



Profile of bioactive compounds in *Syzygium cumini* – a review

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ABSTRACT

The aim of this article is to briefly document the bioactive compounds that have been isolated, purified and characterized from *Syzygium cumini*. Different parts of the plant (bark, leaf, fruit and seed) have been extensively investigated for their bioactive phytochemical constituents. Phytochemicals like mallic acid, oxalic acid, gallic acid, tannins, cynidin glycoside, oleanolic acid, flavonoids, essential oils, betulinic acid, friedelin have been elucidated for their antiallergic, anti-amnesic, anticancer, anticlastogenic, antidiabetic, anti-diarrhoeal, antifertility, anti-inflammatory, antimicrobial, antinociceptive, antihyperlipidemic, antihypolipidemic, antiperoxidase, antiscorbutic, antioxidant, antiradiation, chemotherapeutic, CNS, CVD, free radical scavenging (ROS), gastroprotective, and piles curing properties. Further, investigations on the use of phytochemicals from *S. cumini* towards their pharmacological potentials are warranted for the lead bioactive compounds.

Key words: *Syzygium cumini*; Phytochemicals; Pharmacological potentials; Traditional use;

INTRODUCTION

Syzygium cumini Skeels (Syn. *Eugenia jambolana* Lam.) 'Brahhaspati' in Sanskrit, popularly known as Java plum, Portuguese plum, Malabar plum, Black plum, Indian blackberry, Jamun, Jambu, Jambul, Jambool and Naval belongs to the family Myrtaceae^[1]. *S. cumini* is a large evergreen tree native to India. However, it is found in Eastern Africa, South America, Madagascar and warmer regions of the United States of America.^[1,2]

S. cumini is a common traditional medicinal plant, whose parts have been pharmacologically proven to possess hypoglycemic, antibacterial and anti-HIV activities.^[3-6] Different parts of plant, such as bark, leaves, fruit and seeds have been used in various traditional systems of medicine.^[7] The leaves are used to treat leucorrhoea, stomachache, fever, dermatopathy,^[1] constipation, inhibit blood discharges in the faeces^[8] and reduce radiation induced DNA damage.^[9] Fruits of *S. cumini* are used in Siddha, Ayurveda, Unani besides other folklore system of medicine in India as stomachic,^[10] astringent, antiscorbutic, diuretic, antidiabetic, enlargement of spleen^[11,12] and chronic diarrhea.^[13] Jamun fruit is an effective food remedy for bleeding piles and correcting liver disorders.^[14,15]

Botanical description

Kingdom: Plantae
Division: Angiosperms
Sub Division: Eudicots
Order: Myrtales
Family: Myrtaceae
Genus: *Syzygium*
Species: *cumini*

Habit – A moderately fast emergent tropical evergreen tree, *S. cumini* grows up to 15-30 m tall, with a straight to crooked, short, stout trunk (40-100 cm dia). Crown - irregular/ globular with branches; bark 1.0-2.5 cm thick; brown or dark grey in color; fairly smooth; astringent/ bitter taste. Twigs - light

green (young), grey (matured), slightly flattened, without hairs (Fig. 1).

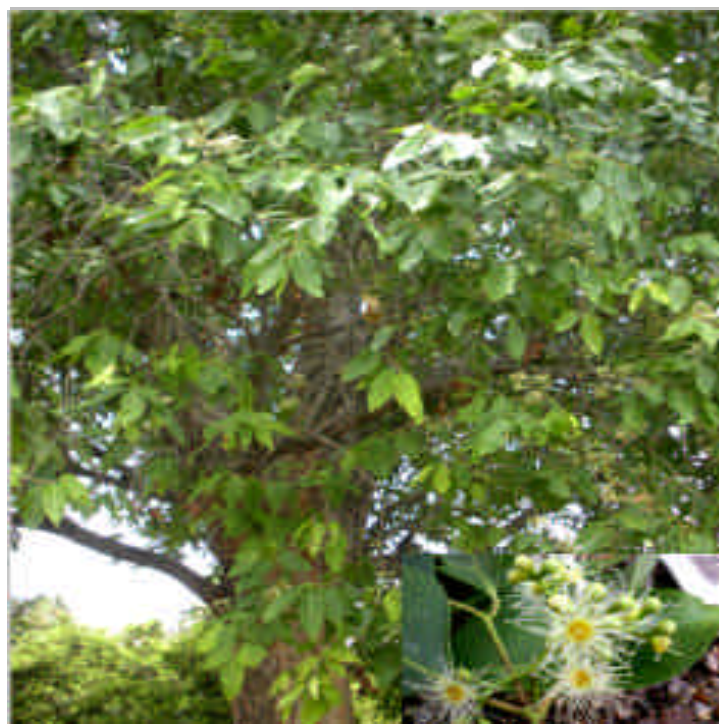


Fig. 1 Native habit of *S. cumini*

Leaves – margin entire, narrow, transparent; size - 5-15 cm long, 2-8 cm broad; arrangement – opposite; appearance - thick, coriaceous, glabrous, upper surface dark green, lower surface yellowish and dull; shape - broadly obovate, elliptic or elliptic-oblong, base cuneate or rounded; apex short, rounded or obtuse; edges not toothed; stalk - slender and light yellow, 1.5-2 cm long; midrib-prominent, light yellow; veins - fine, close together, parallel, gland dotted.

Flowers – clusters on old twigs at the back of leaves, 5-6 cm long and wide, with many paired stout forks at nearly right angles, end flower open first;

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flowers white, many, small, about 7 mm long, slightly fragrant, nearly stalk less, with cuplike, conical, light green base (hypanthium) 3 mm long and broad; calyx with 4 white, rounded, concave petals, more than 2 mm long, united into a cap; stamens many, white or pinkish, threadlike, 5 mm long; pistil with inferior ovary; ovules numerous, tiny and stout; style white, 6-7 mm long.^[1]

Fruits – generally develop in the month of May to Jun and resemble large berries. The fruits are found in clusters of 4-20. However, all the fruits in an inflorescence do not ripe simultaneously. Fruits ovoid-oblong or elliptical berries, numerous, crowded in clusters, almost stalk less along twigs at the back of leaves; often curved, green at first, turning pink and then finally purple-black, 1-2.5 cm (max. 5) long with a centrally placed large seed; the pulp is grayish-yellow, white or pale violet. The ripen fruit has a combination of sweet, mildly sour and astringent flavor.^[1] It is a rich source of Vit A and C.

Seed – in each berry there is centrally placed seed, strongly astringent and slightly bitter, 1-2 cm long; sometimes 2-5 angular, irregularly shaped seeds are compressed together into a mass resembling a single seed. Cotyledons are pale green. Due to recalcitrant nature and short shelf-life-time, seeds cannot be stored viably for a long period of time.

Traditional use

S. cumini has been valued in Siddha, Ayurveda and Unani medication for its therapeutic potentials. The entire plant is used in various traditional system of medicine in India. However, of all, the leaves and bark are regarded as most significant part. In Ayurveda, the bark is acrid, sweet, digestive and astringent to the bowels, anti-helminthes. Besides it is used to cure sore throat, bronchitis, asthma, thirst, biliousness, dysentery, blood impurities and ulcer.^[16]

In Unani, leaf ash is used to strengthen teeth and gums, seeds are used as astringent, diuretic, stop urinary discharge and remedy for diabetes and the bark is known for its wound healing properties.^[10] In Siddha, Jamun is considered to be a haematinic, semen promoting besides thermo-regulant.^[1] Traditional medical healers in Madagascar use seeds of jambolan to debilitate the complications in diabetes.^[17] In Surinam, leaves are used by women to contract vagina after delivery, reduce mucus and odors.

Phytoconstituents

The widespread therapeutic use of *S. cumini* in traditional medicine warrants chemical analysis to elucidate the role of the active principles in different plant parts. The phytochemicals like mallic acid, oxalic acid, gallic acid, tannins, cynidin glycoside, oleanolic acid, flavonoids, essential oils, betulinic acid, friedelin have been reported for antianaemic, gingivitis, antiarrhoeal, antipyretic, antibacterial, antineoplastic, anti-inflammatory, hypoglycemic, gastroprotective and hypolipidamic properties. Pharmacological potentials of bioactive phytochemicals in *S. cumini* have been outlined in Table 1.

Root

The root of *S. cumini* has been reported to possess various flavonoids, glycosides^[18] and isorhamnetin 3-O-rutinoside.^[19]

Stem (bark)

The stem (bark) of *S. cumini* has been reported to possess friedelin, friedelan-3-a-ol, betulinic acid, β -sitosterol, kaempferol, β -sitosterol-D-glucoside, gallic acid, ellagic acid, gallotannin, ellagitannin and myricetin,^[20,21] betulinic acid, eugenin and fatty acid ester of epi-friedelanol,^[22] quercetin,^[23] bergenins,^[24] flavonoids and tannins,^[25] lignan derivatives cuminiresinol, syzygiresinol A, syzygiresinol B, di-demethyl-5-hydroxypinoresinol, dimethylpinoresinol, didemethoxypinoresinol, pinoresinol and 4'-methyl-5'-hydroxypinoresinol.^[26]

Leaves

The leaves of *S. cumini* are known to contain β -sitosterol, betulinic acid, mycaminose, crategolic acid, n-hepatcosane, n-nonacosane, n-hentriacontane, noctacosanol, n-triacontanol, n-dotriconanol, quercetin, myricetin, myricitrin and flavonol glycosides, myricetin 3-O-(4'-acetyl)- α -L-rhamnopyranosides, acylated flavonol glycosides,^[20,27,21] triterpenoids^[28] and tannin,^[11] eicosane, octacosane, octadecane.^[29] Essential oils from leaves are rich in pinocarveol, α -terpeneol, myrtenol, eucarvone, muurolol, α -myrtenal, cineole, geranyl acetone, α -cadinol and pinocarvone.^[30] Further, Sagrawat *et al.* reported that leaves contain ellagic acids, isoquercetin, quercetin, kampferol.^[21]

Flower

The flowers of *S. cumini* have been reported to contain erategolic acid (maslinic acid), flavonoids - isoquercetin, quercetin, kaempferol,^[31] myricetin-3-L-arabioside, quercetin-3-D-galactoside, dihydromyricetin, oleanolic acid, acetyl oleanolic acid, eugenol-triterpenoid A and eugenol-triterpenoid B.^[32]

Fruit pulp

Studies have shown that the pulp of Jamun contains anthocyanins, delphinidin, petunidin, malvidin-diglucosides, and are responsible for the bright purple color^[21,33-35]. Fruits are rich in raffinose, glucose, fructose,^[36] citric acid, mallic acid,^[37] gallic acid,^[38] delphinidin-3-gentiobioside, malvidin-3-laminaribioside, petunidin-3-gentiobioside,^[39] cyanidin diglycoside.^[40] Studies have shown that pulp of Jamun is nutritive and contains minerals like sodium, potassium, calcium, phosphorous, iron and zinc; water soluble vitamins like ascorbic acid, thiamine and niacin; carbohydrates like glucose, mannose, sucrose, maltose, fructose, galactose and mannose; free amino acids like alanine, asparagine, tyrosine, glutamine and cysteine.^[41,42] chrysanthemins,^[43] cinnamaldehyde (cis/trans), cinnamyl acetate (cis/trans), cinnamyl alcohol (cis/trans), citronellol, geraniol, herol oxide, hotrienol, linalool, linalool oxide, nerol, phenylethanol β , phenylpropanal,3, phenylpropanol,3, roes oxide.^[44]

Seed

Seeds are the most studied plant part and are reported to contain jambosine, chlorophyll, fat, resin, albumen,^[45] tannins,^[46] corilagin, 3,6-hexahydroxy diphenylglucose, 4,6-hexahydroxydiphenylglucose, 1-galloylglucose, 3-galloylglucose, quercetin, β -sitosterol,^[20,21] 4-(2-2-dimethyl-6-6-methylenecyclohexyl)butanol,decahydro-8a-ethyl-1,4a,6-tetramethyl naphalene, eicosane, heptacosane, 1-chlorooctadecane, octacosane, tetratetracontane, octadecane,^[29] diphenic acid, ellagic acid,3-3'-4-tri-O-methyl, ellagic acid,3-3'-di-O-methyl, taxifolin,^[25] gallic acid,^[47] coniferyl alcohol, furfural,5-(hydroxymethyl), medioresinol-4'-O- β -, pinoresinol-O- β -glucoside, syringaresinol-O- β -glucoside,^[48] ellagic acid,^[49] elaeostearic acid,^[50] lauric acid, oleic, linoleic acid, malvalic acid, myristic acid, palmitic acid, stearic acid, sterculic acid, vernolic acid,^[51] caffeic and ferulic acids and derivatives, guaicol, resorcinol dimethyl ether.^[51] Monoterpenoids like β -pinene, -terpinene, terpinolene, borbeneol, β -phellandrene, α -terpineol and eugenol.^[52] The seeds are fairly rich in protein and calcium.^[46] Novel compounds 5,6-dihydroxy-3-[(4-hydroxy-6- (hydroxymethyl)-3,5-di {3,4,5-trihydroxy-6-(hydroxymethyl) tetrahydro-2h-2-pyranyl}oxy tritahydro-2h-2-pranyl) oxy] -2-methoxy-10,13-dimethylperhydropentapenta [aphenanthren-17-yl] [phenyl]methyl acetate^[53] 3,15 - dihydroxy - 3 androstene [16, 17-C](6' methyl, 2'-1,3- dihydroxy-1-propene) 4H pyran and 3-hydroxy androstane [16,17- C](6' methyl, 2'-1-hydroxy -isopropene-1-yl) 4,5,6 H pyran^[54] have been characterized.

Due to its overwhelming potentials further work is required to prospect novel bioactive phytochemicals as pharmacological agents.

Table 1 Pharmacological potentials of bioactive phytochemicals in *Syzygium cumini*

Name of the compound	Class	Activity
1,8-Cineole	Monoterpenoid	Antineoplastic, Acaricide, Allelopathic, Anthelmintic, Antiallergic, Antibronchitic, Anticatarrrh, Antifatigue, Antiinflammatory, Antilaryngitic, Antipharyngitic, Antiseptic, Antistaphylococcic, CNS-Stimulant, Candidicide, Choleric, Convulsant, Edemagenic, Gram(-)icide, Hepatotonic, Hypotensive, Insectifuge, Myorelaxant, Nematicide, Perfume, Sedative, Transdermal
Acetyl oleanolic acid	Triterpenoid	Free radical scavenging, antiinflammatory
Anthocyanins	Flavonoid	Anticancer/tumour, antiaging and neurological diseases, antiinflammation, Antidiabetes, antibacterial and fibrocystic disease, antianalgesic, neuroprotective, antioxidant
Bergensins	Iso-coumarin	Antinociceptive, antiarrhythmic, antioxidative, antimicrobial, hepatoprotective, protective against gastric ulcers, antiinflammatory, Insulin enhancing and lypolytic, Enhances Wound Healing
Betulinic acid	Triterpenoid	antiretroviral, antimalarial, antiinflammatory, anticancer agent, antitumour, chemopreventive
Caffeic acids	Phenols	Aldose-Reductase-Inhibitor, AntiHIV, Antiaging, Antiatherogenic, Anti-carcinogenic, Antidepressant, Antiedemic, Antielastase, Antiescherichic, Antihepatoadenomic, Antihepatotoxic, Antihistaminic, Antiinflammatory, Antimutagenic, Antiophidic, Antioxidant, Antiproliferant, Antiseptic, Antisunburn, Antithiamin, Antitumor (Skin), Anxiolytic, Chemopreventive, Cholagogue, Choleric, Collagen-Sparing, Cytoprotective, Cytotoxic, Hepatoprotective, Hepatotropic, Immunostimulant, Insectifuge, Metal-Chelator, Ornithine-Decarboxylase-Inhibitor, Prooxidant, Prostaglandigenic, Sedative, Tumorigenic, Vulnerary
Cinnamaldehyde, (cis/ trans)	Phenylpropanoid	Lipoxygenase/XOD-Inhibitor, antihyperuricemia, Acaricide, Antierococcic, Antiescherichic, Antiinflammatory, Antimutagenic, Antisalmonella, Antistaphylococcic, Antiurease, CNS-Depressant/Stimulant, Candidicide, Choleric, Chronotropic, Cytotoxic, Histaminic, Hypotensive, Insecticide, Monoaminergic, Nematicide, Vibriocide, antidiabetic
Cinnamyl acetate, (cis/ trans)	Phenylpropanoid	Nematicide
Cinnamyl alcohol, (cis/ trans)	Phenylpropanoid	Antimutagenic, Nematicide
Citric acid	Alkane	Antidiabetic- Stimulatives of the insulin release
Citronellol	Monoterpene	Scent ingredient, antibacterial, antiviral, antispasmodic, Free-Radical Scavenging Activities, antioxidant
Coniferyl alcohol	Phenylpropanoid	Antibacterial
Cyanidin diglycoside	Flavonoid-anthocyanin	Anticancer
Delphinidin-3- o-β -d- gentiobiosid	Flavonoid-anthocyanin	Antineoplastic, Chemopreventive
Delphinidin-3-gentiobioside	Flavonoid-anthocyanin	Antineoplastic, Chemopreventive
Ellagic acid	Coumarin	Chemopreventive, Radioprotective
Eugenol	Monoterpene	Acaricide, AntiTNF, Antiarachidonate, Anticonvulsant, Anti-edemic, Anti-feedant, Anti-inflammatory, Antimitotic, Antimutagenic, Antinitrosating, Antioxidant, Antisalmonella, Antiseptic, Antistaphylococcic, Antithromboxane, Antitumor, CNS-Depressant, COX-1-Inhibitor, Candidicide, Carminative, Choleric, Cytochrome-P450-Inhibitor, Cytotoxic, Enterorelaxant, Hepatoprotective, Insecticide, Insectifuge, Juvabional, Nematicide, Prostaglandin-Synthesis-Inhibitor, Sedative, Trichomonistat, Trypsin-Enhancer, Ulcerogenic
Ferulic acids	Phenols	Antibacterial, Allelopathic, Antiallergic, Anticancer (Liver), Anticarcinogenic, Antihepatotoxic, Anti-inflammatory, Antimitotic, Antimutagenic, Antineoplastic, Antioxidant, Antitumor, Antitumor(Liver), Antitumor (Skin), Arteriodilator, Candidicide, Cardiac, Cholagogue, Choleric, Hepatoprotective, Hepatotropic, Immunostimulant, Insectifuge, Metal-Chelator, Ornithine-Decarboxylase-Inhibitor, Phagocytotic, Preservative, Prostaglandigenic, Prostaglandin- Synthesis-Inhibitor, Sunscreen

Name of the compound	Class	Activity
Gallic acid	Benzenoid	Antineoplastic, Chemopreventive, Radioprotective, antioxidant, free radical scavenging
Isoquercetin	Flavonoid	Antielastase, Antifeedant, Anti-inflammatory, Antioxidant, Antitumor, Capillarigenic, Hypotensive, Insectiphile
Kaempferol	Flavonoid	11B-HSD-Inhibitor, 5-Lipoxygenase-Inhibitor, Aldose-Reductase-Inhibitor, Antiallergic, Antigingivitic, Antihistaminic, Antiimplantation, Anti-inflammatory, Antilymphocytic, Antimutagenic, Antioxidant, Antiperiodontic, Antiseptic, Antistaphylococcic, Antitumor, Apoptotic, Choleric, Copper-Chelator, Cytotoxic, Diaphoretic, Estrogenic, Hepatoprotective, Hypotensive, ICAM-1-Inhibitor, Iodothyronine-Deiodinase-Inhibitor, Lipoxygenase-Inhibitor, MAO-Inhibitor, Mutagenic, NO-Inhibitor, Protisticide, Teratologic, iNOS-Inhibitor
Lauric acid	Lipid	Antioxidant, COX-1-Inhibitor, Candidicide
Linalool	Monoterpene	Acaricide, Antiallergic, Antianaphylactic, Anticonvulsant, Antiedemic, Antihistaminic, Antiinflammatory, Antiseptic, Antishock, Bronchorelaxant, Insecticide, Insectifuge, Nematicide, Prooxidant, Sedative, Termitifuge
Linalool oxide	Monoterpene	prevent DNA damage, Acaricide, Antiallergic, Antianaphylactic, Anticonvulsant, Antiedemic, Antihistaminic, Antiinflammatory, Antiseptic, Antishock, Bronchorelaxant, Insecticide, Insectifuge, Nematicide, Prooxidant, Sedative, Termitifuge
Linoleic acid	Lipid	Antioxidant, Antiacne, Antianaphylactic, Antiarteriosclerotic, Antihistaminic, Antiinflammatory, Antiprostaitic, Comedolytic, Hepatoprotective, Insectifuge, Nematicide
Mallic acid	Alkane	Antiatherosclerotic, Antioxidant Synergist, Antiseptic, Antitumor, Bacteristat, Hemopoietic, Mycobactericide
Malvidin	Flavonoid-anthocyanin	Antineoplastic
Malvidin-3-o-β-d- laminaribioside	Flavonoid-anthocyanin	Antineoplastic
Malvidin-diglucosides	Flavonoid-anthocyanin	Antineoplastic
Myricetin	Flavonoid	Anti-neoplastic, Chemopreventive
Myricetin3-O-(4"-acetyl)-α-L-rhamnopyranosides	Flavonoid	prevent DNA damage
Myricetin-3-L-arabinoside	Flavonoid	prevent DNA damage
Myristic acid	Lipid	Antioxidant, Cosmetic, Nematicide
Myrtenol	Monoterpenol	Antiinsomniac, Antimalarial, Antioxidant, Antiplasmodial, Antiradicular, Antithyretropic, Aphrodisiac, COX-2-Inhibitor, Contraceptive, Cyclooxygenase-Inhibitor, Depressant, GABAnergic, Gonadotrophic, Herbicide, Hypnotic, Hypocholesterolemic, Hypothermic, Immunostimulant, Mutagenic, Nematicide, Perfumery, Progesteronigenic, Sedative, Serotonergic, Thyrotropic
Nerol	Monoterpene	Antiseptic, Sedative
N-hentriacontane	Lipid	Antiinflammatory, Cosmetic
N-nonacosane	Lipid	Antimutagenic
Oleanolic acid	Triterpenoid	Antineoplastic, Chemopreventive, Radioprotective, antidiabetic
Petunidin	Flavonoid	Antineoplastic
Quercetin	Flavonol	Antineoplastic, Chemopreventive, Radioprotective, antioxidant, free radical scavenging
Stearic acid	Lipid	Cosmetic
Terpinolene	Monoterpene	Antifeedant, Antioxidant, Deodorant
α-terpeneol	Monoterpene	ACE-Inhibitor, Aldose-Reductase-Inhibitor, Allelopathic, Antiacne, Antiseptic, Insecticide, Nematicide, Sedative, Transdermal, Vulnerary
α-terpinene	Monoterpene	ACE-Inhibitor, Acaricide, Aldose-Reductase-Inhibitor, Insecticide, Insectifuge, P450-2B1-Inhibitor
β-phellandrene	Monoterpene	Expectorant, Fungicide, Perfumery, Topoisomerase-II-Inhibitor
β-pinene	Monoterpene	Anti-inflammatory, Antiseptic, Candidicide, Insectifuge, Transderma
β-sitosterol	Triterpenoids	Antineoplastic, Chemopreventive, Androgenic, Antiadenomic, Anticancer (Cervix), Antiedemic, Antifeedant, Antigonadotrophic, Anti-hyperlipoproteinaemic, Antiinflammatory, Antimutagenic, Anti-ophidic, Anti-oxidant, Antiprostaitic, Antitumor (Cervix), Artemicide, Candidicide, Estrogenic, Hepatoprotective, Spermicide, Ulcerogenic, Hypoglycaemic effect

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