breast cancer cell line) and MDA-MB-231 (nonhormone-dependent breast cancer cell line) were investigated.

Antiproliferation activities of aqueous and methanolic extracts were evaluated by colorimetric MTT assay through time periods of 24, 48, and 72 hours. The result showed that extracts from the fruit has no significant effects for 24 and 48-hour time periods but extracts displayed antiproliferation effects on MCF-7 cell lines in 72 hours, also there were no effects on the non-cancer origin cell line [3].

Health Benefits of Water Apple [3]:

Fights Free Radical Damage: Rose Apple is renowned for its high Vitamin C content, which serves to counteract the damage caused by free radicals, pollutants, and toxins implicated in health conditions like heart disease, cancer, and arthritis. Free radicals arise in the body due to exposure to radiation, tobacco, smoke, and the metabolic breakdown of food.

Vitamin C supports the production and function of white blood cells, acting as an antioxidant to mitigate oxidative damage and promote optimal functioning. Additionally, it is believed to bolster the immune system, aiding in the defense against colds.

Reduced Risk of Stroke: The abundance of Vitamin C in Rose Apples contributes to reducing the risk of stroke and various health conditions, including inflammation, oxidative damage, cardiac issues, atherosclerosis, high blood pressure, and endothelial dysfunction. By countering the development of plaque in the body, Vitamin C plays a crucial role in minimizing the likelihood of strokes and heart attacks.

Boost Good HDL Cholesterol: Rose Apple serves as a natural source of niacin, a nutrient known to regulate cholesterol levels. Niacin supplementation is associated with increased HDL cholesterol levels and decreased levels of triglycerides and LDL cholesterol.

Prevent Diabetes: Research indicates that the consumption of Rose Apple leads to a reduction in blood glucose levels by enhancing the activities of key carbohydrate metabolic enzymes, including glucose-6-phosphate dehydrogenase, hexokinase, and glucose-6-phosphatase.

Prevent Constipation: The dietary fibres present in Rose Apple aid in promoting regular bowel movements and alleviating constipation, thereby supporting overall digestive health. Additionally, these fibres contribute to maintaining a healthy weight and reducing the risk of heart disease and diabetes.

Prevent Muscle Cramping: Rose Apple possess adequate amount of potassium. It enhances the strength of muscles and reduces the muscle cramps which is due to the low level of potassium.

Skin Health: Rose Apple provides ample amounts of Vitamin A and C, crucial for mitigating oxidative stress induced by factors like poor diet, stress, and pollution. These vitamins not only combat oxidative damage but also promote skin health by reducing dryness and diminishing wrinkles.

CONCLUSION: Information on *S. aqueum* was gathered from global publications and review articles, revealing its rich array of phytochemical constituents. Various parts of the plant exhibit pharmacological properties including antioxidant, hepatoprotective, anti-inflammatory, antidiabetic, cosmeceutical, antimicrobial, anticancer, and antiproliferative effects. The review provides insights into the botanical description, geographical distribution, nutritional value, traditional uses, pharmacological properties, and health benefits of *S. aqueum*. It underscores the potential for identifying lead drugs from the plant's diverse bioactive compounds, which have been utilized since ancient times without full understanding of their chemical composition. This review serves as a catalyst for further research on *S. aqueum*.

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