

Received: 2024-06-29

DOI: 10.5604/01.3001.0055.0298

Accepted: 2024-11-20

Available online: 2025-03-31

REVIEW PAPER

The phytochemical, pharmacological, and medicinal properties of *Syzygium cumini* (L.) Skeels. A review

VINOTHA SANMUGARAJAH^{1*} , GOWRI RAJKUMAR² 

¹Department of *Noi Naadal Chikitchai*, Faculty of Siddha Medicine
University of Jaffna
Jaffna, 40 000
Northern Province, Sri Lanka

²Department of Botany, Faculty of Science
University of Jaffna
Jaffna, 40 000
Northern Province, Sri Lanka

Corresponding author: phone +94 777490634; e-mail: vsanmuga@univ.jfn.ac.lk

Summary

Syzygium cumini (L.) Skeels (*S. cumini*), (Jambolan, *Myrtaceae* family) is commonly used to cure several diseases, particularly diabetes mellitus. Several decades ago, the plant became commercially available, and it was recognized as an antidiabetic plant. Numerous scientific studies have documented the antidiabetic properties of this plant. The aim of this study was to present an impression of current state of knowledge and scientific research about *S. cumini*, using mainstream electronic databases and textbooks. According to this review, *S. cumini* possesses notable physicochemical and phytochemical qualities, as well as pharmacological actions, along with unique morphological traits. In addition, it is verified that *S. cumini* is a versatile medicinal herb with a range of applications in nutraceuticals. To develop safer drugs for the treatment of diabetes and other illnesses, further scientific research is required to pinpoint the active principles present in *S. cumini*.

Key words: *medicinal properties, pharmacological, phytochemical properties, Myrtaceae, review, Syzygium cumini*

Słowa kluczowe: *właściwości lecznicze, farmakologiczne i fitochemiczne właściwości, Myrtaceae, praca przeglądowa, Syzygium cumini*

INTRODUCTION

In a traditional healthcare system, a collection of herbal preparations often comprises of many medicinal plants. Plants have been essential in the development of manhood since ancient times, and they provide an exceptional resource of natural remedies [1]. In the earlier studies it was found that the decoction of dry leaves and seeds of *Syzygium cumini* had a glycaemic effect [2–5]. The mid-nineteenth century saw *S. cumini* (*Myrtaceae*) became widely known in allopathic medicine because of its antidiabetic properties [6]. It also recognized as Jambolan, *Eugenia cumini*, Jambul, and Kala Jamun in India [7–9].

S. cumini, a massive evergreen tree has excellent nutritional qualities that are present throughout the entire plant. From February to May, the plant blossoms, and from April to July, the fruits mature [1]. It has undergone tests for its various pharmacological effects, including antioxidant, anti-inflammatory, anti-microbial, anti-HIV, and antifungal, free radical scavenging, antidiarrheal, antifertility, diuretic, gastroprotective, chemoprotective and cardioprotective [1, 10–11]. Moreover, the seeds, bark, leaves, and pulp are utilized for treating diabetes, allergies, viral infections, inflammation, and gastric ulcers [12–13].

The World Health Organization recommends *Syzygium cumini* (*S. cumini*) as a secure drug for a variety of ailments and it has been used for over fifty years in several nations for the management and prevention of several ailments [1]. The goal of this

study was to present an impression of the current state of knowledge and scientific research about *S. cumini* using mainstream electronic databases and textbooks. Future scholars can use this review to provide a description of the current data on the specific information of the *S. cumini* plant in the traditional medical system.

METHODOLOGY

The data collected in this comprehensive review was obtained from previous and current traditional textbooks, as well as numerous electronic databases such as Google Scholar, Research Gate, Academia, DOAJ, Science Direct, PubMed, Scopus, Web of Science and various reputable scientific databases from all available sources using the keywords from January 2022 to August 2024 in Jaffna District, Sri Lanka.

Researchers designed a data entry form to gather detailed information on this medicinal plant, including its classification, morphology, habitat, therapeutic uses, biochemical constituents, phytochemical and physicochemical possessions and several pharmacological activities, based on literature.

RESULTS AND DISCUSSION

Taxonomical classification

Table 1 provides the details of the taxonomic classification of the *S. cumini* plant [1, 14–17].

Table 1.

Classification of the *S. cumini* plant

Classification	Name
Kingdom	Plantae
Order	Myrtales
Family	Myrtaceae
Genus	<i>Syzygium</i>
Species	<i>Cumini</i>
Binomial name	<i>Syzygium cumini</i> (L.) Skeels
Synonyms	<i>Eugenia jambolana</i> Lam.
	<i>Myrtus cumini</i> Linn.
	<i>Syzygium jambolana</i> DC.
	<i>Syzygium jambolanum</i> (Lam.) DC.
	<i>Eugenia djouant</i> Perr.
	<i>Calyptranthes jambolana</i> Willd.
	<i>Eugenia cumini</i> (Linn.) Druce
	<i>Eugenia caryophyllifolia</i> Lam.

Common names:	
Sanskrit	Mahajambu, Ksudrajambu
English	Jambul tree, jambolan, black plum, jamun, java plum, purple plum, Indian blackberry, Portuguese plum, Malabar plum, Jamaica and Damson plum
Tamil	Naval
Hindi	Jamuna
Sinhala	Jambu, jambul, madan, naval

Distribution of *S. cumini*

S. cumini grows throughout the South Asia such as India, Bangladesh, Burma, Nepal, Pakistan, Sri Lanka and Indonesia [18], as well as Asian sub-continent, Madagascar, Eastern Africa, and United States of America [19]. Buddhists recognize the tree in southern Asia, and it is often installed near Hindu temples because of its blessing from Lord Krishna

[20]. Himalayas, Kerala, Karnataka, Andhra Pradesh, North, and East India all have the highest prevalence of *S. cumini* in India [21].

Botanical description of *S. cumini*

S. cumini plant is briefly described botanically in Table 2. Figure 1 also displays images of various parts of this plant.

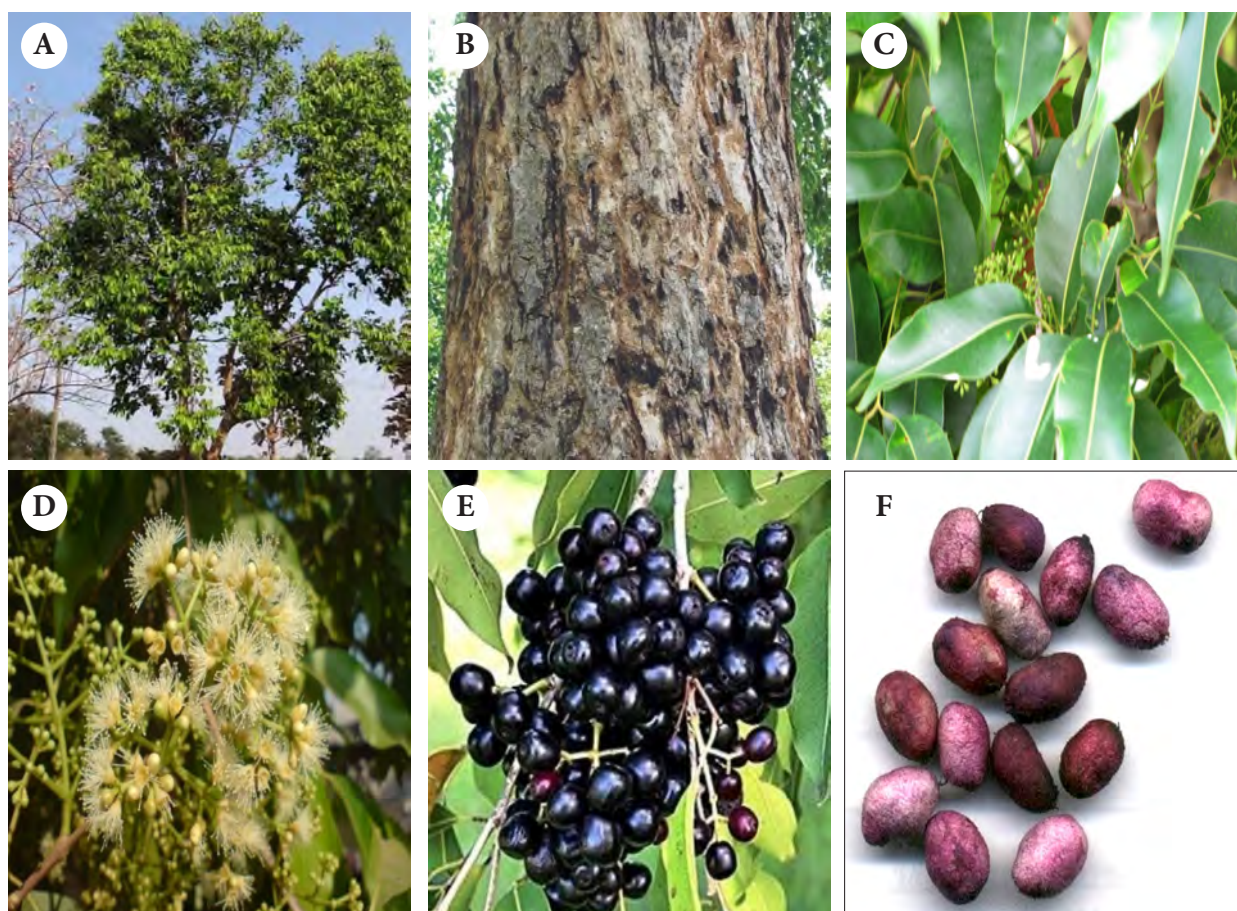


Figure 1.

Different parts of *Syzygium cumini*, A – tree, B – bark, C – leaves, D – flowers, E – fruits and F – seeds

Table 2.Description of *S. cumini* plant

Part	Description	References
Tree	A tree that is large, evergreen, and densely foliaceous; can grow up to 50 feet tall.	[12], [18], [22–23]
Bark	The younger barks are characterized by a pale brown colour, whereas the mature ones are thicker and slightly dark brown or greyish-brown, flaking off in woody scales.	[18], [22–23]
Wood	It is characterized by a whitish, fine grain, and durability; it produces brown dyes and a gum known as Kino.	[12], [18], [22–23]
Leaves	Leathery, oblong-ovate to elliptic, with a length of 6 to 12 cm. The tip is broad and less acuminate, smooth, glossy, and fibrous in nature.	[12], [18], [22–23]
Flowers	Once a year, small, greenish-white, sessile cymes with a few or up to 40 clusters are found in dichotomous paniculate cymes. The calyx is funnel-shaped, approximately 4 mm in length and toothed. The petals cohere and fall together as a small disk.	[12], [18], [22–23]
Fruits	Clusters of 4–20 are found. It takes about 2 months to complete the fruiting process from the flowering stage. Fruits in a group do not ripen at the same time and fall off when they are fully ripe. The fruit is either round, oblong, or ellipsoid in shape, and ranges in size from 1/2 to 2 inches, with large seed situated centrally. As fruits mature, they change from green to light magenta and then to dark purple or black when fully ripe.	[12], [18], [22–23]

Phytochemical constituents

Numerous studies have confirmed that *S. cumini* has higher concentrations of phytochemical compounds in its various parts [6, 10, 12, 18, 23, 24–28]. Different parts of *S. cumini* contain numerous phytochemicals such as alkaloids, carbohydrates, tannins, flavonoids, glycosides, etc. [29]. Meanwhile, terpenoids and phytosterols were not found in the leaf extract, according to another study [30]. Phytochemicals are plant chemicals that are non-

nutritive and have the ability to protect humans from diseases. The ingestion of phytochemicals from several plant families can lead to different well-being benefits, with the prevention of diabetes, obesity, cancer, cardiovascular disorders, and other conditions [16].

Table 3 displays phytochemical compounds that have been found in different parts of the plant and Figure 2 demonstrates the chemical structures of certain constituents.

Table 3.Phytochemical compounds in *S. cumini*

Plant part	Metabolic class	Identified compounds	References
Seeds	polyphenols, including flavonoids, alkaloids, phenolic compound, tannins glycosides and fatty oils	quercetin, caffeic acid, rutin, 3,5,7,4- tetrahydroxy flavones, ellagic acid, ferulic acid, albumen, fat, jambosine, ellagic acid, lauric, myristic, palmitic, stearic, oleic acid, linoleic, malvalic, vernolic acid and phytosterols	[1], [12], [31]

Leaves	phenolic content and acetylated flavanol with new flavanol, glycosides, rhamnosides	triterpenoid, ferulic acid, catechin, critegolic acid, n-dotriconanol, myrcetin, mycaminose, quercetin, tannic acid, BHA, and tocopherol	[24], [32–35]
Fruit	tannins, glycosides, vitamin A, C and volatile flavour components	oxalic acid, malic acid, gallic acid, cyanidine diglycosides, thiamine, riboflavin, nicotinic acid, folic acid	[16], [36]
Fruit pulp	anthocyanins, volatile oils, terpenes	petunidin, α -pinene, β -pinene, malvidin, peonidin, cyanidin, pelargonidin, delphinidin, carbohydrates, protein, calcium and minerals	[12], [36–38]
Stem bark	triterpenoids, resin, phytosterol	oleanolic acid, Eugenia triterpenoid-A, and B, ellagic acid, pentacyclic triterpenoid- betulinic acid, pentacyclic triterpenoid-friedelin, myricetine, β -sitosterol, and myricyl alcohol	[39–40]
Flower	flavonoids, tannins, triterpenoids	erategolic acid, kaempferol, isoquercetin, quercetin, and oleanolic acid	[41–42]
Root	flavonoids, glycosides	isorhamine 3-O-rutinoside, and myricetin 3-O-robinoside	[17], [43]

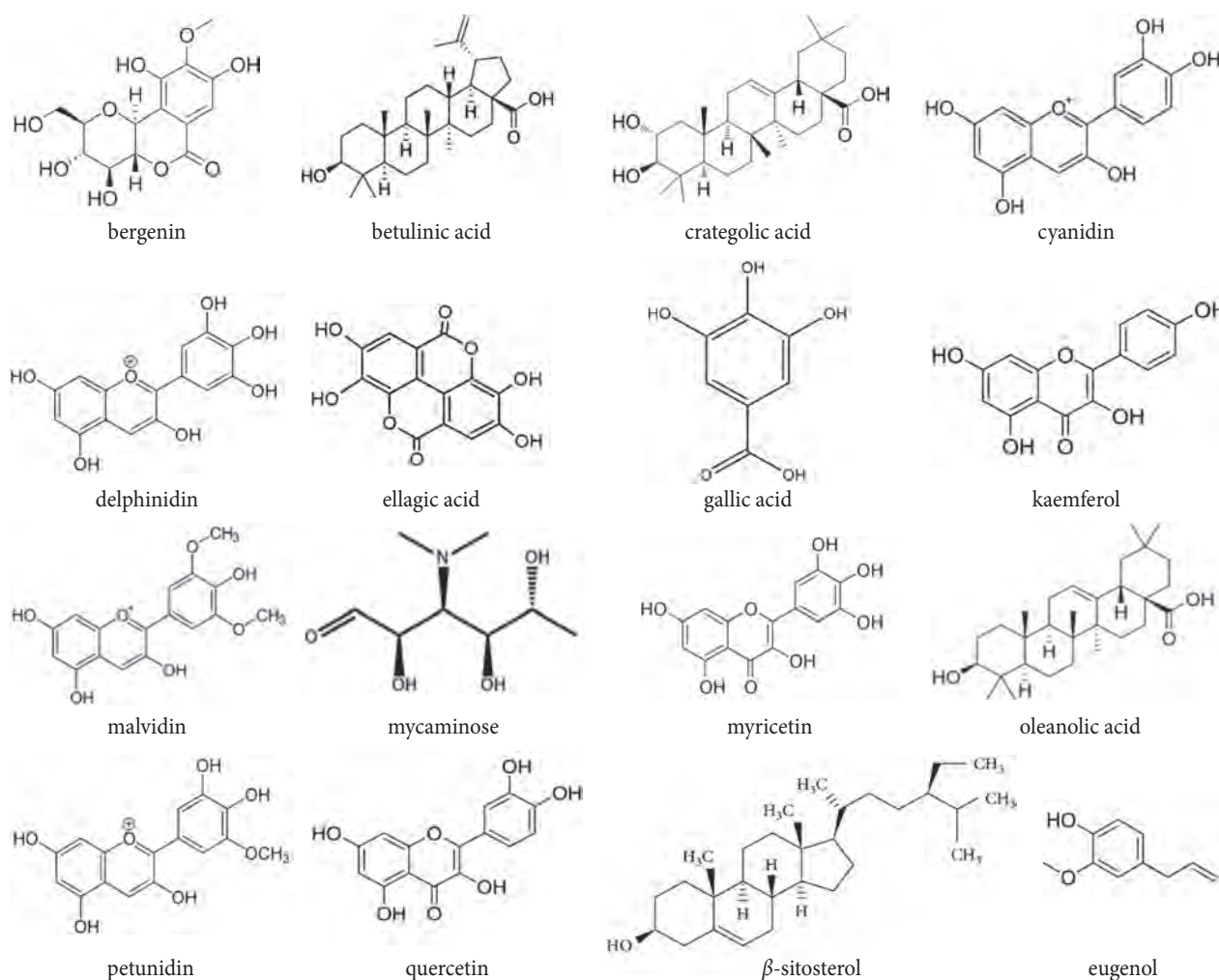


Figure 2.

Structures of chemical constituents in *S. cumini* reported to be used

Medicinal properties

Except its various parts, the *S. cumini* plant also contains a variety of medicinal properties that are responsible for managing bowel-related diseases, particularly diabetes mellitus [10] which are summarized in Table 4.

colic, indigestion, diarrhea, digestive complaints, dysentery, piles, pimples, inflammation, ringworm, stomachache, headache and repeated abortion [48-66].

When someone has jaundice, both adults and children in a Maharashtra community are given the tender leaves orally for two to three days. In addition,

Table 4.

Medicinal properties of the *S. cumini*

Parts	Medicinal properties	Management	References
Plant	astringent, sweet and sour	absorbent, useful in malabsorption syndrome and diarrhoea	[12], [44]
Bark	acid, sweet, digestive, astringent, anthelmintic and blood purifier	sore throat, bronchitis, asthma, thirst, biliousness, dysentery and ulcers	[12], [44]
Fruit	acid, sweet, cooling, astringent, stomachic, carminative, diuretic, antiscorbutic and antidiabetic	removes bad smell from mouth, biliousness, chronic diarrhoea and other enteric disorders	[10], [12], [44]
Seed	sweet, astringent and antidiabetic	diarrhoea and diabetes mellitus	[10], [12], [44]

Physicochemical constituents

The outcomes display that jamun fruits are a good basis of bioactive chemicals, since they include high quantities of ascorbic acid, total anthocyanin, total phenolic contents, and total flavonoid contents and they exhibited the lowest levels of copper and zinc and the highest levels of K, P, Mg, Ca, Mn, and Fe [45]. When compared to seeds and leaves, bark has higher fat content, insoluble ash level, and lower moisture content [46]. According to different study, fruits with higher levels of crude fat and carbohydrates had much lower energy values, while larger fruits had significantly higher amounts of crude fibre and protein [47].

Uses in traditional medicine

Due to the use of all parts, the *S. cumini* tree has been used medicinally for a long time [12]. Various traditional practitioners in Madagascar; North, Eastern and Southern Brazil; Bhutias, Maharashtra, Andhra Pradesh, Karnataka of India use the distinct parts of the plant with variety of preparations such as infusion or decoction, juice, powder, paste employed to cure several ailments such as diabetes, ulcers in mouth and genitourinary tract cancer,

centipede bites and opium intoxication are treated in Northeast Indian cities by oral administration of leaf juice. Also, leaf infusions or decoctions in water with an average content of 2.5 g/l and a mean everyday consumption of roughly one litter are used to treat diabetes in Southern Brazil [18].

Because the bark comprises carbohydrates and tannins, it's been utilized to cure diseases including dysentery. Due to the presence of glycoside, seeds are used to treat reducing blood glucose levels and also said that jamun seeds have a high concentration of ellagitannins, which have antidiabetic properties [10]. Jambolin or antimellin, a glycoside, and the alkaloid jambosine are said to be present in the seeds, and they prevent starch from being converted into sugar through this process [60]. According to reports, streptozotocin-diabetic rats treated with *E. jambolana* seed powder showed hypoglycaemic effects [49–50]. The fruits are utilized for treating many different conditions from all over the world, such as ringworm, cough, diabetes, diarrhoea, and inflammation [10, 57]. According to different research, utilizing *S. cumini* as a treatment outcome in a dose-dependent and substantial rise in body weight, indicating that the hyperglycaemic state was avoided from leading to muscular atrophy [10]. An ethnobotanical and ethnomedical survey reports

that the fruits are used to cure diabetes, the bark to treat dental issues, and the leaves to treat diarrhoea and dysentery [30].

Pharmacological activities

S. cumini has been found to have wide range of pharmacological activities, including antioxidant, antibacterial, antidiabetic, anti-obesity, anti-inflam-

matory, antifertility, antipyretic, antidiarrhoea, anticancer, anticlastogenic, hepatoprotective, diuretic, antihyperlipidemic, antiallergic, antifungal, gastroprotective, antidiarrhoeal, neuroprotective in different parts [11, 18, 35, 44, 67] and several experimental and clinical studies have also validated these findings. In particular, its fruits and seeds have a promising effect on diabetes mellitus [68–77].

Table 5.

Pharmacological activities of the *S. cumini*

Pharmacological activities	Parts	Extract/s	Chemical compounds	Substance-induced animal
Antidiabetic	leaves	methanol, n-hexane	vit. C, gallic acid, tannins, anthocyanins including cyanidin, petunidin, lupeol, β -sitosterol	streptozotocin-induced diabetes in rats [78].
		ethanol		<i>in vitro</i> α -glucosidase inhibitory activity [79]
	seed	acetone extract	orally administered with glibenclamide	alloxan-induced Wistar rats [80]
Anti-inflammatory	bark	ethanol	ellagic acid, gallotannin, betulinic acid, β -sitosterol, eugenin, kaempferol	carrageenan, formaldehyde-induced paw oedema and cotton pellet granuloma in rats [81–82]
		methanol, acetate	triterpenoids, saponins and tannins	carrageenin-induced paw oedema in rats [83]
	seed	methanol, aqueous		carrageenan-induced hind paw oedema in Wistar rats [84]
		aqueous	phenolic compounds and flavonoids	indomethacin induced acute gastric ulceration [85]
		methanol		in experimental acute (carrageenan, histamine and serotonin induced rat paw oedema) and chronic models (cotton pellet induced rat granuloma) [86].
Analgesic and anti-inflammatory	stem	dichloromethane fraction, chloroform fractions and methanolic extract		carrageenan-induced inflammation in mice [87]
Antioxidant and antimicrobial or antibacterial	seed	aqueous	phenols and flavonoid	<i>Candida albicans</i> -infected diabetic rats [88]
	stem	aqueous and alcoholic		<i>in-vitro</i> -agar well diffusion [88]
Antioxidant, anti-inflammatory and antifibrotic	seed	seed powder		male Wistar rats were fed with HCHF diet ad libitum [89]

Antioxidant activity	fruit	infusion (hot)	vitamins, phenolics or tannins and anthocyanins	<i>in vitro</i> – different assays [90]
	bark	80% methanol, ethanol, and acetone extracts		inhibition of linoleic acid oxidation [91]
Antiallergic	leaves and roots	aqueous	ellagitanni, gallotannin and flavonoids	mast-cell degranulator C48/80-induced anaphylaxis oedema in mice [92]
Anti-hyperlipidaemic	plant pulp	ethanol	phenolic content – flavonoids, tannins, triterpenoids	triton X-100 induced hyperlipidaemia in rats [19]
	seed	ethanol	flavonoids, alkaloids, saponins, tannins	[93]
Anti-hypertensive	leaves	hydro-alcoholic	flavonoids, tannins, triterpenoid	rats [94]
Cardio and hepato-protective	seeds	methanol	flavonoids, phenolic contents	CCl ₄ -induced hepatotoxicity in rats [95]
Cardioprotective	seeds	methanol		isoproterenol-induced myocardial infarction in rats [96]
Diuretic	bark	methanol/aqueous	phenolic content – flavonoid, tannin	furosemide-induced diuretic in rats [97]
Antibacterial	seed	chloroform, petroleum ether, ethanol		<i>in-vitro</i> – disk diffusion method [98].
		methanol fraction of ethanol extract		<i>in-vitro</i> – agar cup method [99]
		methanol and ethanol	gallic acid and quercetin	disc diffusion and broth dilution assays [8]
	peel fruit	ethanol		<i>in-vitro</i> – disk diffusion method in ATCC [44]
Anticancer	fruit pulp	crude	flavonoids, alkaloids, steroids	<i>in-vitro</i> – trypan blue dye exclusion method in HeLa, SiHA [100]
		methanol	flavonoid, alkaloid, steroid	<i>in-vitro</i> – trypan blue dye exclusion method in MCF-7 cell line [101]
		chloroform-soluble extracts	quercetin, gallic acid, and oleanolic acid	ovarian cancer cell line PA-1. 3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyltetrazolium bromide tetrazolium assay [102]
Antifungal	leaves, fruit, stem-bark and root-bark	aqueous, ethanol and n-hexane		<i>Ascochyta rabiei</i> (Pass.) Lab, <i>Cicer arietinum</i> L. [103]
Gastro-protective and anti-ulcerogenic		tannins extract	tannins	negative control, an omeprazole group and a tannins group rat [104]
Antifertility	flowers		oleanolic acid	male albino rats [105]

It is evident from Table 5 that *in vitro* and *in vivo* studies have shown that *S. cumini* has various pharmacological properties. Based on the clinical trials, the *S. cumini* is commonly suggested to

decrease blood sugar levels in patients with type 2 diabetes [106-107] and it is regarded as a plant-based antidiabetic agent [108-109]. In an interview-based study, it was found that *S. cumini* infusion is

commonly used by type 2 diabetes patients [110]. In a controlled study, it was discovered that jamun seed powder supplementation had a positive impact on the lipid profile of subjects with type 2 diabetes [111]. Another study also proved that the supplementation of jamun seed powder can improve glycaemic control and dyslipidaemia [112].

Because of its antioxidative, antidiabetic, anti-inflammatory, anticarcinogenic, and hyperlipidaemic properties, jamun has been shown in numerous clinical investigations to have ameliorating benefits against metabolic syndrome [113].

Toxicity studies

Numerous studies related to toxicity have confirmed that different extracts such as methanolic, aqueous, ethyl acetate, and hydroethanolic extracts of diverse portions of the *S. cumini* are non-toxic and safe for long-term management [114–124].

Considering the study's outcomes, rats given alloxan were able to safely receive a prolonged and sustained antidiabetic effect when gliclazide and *S. cumini* seed methanolic extract were combined [114]. When methanolic leaf extract was tested for acute toxicity in mice, the outcomes exhibited that it had a lower LD₅₀ (3,873 mg/kg) than stem bark (>5000 mg/kg) [115]. The hydroalcoholic extract of *S. cumini* was tested by determining its LD₅₀ in mice, and the results showed that it had neither acute hazardous effect or long-term effects when taken orally [117]. A sub chronic toxicity investigation on male albino rats using aqueous extracts of the leaves revealed no appreciable alterations and concluded that *S. cumini* leaves might be a powerful anti-diabetic drug [119]. On diabetic rats induced with alloxan, the application of an aqueous extract of *S. cumini* leaves is useful in the regulation of the changes in glucose metabolism during diabetes without causing toxicity [120]. Experimental rats received an acute oral dosage of up to 5000 mg/kg of ethanolic extract of *S. cumini* leaves, and neither toxic symptoms nor mortality resulted from the administration [121]. In oral acute toxicity investigation, there weren't any observable medical symptoms of toxicity or death associated with ethanol extract of *S. cumini* stem bark [122]. In acute trials on mice or rats, it was discovered that plant elements such as seeds, leaves, and bark were non-toxic [124]. *In vivo* studies with streptozotocin-induced diabetic rats showed that *S. cumini* preparations improved metabolic markers, conserved renal function, and, in a dose-dependent way, decreased the production of glycation adducts [125].

CONCLUSION

For the treatment of several ailments, particularly diabetes and its interrelated difficulties, *S. cumini* plant is widely employed by traditional healers. According to this review, *S. cumini* possesses notable physicochemical and phytochemical qualities, as well as pharmacological actions, along with unique morphological traits. In addition, it verified that *S. cumini* is a versatile medicinal herb with a range of applications in nutraceuticals. To develop safer drugs for the treatment of diabetes and other illnesses, more scientific research is required to pinpoint the active principles present in *S. cumini*.

Ethical approval: The conducted research is not related to either human or animal use.

Conflict of interest: Authors declare no conflict of interest.

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