



## PHYTOCHEMISTRY AND PHARMACOLOGY OF SYZYGIUM AQUEUM: A CRITICAL REVIEW

**Monisha P \*, Shabna E, Subhashri SHR, Sridevi R, Kavimani S**

Department of Pharmacology, College of Pharmacy, Mother Theresa Post Graduate and Research Institute of Health sciences, Puducherry, India.

**\*Corresponding Author: Monisha P.**

Department of Pharmacology, College of Pharmacy, Mother Theresa Post Graduate and Research Institute of Health sciences, Puducherry, India.

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### ABSTRACT

In the last few decades there has been an exponential growth in the field of herbal medicine. Herbal medicines have been the basis of treatment and cure for various diseases and physiological conditions in traditional methods of practice such as Ayurveda, Unani and Siddha. Medicinal components from plants play an important role in conventional as well as western medicine. They were the sole source of active principles capable of curing man's ailments. Thus natural products have been a major source of drugs for centuries. *Syzygium aqueum*, commonly called 'water apple' belonging to the family Myrtaceae is a tropical, evergreen and low growing small tree. The present review is an attempt to highlight the various ethanobotanical and traditional uses as well as phytochemical and pharmacological reports on *Syzygium aqueum*.

**Keywords:** *Syzygium aqueum*, Bell fruit, Antioxidant, Chemical constituents.

### INTRODUCTION

Nature has been a source of medicinal agents and a grand number of modern drugs have been isolated from natural sources for thousands of years that plays a vital role in treatment of diseases.<sup>[1]</sup> Traditional knowledge of medicinal plants has always explored the search for new cures which are often cheaper, locally available and easily consumable, raw or as simple medicinal preparations. These simple medicinal preparations often bring out beneficial responses due to their active chemical constituents.<sup>[2]</sup> Medicinal plants are generally known as "Chemical Goldmines" as they contain natural chemicals, which are acceptable to human and animal systems. All these chemicals cannot be synthesised in

laboratories. Many secondary metabolites of plant are commercially important and find use in a number of pharmaceutical compounds. Human beings have been dependent on plants for their health care needs since the beginning of civilization. Of the 2, 50,000 higher plant species on earth, more than 80,000 are medicinal in Nature.<sup>[3]</sup>

Rose Apple with its scientific name *Syzygium aqueum* belongs to the Myrtaceae family and genus *Syzygium* which is a tropical, evergreen and low growing small tree. It is also called Water Apple and Bell Fruit.<sup>[4]</sup> It is well documented as a medicinal plant, and various parts of the tree have been used in traditional medicine.<sup>[5]</sup>



Fig. 1: Tree of *S. aqueum*.



Fig. 2: Leaves of *S. aqueum*.

Fig. 3: Flowering top of *S. aqueum*.Fig. 4: Fruits of *S. aqueum*.Table 1: Taxonomic Hierarchy of *Syzygium aqueum*<sup>[6]</sup>

Kingdom	Plantae
Subkingdom	Viridiplantae
Infrakingdom	Streptophyta
Superdivision	Embryophyta
Division	Tracheophyta
Subdivision	Spermatophytina
Class	Magnoliopsida
Superorder	Rosanae
Order	Myrtales
Family	Myrtaceae
Genus	<i>Syzygium</i>
Species	<i>Syzygium aqueum</i> (Burm. f.) Alston

**Synonyms<sup>[7]</sup>**

*Cerocarpus aqueus* 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 callophylla* Miq., *Jambosa madagascariensis* Blume, *Jambosa obtusissima* (Blume) DC., *Jambosa subsessilis* Miq., *Jambosa timorensis* Blume, *Malidra aquea* Raf., *Myrtus obtusissima* Blume, *Myrtus timorensis* Zipp. ex Span., *Syzygium obversum* (Miq.) Masam.

**Vernacular Name<sup>[8]</sup>**

English - Bellfruit, Water-apple, Watery rose-apple  
 Tamil - Jambu, Panneer naval  
 Malayalam - Jambakka  
 Telegu - Gulaabijaamichettu, Gulaabijiamikaayalu  
 German - Asserjambuse  
 French - Jambo ayer  
 Malay - Jambu air  
 Spanish - Tambis  
 Swedish - Vattenapple

**Distribution<sup>[4]</sup>****Plant**

The tree is 3 to 10 meters tall with wide spreading branches and flaky brown bark. It has stem about 30 cm. The leaves are glossy and narrow. The tree possesses greenish-white or creamy-white flowers with diameter 7.5 to 10 cm and width 2-4 inch (5 to 10 cm). The plant flowers during midsummer (June-August). The plant

prefers warm and humid climate with an adequate rainfall and it thrives better in well drained soils "Fig. 1".

**Leaves**

Oil dots quite numerous. Leaf blades about 8.5-16 x 2.5-6.2 cm. Midrib grooved or depressed on the upper surface. Two intramarginal veins or a double series of loops often visible "Fig.2".

**Flowers**

Inflorescence peduncles long and slender, about 10-20 x 1 mm, bracts absent at anthesis. Calyx tube (hypanthium) + pedicel about 4-8 mm long, calyx tube (hypanthium) about 3-7 mm diameter, calyx lobes dimorphic, broadly triangular to rounded, about 2-4.5 mm long. Petals broadly spatulate, shortly clawed, about 8 x 6 mm, oil dots visible, more than 100 per petal. Staminal filaments glandular, outer filaments about 10-15 mm long, anthers about 0.6 x 0.4 mm, gland terminal, small and inconspicuous. Ovules about 30-40 per locule, placentas central, ovules radiating, ascending. Style about 10-20 mm long, usually exceeding the stamens "Fig. 3".

**Fruit**

The tree bears fruit from early winter to the late fall. The fruit is about 5 to 8 cm long which is bell-shaped smooth and thin skin. The fruit is pink to red in color with white texture flesh. The fruits which are ripened have light and faintly aroma with moderate sweet taste. Each fruit possess one or two grey seeds "Fig.4".

**Medicinal Uses**

Various part of this plant are used in traditional medicine; while the leaves has been shown to have

antibiotic activity and relieving child birth pains.<sup>[9]</sup> The dried leaves in powdered form have been used to treat mouth ulcers and a preparation of its root have been used to relieve itching and reduce swelling.<sup>[10]</sup> A decoction of the *Syzygium aqueum* astringent bark is used for thrush.<sup>[11]</sup> The leaf extract has also been reported to have cosmeceutical properties, anti-tyrosinase, anticellulite and lypolitic.<sup>[5]</sup>

#### Health Benefits of Rose Apple<sup>[4]</sup>

##### 1. Fights Free Radical Damage

Rose Apple is rich in Vitamin C. It prevents the damage of free radicals, pollutants and toxic chemicals which leads to the health ailments such as heart disease, cancer and arthritis. Free radicals are developed in the body when the body is exposed to the radiation, tobacco or smoke and during the process of breaking down of food.

Vitamin C enhances the white blood cells production and also assists in the functioning. As Vitamin C is an antioxidant, it eliminates the oxidative damage and enhances the smooth functioning. It is also believed that Vitamin C effectively boosts the immune system to counteract the colds.

##### 2. Reduced Risk of Stroke

The presence of Vitamin C in the Rose Apples lowers the chances of stroke and health ailments such as inflammation, oxidative damage, cardiac health, atherosclerosis, blood pressure and endothelial health. The development of plaque in the body results in the stroke or heart attack which could be reduced with the Vitamin C.

##### 3. Boost good HDL Cholesterol

Rose Apple is the source of Niacin which is used to add cholesterol. Niacin enhances the HDL cholesterol levels and reduces the triglycerides and LDL cholesterol.

##### 4. Prevent Diabetes

The research has shown that the use of Rose Apple reduces the level of blood glucose by enhancing the activities of carbohydrate metabolic enzymes such as glucose-6-phosphate dehydrogenase, hexokinase and glucose-6-phosphatase.

##### 5. Prevent Constipation

Dietary fiber in Rose Apple supports the digestive system in the material movement and stimulate stool which is helpful for those having the irregular stools or constipation. It supports in healthy weight and reduces the chances of heart disease and diabetes.

##### 6. 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.

##### 7. Skin Health

An adequate amount of Vitamin A and C could be obtained from the Rose Apple which helps to prevent the damage from the oxidative stress caused from the poor diet, stress and pollution. It also reduces the dryness of the skin and reduces the wrinkles.

##### Chemical Constituents

The plant contains different functional group such as flavonoids,<sup>[12]</sup> anthocyanidins,<sup>[13]</sup> phenolic compounds and terpenoids.<sup>[14, 15]</sup> A brief is presented in Table 2.

**Table 2: Different active components of *Syzygium aqueum*.**

Active Components	Parts
Proanthocyanidins	Samarangenins A and B Leaves
Flavonoids	4-hydroxybenzaldehyde, myricetin-3- <i>O</i> -rhamnoside, europetin-3- <i>O</i> -rhamnoside, phloretin, myriganone-G myriganone-B Leaves
Terpenoids	$\alpha$ -Selinene (13.85%), $\beta$ -caryophyllene (12.72%) $\beta$ -selinene Leaves
	$\gamma$ -terpinene Fruits

##### Nutritional value<sup>[4]</sup>

Rose Apple possess rich amount of iron, calcium, fiber, Vitamin C, protein and Vitamin A. 100 gm of Rose Apple contains calcium (29 mg), potassium (123 mg), sulphur (13 mg). The same amount of Rose Apple provides Vitamin C (24.78%), Total fat (0.86%), Iron (0.88%) and Phosphorus (1.14%).

##### Leaves

##### Acute and Subchronic Toxicity

The acute and subchronic toxicity effects of the *Syzygium aqueum* leaves were evaluated. For this acute toxicity study 2000mg/kg of the *Syzygium aqueum* leaves were given orally to male rats (Sprague - Dawley) and for 14 days and they were observed for toxicity and mortality. In subchronic toxicity study *Syzygium aqueum* leaves were given orally at different

doses like 50, 100, and 200mg/kg for 28 days. In both acute and subchronic toxicity the data clearly shows there were no acute or subchronic toxicity observed.<sup>[16]</sup>

#### Antioxidant Activity

The antioxidant activity and phytochemical contents in ten underutilized fruits of Andaman Islands (India) namely *Malpighia glabra* L, *Mangifera andamanica* L, *Morinda citrifolia* L, *Syzygium aqueum* (Burm.f) Alst, *Annona squamosa* L, *Averrhoa carambola* L, *Averrhoa bilimbi* L, *Dillenia indica* L, *Annona muricata* L. and *Ficus racemosa* L were studied. The antioxidant activity varied from 74.27% to 98.77%.<sup>[17]</sup>

The antioxidant activity of fresh and dried plants extract of *Paederia foetida* and *Syzygium aqueum* were studied using  $\beta$ -carotene bleaching and the 2,2'-azinobis(3-ethyl-benzothiazoline-6-sulfonic acid) (ABTS) radical cation assay. The percentage antioxidant activity for all extract of samples was between 58 and 80%. The fresh samples of both plants had higher antioxidant activity than the dried samples.<sup>[10]</sup>

The Prooxidant/Antioxidant capacity of *Nephelium lappaceum* peel, *Fragaria x ananassa* leaf, *Lawsonia inermis* leaf, *Syzygium aqueum* leaf were analysed. *Syzygium aqueum* leaf has low pro oxidant activity but high DPPH scavenging activity.<sup>[18]</sup>

#### Free Radicals

The leaf extracts of *S. aqueum* were reported to have a significant composition of phenolic compounds, protective activity against free radicals as well as low pro-oxidant capability. The extract displayed other activities, deeming it an ideal cosmetic ingredient. A substantial tyrosinase inhibition activity with an IC<sub>50</sub> of about 60  $\mu$ g/mL was observed. In addition, the extract was also found to have anti-cellulite activity tested for its ability to cause 98% activation of lipolysis of adipocytes (fat cells) at a concentration of 25  $\mu$ g/mL. Therefore, the use of this extract, alone or in combination with other active principles, is of interest to the cosmetic industry.<sup>[5]</sup>

#### Antitrypanosomal

The Screening North American plant extracts *in vitro* against *Trypanosoma brucei* for discovery of new antitrypanosomal drug leads were reported. Eight plants extracts namely, *Alnus rubra*, *Hoita macrostachya*, *Sabal minor*, *Syzygium aqueum*, *Hamamelis virginiana*, *Coccoloba pubescens*, *Rhus integrifolia* and *Nuphar luteum* were identified as highly potent antitrypanosomal extracts with IC<sub>50</sub> values <1  $\mu$ g/ml.<sup>[19]</sup>

#### Diabetes Mellitus

The treatment of diabetes in twelve medicinal plants were reported. The 12 plants were *Lannea coromandelica*, *Alstonia scholaris*, *Catharanthus roseus*, *Enhydra fluctuans*, *Terminalia chebula*, *Coccinia grandis*, *Momordica charantia*, *Cuscuta reflexa*,

*Phyllanthus emblica*, *Syzygium aqueum*, *Drynaria quercifolia*, and *Clerodendrum viscosum*. A review of the scientific literature demonstrated that almost all the plants used by the Garo tribal practitioners have reported antidiabetic and/or antioxidant properties and have enormous potential for possible development of new and efficacious antidiabetic drugs.<sup>[20]</sup>

The insulin-like and/or insulin-sensitising effects of *Syzygium aqueum* leaf extract were studied. Its six bioactive compounds are 4-hydroxybenzaldehyde, myricetin-3-*O*-rhamnoside, europetin-3-*O*-rhamnoside, phloretin, myrigalone-G and myrigalone-B were investigated in 3T3-L1 adipocytes. *S. aqueum* leaf extract (0.04–5  $\mu$ g/ml) and its six bioactive compounds (0.08–10  $\mu$ M) at non-cytotoxic concentrations were effectively enhance adipogenesis, stimulate glucose uptake and increase adiponectin secretion in 3T3-L1 adipocytes. Clearly, the compounds myricetin-3-*O*-rhamnoside and europetin-3-*O*-rhamnoside showed insulin-like and insulin-sensitising effects on adipocytes from a concentration of 0.08  $\mu$ M. These compounds were far better than rosiglitazone and the other isolated compounds in enhancing adipogenesis, stimulating 2-NBDG uptake and increasing adiponectin secretion at all the concentrations tested. These suggest the antidiabetic potential of *S. aqueum* leaf extract and its six bioactive compounds.<sup>[12]</sup>

#### Fruits

##### Postharvest

The postharvest physico-chemical and mechanical properties were determined during the postharvest storage period under ambient conditions of *Syzygium aqueum* fruits. It was observed that weight loss, total soluble solids (TSS) and pH of the jambu air fruits increased with time whilst pulp firmness and the color index of the fruits decreased. Analysis of the antioxidant activity, determined in the jambu fruit methanolic extracts over a period of 18 days after harvesting, using the DPPH (2,2- diphenyl-1-picrylhydrazyl) method, showed that the antioxidant activity increased gradually. The total phenol content determined by the Folin-Ciocalteu method revealed a high concentration of phenol content in the jambu air fruits, with values around 344.25±107.68 mg gallic acid equivalent (GAE) / 100g fresh fruit. The flavonoid content also measured spectrophotometrically, using the aluminium chloride colorimetric assay, showed an increasing trend over the same period. These results represent new data on postharvest changes occurring in *Syzygium aqueum* fruits and show that this increasingly popular fruit has great potential for future development in the agriculture sector.<sup>[21]</sup>

#### Antioxidant Activity

The study was to compare the antioxidant activity of fruit of water apple and fragrant mango against 1, 1-diphenyl-2- picrylhydrazyl as a free radical which was conducted by the visible spectrometry. The water apple and fragrant

mango contain reducing compounds including vitamin C, the content of vitamin C is 0.087% (w/w) for water apple and 0.050% (w/w) for fragrant mango. The inhibitory concentration 50% value of fresh fruit of water apple and fragrant mango was 4.857 µg/ml and 4.379 µg/ml, respectively. Antioxidant activity of water apple fruit was higher than fragrant mango fruit.<sup>[22]</sup>

#### Volatile Constituents

The volatile constituents of five fruits from four *Syzygium* species from Malaysia were isolated by vacuum distillation with subsequent dichloromethane extraction. The concentrated extracts were analysed by capillary GC and GC-MS. A total of 42, 39, 36 and 41 constituents were identified in water apple (*S. aqueum* Alston). In roseapple volatiles about 60% 3-Phenylpropan-1-ol, (*E*)-cinnamyl alcohol and other compounds with the C<sub>6</sub>-C<sub>3</sub> skeleton were constituted but were absent among the volatiles of the other *Syzygium* fruits. Water apple yielded the largest number and proportion (41.4%) of terpenoids, among which γ-terpinene was clearly dominant.<sup>[15]</sup>

#### Antiproliferative Property

The antiproliferative properties of *Syzygium* fruits, namely water apple (*Syzygium aqueum*), milk apple (*Syzygium malaccense*) and malay apple (*Syzygium malaccense* L.) 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 three fruits had no significant effects for 24 and 48 hour time periods but extracts of Water apple and Malay apple displayed antiproliferation effects on MCF-7 cell lines in 72 hours, also there were no effects on the non-cancer origin cell line. The methanolic extracts of the malay apple was more significant with 79% cell viability in the case of MCF7. This finding revealed that fruits extract exhibit antiproliferative activity against MCF-7.<sup>[23]</sup>

#### Antimicrobial Activity

The histochemical test, phytochemical analysis and antimicrobial activity against Gram negative bacteria *Escherichia coli*, *Pseudomonas aeruginosa*; Gram positive bacteria *Staphylococcus aureus*, *Bacillus subtilis*; and fungi *Aspergillus flavus* and *Saccharomyces cerevisiae* were done in the collected fruits and leaves. The screening of bioactive components indicates the presence of alkaloid, tannins, glycosides, formic acid, tartaric acid, flavonoids and steroids. The fruits and leaves of ethanolic extract of the three varieties of *S. aqueum* showed to be effective against the growth of *S. aureus*, *B. subtilis*, *E. coli* and *P. aeruginosa* and there is no inhibition observed against *Aspergillus flavus*, *Saccharomyces cerevisiae*.<sup>[24]</sup>

#### CONCLUSION

*Syzygium aqueum* is easily available and more beneficial for human health. 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. They are still widely used and have considerable importance in international trade herbal medicines are in great demand in developed and developing countries for their primary health care because of their wide range of biological activities, higher safety margins, easy availability and lesser costs. This review has presented the general properties, important chemical constituents and traditional uses along with the wide range of pharmacological activities of *Syzygium aqueum* which will be helpful to the researchers for further study about the plant.

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