

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

S Ramya¹, K Neethirajan¹ and R Jayakumararaj²

¹Department of Zoology, Yadava College for Men, Madurai –625017, TN, India

²Department of Botany, Government Arts College, Melur- 625106, TN, India

Received on:06-05-2012; Revised on: 17-06-2012; Accepted on:28-07-2012

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 malieic 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, antidiarrhoeal, 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,^[11] 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;

*Corresponding author.

R Jayakumararaj
Department of Botany,
Government Arts College,
Melur- 625106, TN, India

flowers white, many, small, about 7 mm long, slightly fragrant, nearly stalk less, with cuplike, conical, light green base (hypoanthium) 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.^[11] 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.

Phyto-constituents

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 malic 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 *Syzygium 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- α -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, cratogenic acid, n-heptacosane, n-nonacosane, n-hentriacontane, noctacosanol, n-triacontanol, n-dotriacontanol, 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 eratogenic acid (maslinic acid), flavonoids - isoquercitrin, quercetin, kaempferol,^[31] myricetin-3-L-arabinoside, 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-8 α -ethyl-1,4 α ,6-tetramethyl naphthalene, 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 trtyahydro-2h-2-pranyl) oxy] -2methoxy-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 prepared and 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, Choloretic, 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
Bergenis	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, Choloretic, 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, Antienterococcic, Antiescherichic, Antiinflammatory, Antimutagenic, Antisalmonella, Antistaphylococcic, Antiurease, CNS-Depressant/Stimulant, Candidicide, Choloretic, 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, Choloretic, 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, Choloretic, 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, Antiprosthetic, Comedolytic, Hepatoprotective, Insectifuge, Nematicide
Malic 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, Hypcholesterolemic, 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, Transdermal
β-sitosterol	Triterpenoids	Antineoplastic, Chemopreventive, Androgenic, Antiadenomic, Anticancer (Cervix), Antiedemic, Antifeedant, Antigonadotrophic, Anti-hyperlipoproteinaemic, Antiinflammatory, Antimutagenic, Anti-ophidic, Anti-oxidant, Antiprosthetic, Antitumor (Cervix), Artemicide, Candidicide, Estrogenic, Hepatoprotective, Spermicide, Ulcerogenic, Hypoglycaemic effect

REFERENCES

- Warrier PK, Nambiar VPK, Ramankutty C. *Indian medicinal plants*. Hyderabad India: Orient Longman Ltd. 1996;5:225-228.
- Li L, Zhang Y, Seeram NP. Structure of anthocyanins from *Eugenia jambolana* fruit. *Nat Prod Comm* 2009;4:217-219.
- Indira G, Mohan RJ. National Institute of Nutrition, Indian Council of Medical Research Hyderabad. 1993;34-37.
- Kusumoto I, Nakabayashi T, Kida H, Miyashiro H, Hattori M, Namba T, et al. Screening of various plant extracts used in ayurvedic medicine for inhibitory effects on human immunodeficiency virus type 1 (HIV-1) protease. *Phytotherapy Res* 1995;9:180-184.
- Bhuiyan MA, Mia MY, Rashid MA. Antibacterial principles of the seed of *Eugenia jambolana*. *Banga J Botany* 1996;25: 239-241.
- Ravi K, Sivagnanam K, Subramanian S. Anti-diabetic activity of *Eugenia jambolana* seed kernels on streptozotocin-induced diabetic rats. *J Med Food* 2004;7:187-191.
- Teixeira CC, Pinto LP, Kessler FHP, Knijnik L, Pinto CP, Gastaldo GJ, Fuchs FD. The effect of *Syzygium cumini* (L.) Skeels on post-prandial blood glucose levels in non-diabetic rats and rats with streptozotocin-induced diabetes mellitus. *J Ethnopharmacol* 1997;56:209-213.
- Bhandary MJ, Chandrashekar KR, Kaveriappa KM. Medical ethnobotany of the siddis of Uttara, Kannada district, Karnataka, India. *J Ethnopharmacol* 1995;47:149-158.
- Jagetia GC, Baliga MS. *Syzygium cumini* (Jamun) reduces the radiation induced DNA damage in the cultured human peripheral blood lymphocytes: A preliminary study. *Toxicol Lett* 2002;132:19-25.
- Nadkarni KM. *Indian materia medica*. Bombay: Popular Prakashan Ltd. 1976.
- Morton J. *Jambolan*. In: Morton JF (Ed) *Fruits of warm climates*. 1987;375-378.
- Achrekar S, Kaklij GS, Pote MS, Kelkar SM. Hypoglycemic activity of *Eugenia jambolana* and *Ficus bengalensis*: Mechanism of action *In Vivo* 1991;5:143-147.
- Migliato KF. Standardization of the extract of *Syzygium cumini* (L.) skeels fruits through the antimicrobial activity. *Caderno de Farmacia* 2005;21(1):55-56.
- The Wealth of India, Council of Scientific and Industrial Research. New Delhi. 1954.
- Joshi SG. *Medicinal plants*. New Delhi: Oxford & IBH Publishing Co. 2001
- Kirtikar KR, Basu BD. *Indian Medicinal Plants*. Periodical Experts. New Delhi. 1975;2:1052-53.
- Ratsimamanga U. Native plants for our global village. *TWAS Newsltt* 1998;10:13-15.
- Vaishnava MM, Tripathy AK, Gupta KR. Flavonoid glycosides from roots of *Eugenia jambolana*. *Fitoterapia* 1992;63:259-260.
- Vaishnava MM, Gupta KR. Isorhamnetin 3-O-rutinoside from *Syzygium cumini* Lam. *J Indian Chem Soc* 1990;67:785-786.
- Rastogi RM, Mehrotra BN. *Compendium of Indian medicinal plants*. Lucknow India: Central Drug Research Institute 1990;1:388-389.
- Sagrawat H, Mann AS, Kharya MD. Pharmacological potential of *Eugenia jambolana*: A review. *Pharmacog Magazine* 2006;2:96-105.
- Sengupta P, Das PB. Terpenoids and Related compounds, Part IV Triterpenoids the stem –bark of *Eugenia jambolana* Lam. *Indian Chem Soc* 1965;42(4): 255-258.
- Bhargava KK, Dayar R, Seshadri TR. Chemical components of *Eugenia jambolana* stem bark. *Current Sci* 1974;43(20):645- 646.
- Kopanski L, Schnelle G. Isolation of Bergenin from Barks of *Syzygium cumini*. *Planta Med* 1988;54(6):572.
- Bhatia IS, Bajaj KL. Chemical constituents of the seeds and bark of *Syzygium cumini*. *Planta Med* 1975;28(4):346-52.
- Mir QY, Ali M, Alam P. Lignan derivatives from the stem bark of *Syzygium cumini* (L) Skeels. *Nat Prod Res* 2009;23(5):422-30.
- Mahmoud II, Marzouk MS, Moharram FA, El-Gindi MR, Hassan AM. Acylated flavonol glycosides from *Eugenia jambolana* leaves. *Phytochemistry* 2001;58:1239-1244.
- Gupta GS, Sharma DP. Triterpenoid and other constituents of *Eugenia jambolana* leaves. *Phytochemistry* 1974;13:2013-2014.
- Kumar A, Jayachandran T, Aravindan P, Deccaraman D, Ilavarasan R, Padmanabhan N. Neutral components in the leaves and seeds of *Syzygium cumini*. *African J Pharm Pharmacol* 2009;3(11):560-561.
- Shafi PM, Rosamma MK, Jamil K, Reddy PS. Antibacterial activity of *Syzygium cumini* and *Syzygium travancoricum* leaf essential oils. *Fitoterapia* 2002;73:414-416.
- Nair AR, Subramanian SS. Chemical examination of the flowers of *Eugenia jambolana*. *J Sci Industry Res* 1974;21B:457-458.
- Subramanian SS, Nair RAG. Flavonoids of the flowers of *Eugenia jambolana*. *Curr Sci* 1972;41:703-704.
- Veigas JM, Narayan MS, Laxman PM, Neelwarne B. Chemical nature, stability and bioefficacies of anthocyanins from fruit peel of *Syzygium cumini* Skeels. *Food Chem* 2007;105:619-627.
- Sharma B, Viswanath G, Salunke R, Roy P. Effects of flavonoid-rich extract from seeds of *Eugenia jambolana* (L.) on carbohydrate and lipid metabolism in diabetic mice. *Food Chem* 2008;110:697-705.
- Sharma B, Balomajumder C, Roy P. Hypoglycemic and hypolipidemic effects of flavonoid rich extract from *Eugenia jambolana* seeds on streptozotocin induced diabetic rats. *Food Chem Toxicol* 2008;46:2376-2383.
- Srivastava HC. Paper chromatography of fruit juices. *J Sci Ind Res* 1953;12B:363-365.
- Lewis YS, Dwarakanath CT, Johar DS. Acids and sugars in *Eugenia jambolana*. *J Sci Ind Res* 1956;15C:280-281.
- Jain MC, Seshadri TR. Anthocyanins of *Eugenia jambolana* fruits. *Indian J Chem* 1975;3: 20-23.
- Venkateswarlu G. On the nature of the colouring matter of the jambul fruit (*Eugenia jambolana*). *J Indian Chem Soc* 1952;29:434-437.
- Sharma JN, Sheshadri TR. Survey of anthocyanins from Indian sources Part II. *J Sci Ind Res* 1955;14:211-214.
- Noomrio MH, Dahot MU. Nutritive value of *Eugenia jambosa* fruit. *J Islamic Acad Sci* 1996;9:9-12.
- Paul DK, Shaha RK. Nutrients, vitamins and mineral content in common citrus fruits in the northern region of Bangladesh. *Pakistan J Bio Sci* 2004;7:238-242.
- Bobbio-adilma FO, Scamparini RP. Carbohydrates, organic acids and anthocyanin of *Eugenia jambolana* Lamarck. *Ind Aliment* 1982;21:296-298.
- Vernin G, Metzger J, Roque C, Pieribattesti JC. Volatile constituents of the jamrosa aroma *Syzygium jambos* L.aston from reunion island. *J Essent Oil Res* 1991;3:83-97.
- Nadkarni KM. *Indian Materia Medica*, Vol-I, Bombay popular prakashan, Bombay. 1944;516-518.
- The Wealth of India, Vol-X, CSIR, New Delhi. 1982;100-104.
- De Lima TCM, Klueger PA, Pereira PA, Macedo-Neto WP, Morato GS, Farias MR. Behavioural effects of crude and semi-purified extracts of *Syzygium cumini* Linn Skeels. *Phytother Res* 1998;12:488-493.

48. Martin TS, Ohtani K, Kasai R, Yamasaki K. Lignan glucoside from *Syzygium cumini*. *Natural Med* 1998;52:360-363.
49. Steinmetz EF. A botanical drug from the tropics used in the treatment of diabetes mellitus. *Acta Phytother* 1961;7:23-25.
50. Das S, Banerjee AK. Studies on *Syzygium cumini* seed oil. *J Oil Technol Ass India* 1995;27:243-244.
51. Daulatabad CMJD, Mirajkar AM, Hosamani KM, Mulla GMM. Epoxy and cyclopropenoid fatty acids in *Syzygium cumini* seed oil. *J Sci Food Agric* 1988;43:91-94.
52. Williamson EM. *Major Herbs of Ayurveda*. Churchill Livingstone, China. 2002;279-282.
53. Daisy P. A process for preparation of a novel compound 5,6-dihydroxy-3-[(4-hydroxy-6-(hydroxymethyl)-3,5-di {3,4,5-trihydroxy-6-(hydroxymethyl) tetrahydro-2h-2-pyranyl}oxy trtahydro-2h-2-pranyl oxy] -2methoxy-10,13-dimethylperhycyclopenta [aphenanthren-17-yl [phenyl]methyl acetate from *Syzygium cumini* (L.) skeels seeds with antibacterial and antidiabetic activity, Patent Application No.810/CHE/2007,2007.
54. Shankar MB, Parikh JR, Geetha M, Mehta RS, Saluja AK. Antidiabetic acitivity of novel androstone derivatives from *Syzygium cumini* Linn. *J Nat Remed* 2007;712:214-219.

Source of support: Nil, Conflict of interest: None Declared