REVIEW ARTICLE

An Overview of Phytochemical Constituents and their Potential Pharmacological Activities of Plants of the Genus *Syzygium*

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Abstract

A number of plant species belonging to the *Syzygium* genus are found all over the world. The majority of these plants exhibit a variety of biological activities, some of which have been documented and others which have not. Researcher interest therefore exists in the *Syzygium* genus. In an effort to discover new uses for them or a better dose at which they can be employed, all *Syzygium* species are being intensively researched. The diverse *Syzygium* species, their phytochemical components, and their pharmacological properties are the main topics of this review. *Syzygium aromaticum*, also known as clove; *Syzygium samarangense*, also known as Java apple; *Syzygium anisatum; Syzygium caryophyllatum*, also known as lilly pilly; *Syzygium aqueum*, also known as water apple; *Syzygium jambos*, also known as mountain apple; *Syzygium cumini*, also known as Java plum; and *Syzygium australe* were discussed in this review paper. Plants of the *Syzygium* species have been reported to have biological properties such as anti-diabetic, antioxidant, anti-bacterial, anti-inflammatory, platelet inhibition, and hepatoprotective. All of the anti-diabetic properties are specifically mentioned in our current review. We made an effort to compile information as best as we could and hope that anyone studying or researching *Syzygium* will find it helpful. In this review article, *S. cumini* is given emphasis since it has a variety of applications and most of the plant's parts have their own usage in the medical industry.

Key words: Anti-diabetic, Myrtaceae, Syzygium cumini, Syzygium

INTRODUCTION

Syzygium is a genus of woody flowering plants that are a member of the *Myrtaceae* family of bushes. There are over 1200 species in the genus:[1] The genus *Syzygium* currently contains a large number of species that were earlier included in the Eugenia genus.[2] *Syzygium* plants are used to cure a variety of ailments, primarily diabetes. The medicinally beneficial portion of some species is the leaves, while in others, it may be the root, fruit, seed, or bark.[3] The fruits of *Syzygium cumini*, *Syzygium jambolanum*,[4] *Syzygium australe*, and *Syzygium luehmannii*, among others, are consumed as food under the *Syzygium* genus.[5] The buds of *Syzygium aromaticum* are used as spices because of its flavorful, anti-tooth decay, and anti-halitosis characteristics. It has economic significance since Indians and other Asians are aware of these uses and because it is frequently used in Asian and Indian cuisine. Other than for therapeutic uses, only the fruits and buds were widely used.[6] In this review study, the anti-diabetic properties of *S. cumini*, *S. aromaticum*, and *Syzygium aqueum* were thoroughly covered. Taxonomic information:[7] Kingdom Plants Clade Tracheophytes Clade Angiosperms Order Myrtales Family Myrtaceae Genus Syzy Clade Eudicots Clade Rosids.

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Kingdom	Plantae
Clade	Tracheophytes
Clade	Angiosperms
Clade	Eudicots
Clade	Rosids
Family	Myrtales
genus	*Syzygium*

S. CUMINI

S. cumini also goes by the names *S. jambolanum* [8] and *Eugenia cumini*.[9] Jambul, Black Plum, Java Plum, Indian Blackberry, Jamblang, Jamun,[10] and other common names are among them.[11] Habitat: These trees can be found in Florida and Hawaii in the United States of America,[12] as well as in Asia, Eastern Africa, South America, and Madagascar.[13] In India, *S. cumini* is a widely cultivated plant, and its fruits are used to make jam, among other things,[14] and as natural food with anti-diabetic properties.[15] Taxonomy specifics: Kingdom plantae clade rosids clade angiosperms clade tracheophytes family myrtaceae order[16] myrtales genus syzygium species *S. cubi* cumini is recognized[17] to have a variety of pharmacological effects against diabetes mellitus, [18] and other conditions. Pre-clinical investigations have also demonstrated that it has chemopreventive, radioprotective,[19] and antineoplastic qualities, in addition to its ability to treat diarrhea, ulcers, inflammation, and among other conditions.[20] The plant has significant concentrations of anthocyanins, glucoside, isoquercetin, kaempferol, ellagic acid, and myricetin.[21] The cumini is a diuretic, carminative, and herb used to treat stomach pain.[22] Jamun vinegar is used to treat urinary retention issues, diarrhea, and spleen enlargement.[23]

Pharmacological uses

Cumini has a number of pharmacological effects against diabetes mellitus,[25] inflammation, ulcers, and diarrhea, additionally demonstrated to have chemopreventive, radioprotective, and antineoplastic activities in pre-clinical trials. The plant has significant concentrations of anthocyanins, glucoside, isoquercetin, kaempferol, ellagic acid, and myricetin.

The cumini is a diuretic, carminative, and remedy for stomach ache. Jamun vinegar is used to treat persons with urinary retention issues, diarrhea, and spleen enlargement.[3]

Phytochemicals of Jamun with reported chemopreventive effects

Oleanolic acid, ellagic acid, gallic acid, quercetin, myricetin, kaempferol, betulinic acid, β-sitosterol, delphinidin.

Phytochemicals of Jamun with reported radioprotective activities

Oleanolic acid, quercetin, gallic acid, ellagic acid.[24]

Anti-diabetic activity of *S. cumini*

Fruit

On alloxan-induced diabetes mice, *S. cumini* fruit has been shown to have dose-dependent anti-diabetic effects.

The blood glucose level was eventually lowered by administering 100 and 200 mg of *S. cumini* fruit mash aqueous extract/kg of diabetic rat body weight. This demonstrates the fruit extract's ability to fight diabetes. Treatment with *S. cumini* led to an increase in body mass, which suggests that muscle wasting was prevented.[25]

Leaf

S. cumini leaf extract exhibited anti-diabetic action in diabetic rats.

Bark

Given that *S. cumini* bark contains alkaloids, glycosides, tannin, and carbohydrates, among other substances, it is known that the bark has biological properties such as anti-diabetic and anti-dysentery,[25] among others. The experiment below was carried out by Perera PR, Ekanayake S.[26] in 2014 to investigate the bark of *S. cumini*'s potential anti-diabetic properties. According to OECD recommendations, dosage should be chosen based on an acute oral toxicity study (300–5000 mg/kg body weight). A single intraperitoneal STZ dose of 50 mg/kg body weight causes diabetes in rats. In fasting diabetic and normal rats, the effects of *S. cumini* bark extracts (500 mg/kg) on post-meal blood glucose level were examined. In the OGTT trial, blood glucose levels were assessed at 0, 30, and 90 min following the delivery of glucose.

In the instance of chronic research, 500 mg/kg of the cumini bark extracts were given orally for 21 days. As a standard form of therapy, glibenclamide (2.5 mg/kg) was employed.

When *S. cumini* extracts were given to treated rats 30 min before oral glucose delivery, the rise in postprandial blood glucose levels was significantly (P = 0.001) reduced compared to control rats but not as significantly as in diabetic rats treated with glibenclamide.

For at least 3 weeks, STZ-induced diabetics who received continuous oral administration of several *S. cumini* extracts saw significant drops in their fasting blood glucose levels compared to diabetic controls. The most effective cumini bark extracts were those made from ethanol and water.

Seeds

The seed powder of *S. cumini* is reported to have hypoglycemic action in streptozotocin-induced diabetic rats.

Anti-inflammatory activity of S. cumini seeds

The following experiment was conducted by Sobeh M, Mahmoud MF, Sautron C, Cock IE, 2010.[27]

Preparation of extracts

The seeds and pulp of the *S. cumini* fruits were separated after thorough washing. To get rid of any remaining pulp, the seeds were washed with distilled water, dried at room temperature, then ground into a coarse powder. Hexane was used to extract the powder's lipids. Next, the extract is filtered. Using the cold percolation process, the residue is extracted using methanol and ethyl acetate. The yields in terms of percentage were 10.36% for methanol and 1.81% for ethyl acetate. The triterpenoids, saponins, and tannins were detected during the phytochemical screening.

Animals

Wistar rats of any sex and weight between 160 and 180 g were chosen for the experiment. They were provided with free access to water as well as commercial pelleted rats chow for food. Drug used in the experiment with 1% sodium carboxymethylcellulose (SCMC) acting as a suspending agent, extracts, and conventional medications were given as suspensions in water.

Anti-inflammatory activity

The animals either sex were divided into six groups each composed of six animals.

Group I – Control animals were given 1% SCMC 10 ml/kg p.o.

Group II – Animals received ethyl acetate extract of cumini seed at the dose of 200mg/kg p.o.

Group III – Animals received ethyl acetate extract of cumini seed at the dose of 400 mg/kg p.o.

Group IV – Animals received methanolic extract of cumini seed at the dose of 200mg/kg p.o.

Group V – Animals received methanolic extract of cumini seed at the dose of 400mg/kg p.o.

Group VI- Animals received standard diclofenac sodium 5 mg/kg, p.o.

Each rat's left paw was injected with 0.1 ml of 1% carrageenan in physiological saline to cause paw edema. 30 min before giving carrageenan, *S. cumini* extracts (in ethyl acetate and methanol) were given orally. The paw volume was measured every 60 min. Using a plethysmograph, 120, 180, and 240 min were recorded. In this drug treated group is compared with carrageenan treated control group regarding percentage inhibition of paw volume. As a conventional medication, diclofenac sodium (5 mg/kg/p.o.) was utilized. This work has demonstrated the anti-inflammatory properties of ethyl acetate and methanolic extracts of *S. cumini* seed. The extracts did inhibit the carrageenan-induced rat paw edema, a test for anti-inflammatory agents acting by inhibiting the mediators of acute inflammation. Inflammation caused by carrageenan can be used to identify oral anti-inflammatory drugs. Carrageenan-induced edema development in the rat paw is a diphasic occurrence. First, histamine and other chemicals are released. Serotonin is created. When tested at doses of 200 and 400 mg/kg, the *S. cumini* seed extracts exhibited anti-inflammatory efficacy. In comparison to diclofenac sodium at a dose of 5 mg/kg, the methanolic extract at a dose of 400 mg/kg showed strong anti-inflammatory action at 4 h, when it produced 62.6% inhibition.

S. AROMATICUM

Cloves are the pink flowering buds of a form evergreen tree (*Eugenia aromatica*), which are dried until brown and used for medicinal and spicing purposes.

Taxonomical classification[3]

Kingdom	Plantae
Clade	Tracheophytes
Clade	Angiosperms
Clade	Eudicots
Clade	Rosids
Order	Myrtales
Family	Myrtaceae
Genus	*Syzygium*
Species	*S. aromaticum*[3]

Phytochemicals Present

Phenolic molecules	Hydroxybenzoic acids, flavonoids, hydroxyphenyl propanes, hydroxycinnamic acids, and eugenol
Gallic acid derivatives	Hydrolyzable tannins
Flavonoids	Quercetin and kaempferol
Phenolic acids	Ferulic, caffeic, ellagic, and salicylic acids.

Pharmacological uses

Eugenol has a number of beneficial properties, including analgesic, antioxidant, anticancer, antiseptic, antidepressant, antispasmodic, anti-inflammatory, antiviral, antifungal, and

antibacterial action against a number of pathogenic bacteria, including methicillin-resistant *Staphylococcus aureus* and *S. epidermidis*. Asia's tropic cloves have been used to cure a variety of illnesses, including scabies, malaria, cholera, and tuberculosis. It has long been used to treat worms, viruses, candida, and numerous bacterial and protozoan illnesses in America.

Phytochemicals Present in *S. aromaticum* and their Respective Pharmacological Activities

S. No	Phytochemical	Pharmacological activity	References
1	Eugeniin	antiviral efficacy	Cortés-Rojas *et al.*, 2014 Hussein *et al.*, 2000
2	Carvacrol and eugenol	fungicidal	Velluti *et al.*, Manohar *et al.*, 2004 Tampieri *et al.*,
3	Eugenol	anti-depressant	Tao, *et al.*, 2005
4	Carvacrol and thymol, cinnamaldehyde and eugenol	Anti-bacterial	Pei, *et al.*, 2009
5	Cinnamaldehyde	Anti-bacterial	Amanda *et al.*, 2019

Anti-diabetic activity of *S. aromaticum*

The findings and conclusions from a study by Goyal MR, Ayeleso AO, Editors. from 2010 are as follows.[28] In streptozotocin-induced diabetic rats, clove oil is known to lower diabetes. This investigation examines the anti-hyperglycemic properties of cloves (*S. aromaticum*). Streptozotocin-induced diabetic male Sprague–Dawley rats received the cloves (containing 100 mg total eugenol/kg body weight/day) orally. Physical and molecular markers of organ tissue as well as fasting blood glucose levels were observed. Cloves reduced tissue damage, protected lenses, and to a lesser amount in the liver but not the kidneys, as well as heart muscle damage. By raising the levels of antioxidant enzymes, the cloves therapy effectively decreased blood sugar and lipid peroxidation in streptozotocin-induced diabetic mice. Cloves reduce the oxidative tissue damage and cataract development brought on by hyperglycemia. This investigation demonstrates clove's *in vivo* antioxidative organ-protecting properties in diabetics.

SYZYGIUM AQUEUM

Syzygium aqueum is widely grown in India, and its fruits are edible and widely consumed.

Taxonomic Classification[3]

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

Phytochemical present

Biologically active compounds have been isolated from the plant, among them, epigallocatechin, epigallocatechin gallate, vescalagin, castalagin, and samarangenins A and B.[21]

Biological activity

Antioxidant, hepatoprotective, anti-inflammatory, anti-nociceptive, analgesic activity.

Phytoconstituents and biological activities of *Syzygium aqueum*

S. No	Phytoconstituents	Biological activity	References
1	Six flavonoid compounds, 4-hydroxybenzaldehyde, myricetin-3-O-rhamnoside, europetin-3-O-rhamnoside, phloretin, myrigalone-G and myrigalone-B	Antihyperglycemic activity	Manaharan *et al.*, 2012; Mansour Sobeh *et al.*, 2018[20] Nonaka *et al.*, 1992[21]
	(epigallocatechin, epigallocatechin gallate, vescalagin, castalagin, and samarangenins A and B)[21]	(Antioxidant, hepatoprotective, painkilling, and anti-inflammatory)[20]	
2	Terpenoids: γ-terpinene	Antioxidant activity	Tehrani *et al.*, 2011
3	Epigallocatechin	Blood anticoagulation and antiplatelet activity	Chen *et al.*, 2013

Anti-inflammatory activity[29]

The experiment below was carried out by Mansour Sobeh *et al.* in 2018. Using a kit for screening lipoxygenase inhibitors, the extract's ability to inhibit lipoxygenase was identified. The extract's capacity to inhibit ovine COX-1 and COX-2 was assessed by employing an enzyme immunoassay (EIA) kit in accordance with the instructions provided by the manufacturer and published research. The information is presented as an IC50 value or the concentration that inhibits an enzyme by 50% (IC50). Additionally, celecoxib, indomethacin, and diclofenac – which were utilized as standards – were used to construct the COX-2 selectivity index (SI values), which is defined as IC50 (COX-1)/IC50 (COX-2).

Carrageenan-induced hind paw edema[20]

Rats' right paws were injected with a carrageenan solution (1% in 0.9% NaCl, 0.1 mL) to cause edema. The vehicle, *S. aqueum* extract (300 mg/kg, p.o.), or diclofenac (10 mg/kg) was administered 1 h earlier, according to their categories, given orally. Before and following the carrageenan injection, the paw thickness (mm) was measured hourly for 6 h, then at 24 h. By estimating the area under changes in the paw thickness-time curve, the overall anti-inflammatory impact during the entire period (0–24 h) was determined.

Syzygium caryophyllatum[30]

This research was done in 2012 by Annadurai *et al*. Different concentrations of the *S. caryophyllatum* ethyl acetate extract were tested for its antimicrobial properties (100–1000 g/disk), which produced a maximal zone of inhibition against *S. aureus* and *Enterobacter faecalis*' minimal zone of inhibition, as well as Alternaria alternata's susceptibility to antifungal action. For all strains, the zone of inhibition expanded as the extract concentration was raised.

Syzygium alternifolium[23]

Kasetti *et al*. (2012) conducted the following study. Cinnamic acid is a substance that has antihyperglycemic properties. Giving fraction C - cinnamic acid (50 mg/kg b.w.) was used in a thorough investigation to clarify its route of antidiabetic effect. In diabetic rats treated with STZ, once daily for 30 days. The treatment of portion C significantly ($P = 0.01$) restored the impaired enzyme activity of carbohydrate metabolism in the liver and kidney of diabetic rats. After 30 days of treatment, fraction C had modulatory effects on enzymes involved in glucose homeostasis similar to those of glibenclamide, lowering blood sugar as expected, suggesting that cinnamic acid may be helpful in the management of diabetes.

CONCLUSION

Molecular docking studies should be done to know which chemical constituent is responsible for pharmacological acticity of the above described various species of genus syzium.

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