



Research Article

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## **SYZYGIVM CUMINI (L.) SKEELS: A REVIEW OF ITS PHYTOCHEMICAL CONSTITUENTS, TOXICITY STUDIES, AND TRADITIONAL AND PHARMACOLOGICAL USES**

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### **ABSTRACT**

*Syzygium cumini (L.) Skeels is one of the most widely used medicinal plants for various conditions and is a popular fruit for food consumption. This review aims to provide information regarding its phytochemical constituents, toxicity, and traditional and pharmacological uses from vast number of published literatures inside and outside the Philippines. The authors hope that this article provides essential directions for future researchers who wish to focus on this medicinal plant.*

**Keywords:** Syzygium, cumini, phytochemicals, toxicity, traditional, pharmacological

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### **INTRODUCTION**

*Syzygium cumini (L.) Skeels is a tree from the myrtle family, Myrtaceae (Faria et al., 2011; Ayyanar and Subash-Babu, 2012; and Ramya et al., 2012). It is also known as *Eugenia jambolana* Lam., *Myrtus cumini* Linn., *Syzygium jambolana* DC., *Syzygium jambolanum* (Lam.) DC., *Eugenia cumini* (Linn.) Druce, and *Eugenia caryophyllifolia* Lam. according to Ayyanar and Subash-Babu (2012). Many of its common names include black plum, purple plum, jambolão, jambolan, jamun, jambu, jambul, jambool, Jamblang, Naval, Indian blackberry, Java plum, Portuguese plum, Malabar plum, Jamaica, and damson plum (Faria et al., 2011; Ayyanar and Subash-Babu, 2012; and Ramya et al., 2012). In the Philippines, it is locally known as duhat, longboi, or lomboi (Ramos and Bandiola, 2017 and Quisumbing, 1978). In Sanskrit, it is called Brahaspati, Mahajambu, and Ksudrajambu (Ramya et al., 2012 and Jadhav et al, 2009).*

### **History and Distribution**

The tree is known to be native in India, Bangladesh, Nepal, Sri Lanka, Indonesia, and Malaysia (Ayyanar and Subash-Babu, 2012) and has been naturalized throughout Southeast Asia and the Pacific Islands (Dacanay, 2007). In the Philippines, it is found throughout the country and is one of the most popular fruits (Ramos and Bandiola, 2017). The tree is also grown in Myanmar, Thailand, Nepal, Australia, Kenya, Zambia, Zimbabwe, Madagascar, Colombia, Cuba, Mexico, Brazil, and some parts of the United States of America particularly Florida and Hawaii (Sharma et al., 2012; Faria et al., 2011; and Swami et al., 2012). In southern Asia, the tree is of significant importance in Hinduism. It is planted commonly near Hindu temples because it is considered sacred to Lord Krishna (Ayyanar and Subash-Babu, 2012).

Commercially, the ripe fruits are used in making health drinks, preserves, squashes (Indian drink), jellies, wines, and syrup (Swami et al., 2012 and Ayyanar and Subash-Babu, 2012). The tree has also been utilized as a fruit producer, an ornamental, and in making cheap furniture and village houses although it is relatively hard to process (Ayyanar and Subash-Babu, 2012 and Kumar and Kalakoti, 2015). Since the wood is strong and is water-resistant, it is used in railway sleepers and in installing motors in wells. In livestock, the leaves are used as food and have a good nutritional value (Kumar and Kalakoti, 2015).

### Botanical Description and Taxonomy

*Syzygium cumini* is an evergreen tree that grows up to 25 meters (80 feet) tall, with grayish white stems and coarse and discolored lower bark. The leaves are simple, opposite, elliptic to oblong, smooth, glossy, and somewhat leathery. The midrib of the leaves is prominent and yellowish (Sharma et al., 2012). Also, the leaves are 5 to 15 centimeters long and 2 to 8 centimeters broad. The base is cuneate or round; apex is short, rounded, or obtuse; edges are toothed; stalk is slender and light yellow; veins are fine, close together, parallel, and gland dotted (Ramya et al., 2012).

The flowers are white to pinkish, about 1 centimeter (0.5 inch) across with four petals and many stamens (Sharma et al., 2012). The calyx is cup-like, about 4 millimeters long, and toothed. The petals adhere and fall together as a small disk. The stamens are many and almost the same length as calyx (Ayyanar and Subash-Babu, 2012).

The fruits are ovoid, 1-seeded berry, with a length of 2 centimeters (0.8 inch), dark purple red, shiny, with white to lavender flesh (Sharma et al., 2012). The Philippine description of the fruit's shape is from oval to elliptic, length from 1.5 to 3.5 centimeters, and color from dark purple to black (Quisumbing, 1978). The fruit has a combination of sweet, mildly sour, and astringent flavor, and it tends to color the tongue purple. Also, because of the dark violet color of the fruit, it gives the impression of the olive tree fruit, both in shape and weight (Ayyanar and Subash-Babu, 2012).



Figure 1: *S. cumini* Leaves, Stems, and Fruits © Authors

**Kingdom:** Plantae  
**Subkingdom:** Viridaeplantae  
**Infrakingdom:** Streptophyta  
**Division:** Tracheophyta  
**Subdivision:** Spermatophytina  
**Infradivision:** Angiospermae  
**Class:** Magnliopsida  
**Superorder:** Rosanae  
**Order:** Myrtales  
**Family:** Myrtaceae  
**Genus:** *Syzygium*  
**Species:** *Cumini*  
**Scientific Name:** *Syzygium cumini*

### Phytochemical Constituents

*Syzygium cumini* is found to be rich in tannins, alkaloids, carbohydrates, flavonoids, sterols, glycosides, and among other phytoconstituents in different parts of the tree.

Table 1: Summary of Phytochemical Constituents Present in *Syzygium cumini*

| CONSTITUENTS   | FINDINGS   |
|--|--|
| Tannins (13.4%) from the bark  | Tannins exerted gastroprotective and anti-ulcerogenic effects (Ramirez R.O. & Roa C.C. Jr., 2003).   |
| Alkaloids, flavonoids, saponins, tannins, glycosides, phenols, proteins, triterpenoids, steroids, and fixed oils and fats in five extracts of the leaves: aqueous, ethanol, methanol, ethyl acetate, and hexane. | Proteins have the highest amount in all five solvent extracts (Ramos, I.L. and Bandiola, T.M.B., 2017).  |
| Tannins, alkaloids, flavonoids, sterols, glycosides, and carbohydrates from the leaves   | a) Ethanolic extract of leaves showed the presence of tannins, alkaloids, flavonoids, sterols, glycosides, and carbohydrates.<br>b) Methanolic extract of leaves demonstrated the presence of flavonoid.<br>c) The High Performance Liquid Chromatography (HPLC) data indicated that ferulic acid and catechin are present in leaf extracts. (Sharma, S. et al., 2012).  |
| Phenols, Flavonoids, and Anthocyanins from fruits  | a) Phenol Content was the highest, followed by Flavonoid Content and Anthocyanin Content, respectively (Siti-Azima, A.M. et al., 2013).  |
| Phenols and Flavonoids from the fruits and seeds; anthocyanin from the fruits  | Total Phenolic Content in fruits was lower than in seeds. Total Flavonoid Content in fruits was lower than in seeds. Total Anthocyanin Content in fruits was present but seeds exhibited no anthocyanin contents (Raza, A. et al., 2015).  |
| Alkaloids, glycosides, triterpenoids, steroids, saponins, flavonoids, and tannins from the seeds   | Saponins and Flavonoids were in more quantity than alkaloids, glycosides, triterpenoids, steroids, and tannins in the ethyl acetate and methanol extracts of seeds. (Kamal, A., 2014).   |
| Phenols and flavonoids from leaves, seed, and pulp   | The total phenol and flavonoid contents were highest in the leaves, followed by the seed and the pulp, respectively (Margaret, E., et al., 2015).  |
| Phenolic content from leaves, barks, and seeds   | Total phenolic content in the methanolic crude extract was highest in the leaves followed by the barks and seeds, respectively (Haroon, R. et al., 2015).  |
| Flavonoids from leaves, barks, and seeds   | a) Total Flavonoid Content for leaves: Crude Methanolic extract> Ethyl acetate fraction> Butanol fraction> Chloroform fraction >Hexane fraction > Aqueous fraction<br>b) Total Flavonoid Content for barks: CME> Ef> Bf> Hf> Cf > Af<br>c) Total Flavonoid Content for seeds: Af> Cf> Ef> Bf> CME> Hf (Haroon, R. et al., 2015)  |
| Essential oil  | High amount of $\beta$ -caryophyllene in the essential oil exerts anti-inflammatory activity while the caryophyllene oxide in the oil exerts antimycobacterial action (Machado, R.R.P. et al., 2013).  |
| Alkaloids, steroids, saponins, cardiac glycosides, carbohydrates, protein, tannins, and phenols  | Methanolic extract of leaves was positive for alkaloids, steroids, saponins, cardiac glycosides, carbohydrates, protein, tannins, and phenols and was reported to possess an antioxidant property at concentration 106.34 $\mu$ g/mL (Kumar, A. and Kalakoti M., 2015).  |
| Carotenoids and anthocyanins   | All-trans-lutein (43.7%) and all-trans- $\beta$ -carotene (25.4%) were identified in the fruits while the anthocyanin composition was characterized by the presence of 3,5-diglucosides of five out of six aglycones and was shown to exert an anti-oxidant property (Faria, A.F. et al., 2011).   |
| Alkaloids, flavonoids, saponins, tannins; glycosides, phenols, proteins; triterpenoids, steroids, and fixed oils and fats  | Phytochemicals were analyzed using hexane, ethyl acetate, and methanol. Results showed that the methanolic extract contained most of the phytochemical constituents, followed by the ethyl acetate and hexane extracts, respectively. Also, the methanolic extract was reported to possess the highest total flavonoid content (87.5 mgQE/g), followed by ethyl acetate (56.1 mg QE/g), and hexane (32.5 mgQE/g), respectively (Bandiola, 2017). |

Table 1 showed that *Syzygium cumini* is abundant of phytoconstituents. The major phytochemicals that are mostly studied are phenols, flavonoids, anthocyanins, and tannins.

### Toxicity Studies

Ugbabe et al. (2010) used 70% methanolic extract for acute toxicity studies in mice using the leaves and stem bark of *S. cumini*. Nine mice were divided into three groups of three each for the phase I study. Three dose levels of 10mg/kg, 100mg/kg and 1000mg/kg were administered orally to group 1, 2, and 3, respectively. Saline water was used as control for both the phase I and the phase II studies. In the phase II study, doses of 4 sets of doses corresponding to the outcome of phase 1 study was adopted from the table provided by Lorke (1983) and given to 4 groups of one mouse and the LD<sub>50</sub> was estimated according to Lorke's model: LD<sub>50</sub> = Square root of the product of A and B (where, A = Lowest dose that is lethal = 3,000 mg/kg; B = highest dose that is safe = 5,000 mg/kg). Results revealed that the leaf has an LD<sub>50</sub> value of 3,873mg/kg and for stem bark >5,000 mg/kg. This observation may infer the presence of more potent compounds in the leaves as compared to the stem bark.

In the study of anti-diabetic potential of *S. cumini* by Deb et al. (2013), acute toxicity study of methanolic and aqueous extracts of leaves, seeds, barks, and roots was conducted in albino mice of either sex of 8-25 grams of body weight using OECD 423 Guidelines. Acute toxicity study of the different extracts (except methanolic extract of seed), did not show mortality at the dose of 2,000 mg/kg. Therefore, 2,000 mg/kg dose was considered as LD<sub>50</sub> cut off dose under Globally Harmonised Classification System (GHS) category 5 (safe dose), as per OECD guideline 423. And for methanolic seed extract, LD<sub>50</sub> cut off was 200 mg/kg b.w. (GHS, category 3). Common side effects such as, mild diarrhea, loss of weight and depression in treated groups of animals were not recorded within the 7 days of observation.

Roy et al. (2011) conducted the Acute Oral Toxicity for the methanolic leaf extract of *S. cumini* in male Swiss albino mice and found out that the extract was safe up to 3,500 mg/kg BW.

In a study by Kumar et al. (2007) for the determination of Central Nervous System Activity of *S. cumini* seeds, the methanolic and ethyl acetate extracts of *S. cumini* seeds were subjected to Acute Toxicity Testing using OECD 423 (albino mice, n=6 of either sex). The two extracts were administered orally at the dose level of 5 mg/kg body weight by intragastric tube and observed for 14 days. Mortality was not observed and the procedure was repeated using higher doses of 50, 300, and 2,000 mg/kg BW. Acute toxicity studies showed no mortality up to the doses of 2,000mg/kg and the two extracts are safe for long term administration.

In a study by Silva et al. (2012), the acute toxicity of 70% hydroethanolic extract of *S. cumini* (L.) Skeels was evaluated through the determination of a LD<sub>50</sub> in mice and rats (up to 14 days). In mice, the oral administration (p.o.) of the HE (0.1 at 6 g/kg) did not cause any death. When administered by intraperitoneal route (i.p.) the HE (0.1 at 1 g/kg) caused death of the animals (LD<sub>50</sub> of 0.489 g/kg). In rats, the HE (0.5, 1 and 2 g/kg, p.o.) did not cause any death, while by i.p., only the 2 g/kg dose was lethal to 67% of the animals. To evaluate chronic toxicity, groups of rats daily received the HE (0.05, 0.1 and 0.25 g/kg) through p.o., during 30, 90 or 180 days and the effects on behavior, body weight, feed consumed were measured. Histology, hematology and biochemical parameters were measured at the end of the treatment. After a 30-day treatment, the HE caused changes in some biochemical parameters. Histological examination of the liver, kidneys, lungs, heart, stomach, intestine and pancreas showed normal architecture suggesting no morphological disturbances. These data may mean that the HE of *S. cumini* does not exert acute or chronic toxic effects by oral administration.

In a study by Ayanna et al. (2015), the acute toxicity study of ethanolic extract of *S. cumini* was carried out using the fixed dose method according to OECD guideline no. 423. The different doses like 500, 1,000, 2,000, 3,000, 4,000 and 5,000mg/Kg body weight were administered orally to the animals, observed for 24 hr after dosing and also observed for 14 days without giving drug. In subchronic oral toxicity study, evaluations were carried out after administering daily oral doses of 1,250, 2,500 and 5,000 mg/kg body weight for 28 days to the rats. Body weights of the rats observed weekly and Biochemical, hematological, histopathological assessments and relative organ weights of the rats were observed on 29<sup>th</sup> day. Acute oral administration of Ethanolic extract of *S. cumini* leaves to experimental rats at a dose level of up to 5,000mg/kg did not cause any mortality or toxic symptoms but in subchronic repeated oral administration caused significant increase in kidney size, Hematological parameters (RBC, WBC & Hb) and Increase urea and creatinine levels in group II, III and IV compare to group-I. By observing the hematological, biochemical parameters and the histopathological studies it is finally concluded that Ethanolic extract of *Syzygium cumini* leaves produces Multifocal Moderate tubular nephritis, multifocal moderate tubular degeneration in the kidney at oral doses of 1,250, 2,500 and 5,000mg/kg body weight. In an Acute Toxicity Study by Prasad et al. (2016), the ethanolic extract of *S. cumini* stem bark showed that the LD<sub>50</sub> was greater than 5,000 mg/kg body weight.

In the Acute Toxicity Study of the aqueous leaf extract of *S. cumini* (n=6 rats) by Prasad et al. (2014), doses ranging from 100 mg-1,000 mg/kg of BW/day and 2,000-5,000 mg/kg of BW/day did not result to any toxic effects and there were no deaths in all groups. In an Acute Oral Toxicity by Mastan et al, (2009), the methanolic extract of *Syzygium cumini* seeds (SME) was found to be 5,000 mg/kg body weight using OECD Guidelines.

In a study of Acute Toxicity by Ayanna et al. (2015) using OECD 423, the ethanolic extract of *S. cumini* leaves were conducted using healthy adult albino rats weighing between 150 to 180 g. Animals were divided into five groups of six animals each and kept fasted overnight. The different doses like 500, 1,000,

2,000, 3,000, 4,000, and 5,000mg/Kg body weight were administered to the group I, II, III, IV, V, VI, respectively. After administering the ethanolic extract of *S. cumini* leaves in different groups the behavioral changes, Eyes, Salivation, Diarrhea, Mortality etc. were observed for 24 hr and also observed for 14 days without giving drug. The results revealed that the Ethanolic extract of *S. cumini* leaves have been found to be non-toxic up to dose level 5,000mg/kg body weight of experimental animals. No mortality was observed during either on first day and up to 14 days of observation.

In a Sub-acute Toxicity study of ethanolic leaf extract of *S. cumini* leaves by Ayanna et al. (2015), Wistar rats of either sex were used weighing from 110 to 130 g. During the experimental period, all rats showed a significant increase in body weight compared to their initial values. However, no mortality was observed during the whole experiment period.

In other species from Myrtaceae family, the Acute Oral Toxicity of *Syzygium alternifolium* methanolic leaf extract was conducted using OECD 423 (n=6 Wistar rats of either sex) in preparation for the anti-inflammatory activity using 200 and 400 mg/kg BW. The toxicity testing began by administering 5 mg/kg BW of the methanolic leaf extract by intragastric tube for 14 days. Mortality was not observed in 2-3 animals, and the same dose was observed in one animal, then the same dose was repeated again. Since mortality was not observed, the procedure was repeated using higher doses: 50, 300, and 2,000 mg/kg BW. Results showed that the methanolic leaf extract *Syzygium alternifolium* did not exhibit mortality up to the dose level of 2,000 mg/kg BW. The results also revealed that the extract of 200 and 400 mg/kg BW doses can cause a significant anti-inflammatory activity in Carrageenan-induced paw edema in Wistar rats (Bharathi et al., 2012).

**Table 2: Summary of the Traditional Uses of *Syzygium cumini***

| FOLKLORIC USES  | FINDINGS   |
|---|--|
| Diabetes  | a) Kani tribals in Southern India mix leaf juice with honey or cow's milk and is taken orally. Fresh fruits are taken orally.<br>b) In rural population in Madeira (Europe), tea or infusion of leaves is taken orally for diabetes.<br>c) Traditional healers in Brazil use tea prepared from infusion/decoction of leaves (taken orally) for diabetes. (Ayyanar et al, 2013).<br>d) In Southern Brazil, leaves (either infusion or decoction in water) at an average concentration of 2.5 g/L; mean daily intake of about 1 liter is used for diabetes (Ayyanar and Subash-Babu, 2012).<br>e) Also, in Madagascar, seeds are taken orally for generations as the centerpiece for an effective therapy for counteracting the impacts of diabetes (Ayyanar and Subash-Babu, 2012).<br>f) In the Philippines, the bark is utilized for diabetes (Quisumbing, 1978). |
| Sores and ulcers, dysentery, opium poisoning, centipede bites, gastric problems, abortion, anorexia, headache, and renal problems     | The seeds are used for sores and ulcers; the fruits, seeds, and bark for dysentery; the leaves for opium poisoning, centipede bites, and renal problems; the leaves, fruits, and bark for gastric problems; the bark for repeated abortion; and the fruits and bark for anorexia and headache (Ayyanar & Subash-Babu, 2012).   |
| Leaves are used for fever, dermatopathy, stomachache, leucorrhea, constipation, and to inhibit blood discharges in the feces.         | The fruits are used in Siddha, Ayurveda, Unani besides other folkloric uses in India as stomachic, astringent, antiscorbutic, diuretic, antidiabetic, and for the enlargement of spleen and chronic diarrhea (Ramya, S. et al, 2012).  |
| Treatment of Jaundice   | In a Maharashtra tribe, the tender leaves are given orally for jaundice for 2-3 days by adults and children (Ayyanar and Subash-Babu, 2012).   |
| Antidote in Opium Poisoning and in Centipede Bite   | In Lakher and Pawi in Northeast India, the juice of leaves is given orally as antidote in Opium poisoning and in centipede bite (Ayyanar and Subash-Babu, 2012)  |
| a) Teeth and gums strengthening<br>b) Haematinic<br>c) Semen-producing<br>d) Thermo-regulant<br>e) Vaginal contraction after delivery | a) In Unani medication, leaf ash is used to strengthen teeth and gums.<br>b-d) In Siddha medication, jamun is used as hematinic, semen-producer, and thermo-regulant.<br>e) In Surinam, leaves are used by women to contract vagina after delivery (Ramya et al., 2012).   |

Table 2 showed that in traditional practice, *Syzygium cumini* is used for many common conditions, especially for diabetes.

Also in another species from Myrtaceae family, the Acute Toxicity study of methanolic leaf extract of *Syzygium guineense* was conducted prior to its antimalarial activity. Following the OECD 425 Guidelines, a fixed dose of 2,000 mg/kg BW of the crude extract was administered to a single mouse via oral gavage. The mice were observed for an hour, occasionally for 4 h in a day for a total of 14 days. Results showed



that the crude extract did not cause death at the limit dose of 2,000 mg/kg BW. Similarly, both physical and behavioral observations did not point out any visible signs of toxicity (Tadesse and Wubneh, 2017).

### Traditional Uses of *Syzygium cumini*

*Syzygium cumini* is used in folkloric practices for diabetes, sores and ulcers, dysentery, opium poisoning, centipede bites, jaundice, gastric problems, repeated abortion, anorexia, headache, and renal problems by using various parts of the plants.

### Pharmacologic Activities of *Syzygium cumini*

*Syzygium cumini* (duhat) was proven to have antioxidant, antibacterial, anti-diabetic, vibriocidal, anti-allergic, anti-nociceptive, anti-inflammatory, chemopreventive, and anti-fungal properties through various parts of the plant.

**Table 3: Summary of Pharmacologic Studies of *Syzygium cumini***

| PHARMACOLOGICAL ACTIVITY   | FINDINGS   |
|--|--|
| Antioxidant property   | <p>a) Flavonoids, anthocyanins, and phenols exhibited very strong antioxidant activities (Siti-Azima, A.M. et al., 2013).</p> <p>b) Antioxidant activity was observed in the leaves, seed, and pulp (Margaret, E. et al., 2015).</p> <p>c) Tannins extracted from <i>S. cumini</i> fruit showed a very good 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical scavenging activity and ferric reducing/antioxidant power (Sharma, S. et al., 2012).</p> <p>c) Aqueous and ethanolic seed extracts revealed significant protective effect against hydroxyl radical (Sharma, S. et al., 2012).</p> <p>d) There was a strong correlation between higher antioxidant activities and high total phenolic and flavonoid contents in the methanol leaf gall extracts of <i>S. cumini</i> than in the aqueous extract (Eshwarappa, R.S.V. et al., 2014).</p> <p>e) In both diphenylpicrylhydrazyl (DPPH) and ferric reducing power (FRAP) methods, the methanol extract exhibited the highest antioxidant activity than methylene chloride extract and essential oil extract. Also, a higher content of both total phenolics and flavonoids were found in the methanolic extract compared with the two extracts. (Mohamed, A.A. et al., 2013).</p> <p>f) Methanolic extract of leaves was reported to possess an antioxidant property at concentration 106.34 ug/mL with IC<sub>50</sub> value of 0.584 ± 4.0 ug/mL (Kumar, A. and Kalakoti M., 2015).</p> <p>g) The functional extract rich in anthocyanins showed a free radical scavenging activity that varied according to the pH values, with a tendency to increase activity at higher pH values (Faria, A.F. et al., 2011).</p> <p>h) <i>Syzygium cumini</i> (duhat) and <i>Syzygium polycephaloids</i> (balig-ang) exerted 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical scavenging activity (Guevarra, M.K.V., 2003).</p> |
| Gastroprotective and anti-ulcerogenic effects                      | Tannins exerted gastroprotective and anti-ulcerogenic effects (Ramirez R.O. & Roa C.C. Jr., 2003).   |
| Quercetin from <i>S. cumini</i> as chemopreventive and antioxidant | <i>S. cumini</i> is chemopreventive against 4-nitroquinoline 1-oxide-induced and tongue carcinoma in rats. Quercetin prevents benzo(a)pyrene-induced carcinogenesis by modulating the antioxidants and decreasing lipid peroxidation (Swami, S. B. et al., 2012).  |
| Antibacterial activities   | <p>a) Leaf extract showed antibacterial activity but the seed and the pulp extracts did not show any antibacterial activity (Margaret, E. et al., 2015).</p> <p>b) Methanolic and ethanolic seed extracts exerted a broad spectrum of bacteriostatic action against different gram-positive and gram-negative bacteria (Sharma, S. et al., 2012).</p> <p>c) Methanol extract had higher antibacterial activity compared to methylene chloride extract and the essential oil extract (Mohamed, A.A. et al., 2013).</p> <p>d) The crude extract of <i>S. cumini</i> showed 15mm and standard drug 24mm of diameter zone of inhibition against <i>Vibrio parahimolyticus</i> (Labu et al., 2017).</p>   |
| Anti-diabetic property   | The maximal hypoglycemic effect was observed in rabbits and produced a significant decrease in the blood sugar level in alloxan diabetic rats (Sharma, S. et al., 2012).   |
| Vibriocidal activity   | <i>S. cumini</i> extract was active against <i>V. ogawa</i> and <i>inaba</i> (Sharma, S. et al., 2012).  |
| Anti-allergic activity   | Oral pre-treatment of <i>S. cumini</i> extract inhibited edema formation to almost the same extent as promethazine, an anti-histamine drug (Sharma, S. et al., 2012).  |
| Central Nervous System (CNS) Activity                              | a) The ethyl acetate and methanolic seed extracts exhibited significant reduction of CNS activity (Sharma, S. et al., 2012).   |
| Alpha-amylase inhibiting activity                                  | Aqueous extract from seed showed inhibition against the porcine pancreatic alpha-amylase (Sharma, S. et al., 2012).  |
| Antinociceptive activity   | b) The <i>S. cumini</i> extract significantly reduced pain scores in all the phases of the formalin test with an analgesic efficacy (Sharma, S. et al., 2012).   |
| Anti-inflammatory activity   | a) The methanol extract showed highly significant anti-inflammatory activity, showing a high percentage of inhibition (62.6%) (Sharma, S. et al., 2012).   |
| In vitro glucose uptake activity                                   | The methanol extracts of <i>S. cumini</i> were found to have glucose uptake activity, comparable to insulin and rosiglitazone (Sharma, S. et al., 2012).   |
| Antifungal activity  | Antifungal activity was proven against <i>Ascochyta rabiei</i> by the aqueous, ethanol, and n-hexane extracts from leaves, fruit, root-bark, and stem-bark of <i>S. cumini</i> (Sharma, S. et al., 2012).  |

|  |  |
|--|--|
| Anti-inflammatory activity in -vivo and antimycobacterial action in-vitro                                      | $\beta$ -caryophyllene and caryophyllene oxide in the essential oil exerted anti-inflammatory activity and antimycobacterial action, respectively (Machado, R.R.P. et al, 2013).   |
| Anti-amnesic effects   | Antiamnesic effects of methanolic extract of <i>Syzygium cumini</i> were evaluated using 200mg/kg BW and 400 mg/kg BW on spatial memory impairments induced by scopolamine (1 mg/kg, i.p.) in rats. 400 mg/kg dose showed more prominent results when compared to 200 mg/kg dose. These results indicate that the methanolic extract may exert anti-amnesic activity via inhibition of acetylcholinesterase and antioxidant mechanisms in the brain (Alikatte, K.L., et al., 2012).  |
| Anti-fatigue activity  | Aqueous, methanolic, and ethyl acetate extracts of <i>S. cumini</i> leaves were evaluated in rats for 21 days. Using doses of 200 mg/kg and 400 mg/kg BW, the extracts were capable of increasing tolerance for non-specific stress during swimming endurance and post-swimming anti-fatigue tests. Gallic acid was one of the active principles responsible (Bhanumathy, M. et al., 2013).  |
| Quorum quenching activity  | Based on docking analysis, methanol extract was enriched for its total anthocyanin (STA) and its effect on quorum sensing (QS) regulated phenotypes was assessed. STA specifically inhibited the violacein production in <i>Chromobacterium violaceum</i> ; biofilm formation and EPS production in <i>Klebsiella pneumoniae</i> up to 82, 79.94 and 64.29% respectively. Synergistic activity of conventional antibiotics with STA enhanced the susceptibility of <i>K. pneumoniae</i> up to 58.45%. Molecular docking analysis of active components attributes the QS Inhibition activity of <i>S. cumini</i> to malvidin (Gopu, V. et al., 2015). |
| Decrease Adenosine Deaminase, 5'Nucleotidase Activities, and Oxidative Damage in Platelets of Diabetic Patient | <i>Syzygium cumini</i> ethanolic leaf extract decreased significantly the 5'NT and ADA activities in the platelets of subjects with type 2 DM (De Bona, K.S. et al., 2010).  |
| Hepatoprotective and cardioprotective activities   | Methanolic extract of <i>S. cumini</i> seeds (at 200 mg/kg) was proven to reverse liver and cardiac damage in diabetic rats caused by Alloxan, attributed to saponins, tannins, and flavonoids (Nahid, S. et al., 2017).   |
| Thrombolytic activity and Membrane stabilizing activity  | a) Moderate thrombolytic activity was found in Ethanol soluble fraction (45.33%), petroleum ether soluble fraction (30.33%), carbon tetrachloride soluble fraction (33.76%), chloroform soluble fraction (22.85%) and aqueous soluble fraction (17.46%) of <i>S. cumini</i> leaves (Labu et al., 2017).<br>b) The different extractives of <i>S. cumini</i> also significantly confirm that the plant has moderate membrane stabilizing activity at 59.33 % ( induced by hypotonic solution) and 29.46 % ( induced by heat (Labu et al., 2017).  |
| Platelet and Leukocyte-increasing effects  | <i>S. Cumini</i> methanolic leaf extract was reported to increase platelets at 400 and 800 mg/kg and increase leukocytes at 800 mg/kg in Sprague-Dawley rats (Bandiola, 2017).   |

Table 3 showed that *Syzygium cumini* (duhat) is mostly studied for its anti-oxidant property. Significantly, quercetin in *S. cumini* was reported for its chemopreventive and antioxidant properties (Swami. et al., 2012).

To add, many studies revealed that flavonoids and anthocyanins exhibited very strong anti-oxidant activities. Major plant parts used for this property are the leaves and fruits including the seed and pulp.

### CONCLUSION AND FUTURE DIRECTIONS

Given the abundant phytochemicals in *S. cumini* (L.) Skeels, its toxicity studies, and uses particularly in diabetes, it is clear that this tree is of high value in terms of its potential for pharmaceutical formulation. However, many of the phytochemicals are not isolated or semi-purified and were not tested specifically for their uses. Also, not many works are in search to validate the traditional uses of this plant. And while many pharmacological uses were already reported from this tree, the study on their specific mechanisms of action was not that numerous, either.

Based on these facts, the authors hope that future researchers would focus on the plant's mechanisms of action and include also in their quest the least studied plant parts such as the roots.

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