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Jamun (*Syzygium cumini* L.), an Underutilized Fruit crop of India: An Overview

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ABSTRACT

Syzygium cumini L.is one of the widely used medicinal plants in the treatment of various diseases particularly on the diabetes. The present review has been primed to compile the existing information on the botany, phytochemical constituents, traditional uses and pharmacological applications of Jamun. The leaves are leathery, oblong- ovate to elliptic, 6 to 12 centimetres long. The panicles are borne mostly from the branchlets below the leaves, often bearing axillary or terminal and are 4 to 6 centimetres long. It is rich in compounds containing anthocyanins and the seeds contain alkaloids, jambosine, antimellin, which halts the diastic conversion of starch into sugar. The extracts from different parts of Jamun showed significant pharmacological actions. The major part of the fruit is water (80.80%), ash (0.70%), protein (0.81%). sugar (12.70%), acidity (0.63% as sulphuric and 0.88% as malic). Nanoparticles have been successfully synthesized using the leaf and plant extracts of jamun and also used as a potential candidate for bio-remediation and bio-control. Studies should also be undertaken to understand to which of the phytochemicals are responsible for the observed results and their mechanism of action. More attention should be given in popularising this underutilized fruit tree and its integration in the agro-forestry programmes.

Key words **:** *Jamun, Syzygium cumini, Antibacterial activity, Alkaloids, Underutilized fruit.*

Introduction

Syzygium genus, includes about 1200 species, is considered as the largest genus in the myrtle family (Myrtaceae) with some species economically important and widely cultivated for their edible fruits and medicinal properties (Parnell *et al*., 2007 & Byng *et al*., 2015). Among the economically important *Syzygium* species, *Syzygium cumini* L. (jambolana or jambul) is an Indo-Malaysian tree which is cultivated in many tropical and subtropical countries with a variety of uses, including food, timber, landscape, dye and medicine. It is an evergreen tropical tree in the flowering plant family Myrtaceae and large evergreen fruit tree in the Indian subcontinent. It is considered as one of the medicinally important fruit tree but still under explored indigenous fruit crop of India. It is a native to the Indian sub-continent and the adjoining regions of Southeast Asia, China and Queensland. The tree is rich in phenolic compounds especially, flavonoids, ligans, phenolic acids and tannins. Scientific studies revealed that various extracts of jambul showed significant biological actions especially antibacterial, antifungal, antiviral, antiallergic, anti-inflammatory, antidiarrheal, chemoprotective, anticancer, antioxidant and antidiabetic properties (Swami *et al*., 2012; Raju *et al*., 2014).

Nanoparticles have been successfully synthesized using the leaf and plant extract of jamun and

also used as a potential candidate for bioremediation and biocontrol. Despite of the great economic prospects and increasing the global demand in pharmaceutical industry, no comprehensive or consolidated information is available on various aspects of *S. cumini* (L.) in India. *Syzygium cumini* is also known as *Syzygium jambolanum* (Lam.) DC and *Eugenia cumini* (L) Druce. The other common names are Jamun, Jambul, Jambolan, Black Plum, Java Plum, Indian Blackberry, Jamblang, Portuguese plum, Malabar plum, Purple plum, Jamaica and Damson plum (Table 1). The tree yields fruits once in a year and the berries are sweetish sour to taste. The ripe fruits are used for health drinks, making preservatives, squashes, jellies and wine (Raju *et al*., 2014).

Table 1. Different vernacular names of *Syzygium cumini* L. around the globe and India.

Language	Names
Scientific names	*Syzygium cumini* L.
Name in various global languages	
French	Jamblon
German	Jambulbaum
English	Black plum
Name in various Indian languages	
Sanskrit	Jambu
Hindi	Jamun
Urdu	Jamun
Marathi	Jambul
Kannada	Narale
Telugu	Neredu
Malayalam	Njaval
Tamil	Nagai

History and distribution

S. cumini L. is one of the best known species and it is most commonly cultivated. The tree is known to grown in the Indian sub-continent especially India, Bangladesh, Burma, Nepal, Pakistan, Sri Lanka and Indonesia. It is planted near to Hindu Temples and considered as a sacred tree for Lord Krishna. The plant has been utilized as a fruit tree, ornamental and also for its timber.

Botany

Jamun is a large evergreen tree with greyish-brown thick bark with woody scales. The leaves are leathery, oblong- ovate to elliptical with 6 to 12 centimetres long. The panicles are borne mostly from the branchlets below the leaves, often bearing axillary or terminal and are 4 to 6 centimetres long. Flowers are scented, greenish-white, in clusters and are round or oblong in shape, found in dichotomous paniculate cymes. The calyx is funnel shaped, about 4 millimetres long and toothed. The petals cohere and fall together as a small disk. The stamens are numerous and as long as the calyx. The fruits are berries and are often oblong, 1.5 to 3.5 centimetres long, dark-purple or nearly black, fleshy with a single large seed. The fruit has a combination of sweet, mildly sour and astringent flavour and tends to colour the tongue purple (Singh *et al., 2019*; Patil *et al*., 2012).

Description

The trees of *S. cumini* are slow growing species, it can reach heights of upto 30 m and can live more than 100 years. Its dense foliage provides shade and is grown for its ornamental value. At the base of the tree, the bark is rough and dark grey to lighter grey and becoming smoother as the tree grown up. The leaves which have an aroma similar to turpentine, are pinkish when young, transforming to a leathery, glossy dark green with a yellow midrib as they mature. The leaves are used as food for livestock, as they have good nutritional value. *S cumini* trees start flowering from March to April. The flowers are fragrant and small, about 5 mm in diameter. The fruits develop by May or June and resemble large berries and are described as drupaceous. The fruit is oblong and ovoid. Unripe fruit looks green. As it matures, its colour changes to pink, then to shining crimson red and finally to black colour (Saurabh Singh *et al*., 2019; Anju Bajpai *et al.,* 2012).

There are about 400 to 500 species of which a few provide edible fruits. In India, jamun trees are found scattered throughout the tropical and subtropical regions, mainly as roadside avenues. It is valuable for reforestation programmes in arid and semiarid areas due to its ability to adapt to highly alkaline soils.

Taxonomic classification

Kingdom : Plantae—planta, plantes, plants, vegetal
Subkingdom : Tracheobionta
Superdivision : Spermatophyta
Division : Magnoliophyta
Class : Magnoliopsida
Order : Myrtales

Family : Myrtaceae
Genus : Syzygium
Species : *Syzygium cumini* L.

Composition of the fruit

The major part of the fruit is water (80.80%), ash (0.70%), protein (0.81%) and sugar (12.70%), acidity (0.63% as sulphuric and 0.88% as malic. The fruit also contains 8.30 - 15.00 mg of calcium, 35.00 mg of magnesium, 15.00 - 16.20 mg of phosphorus, 1.20 - 1.62 mg of iron, 26.20 mg of sodium, 55.00 mg of potassium, 0.23 mg of copper, 13.00 mg of sulfur, 8.00 mh of chlorine, 8. I.U of vitamin A, 0.01 - 0.03 mg of thiamine, 0.009 - 0.01 mg of riboflavin, 0.20 - 0.29 mg of niacin, 5.70 - 18.00 mg of ascorbic acid, 7.00 mg of chlorine and 3.00 mcg of folic acid per 100 g of edible portion (Patil*et al*., 2012).

Phytochemical constituents

Jambul is rich in compounds containing anthocyanins, glucoside, ellagic acid, isoquercetin, kaemferol and myricetin. The seeds contain alkaloid (jambosine) and glycoside (jambolin or antimellin) which halts the diastatic conversion of starch into sugar. The seeds also contain proteins, calcium, flavonoids and phenolics with significant antioxidant activity. Essential oils are also isolated from freshly collected leaf, stem, seed and fruits. The structure of phytochemicals (Fig.2), types of phytochemicals present (Table 3) and phytochemicals along with reported radio protective activities in jamun plant are presented in Table 4 (Swami *et al*., 2012).

Table 2. Description of flower morphology in Jamun plant

Character	Range
Breeding type	Bisexual
Flower colour	Creamish pale yellow
Inflorescence	Terminal and axillary
No. of flowers per inflorescence	18-50
Flower diameter (mm)	4-5
Length of stamen (mm)	5.87-7.88
No. of stamens (mm)	59-65
Anther size (mm)	0.6-07
Pollen grain	Tricolporate
Pollen shape	Triangular in dry, white circular when hydrated
Pollen size mm (hydrated)	15-20 mm (dry), 20
Pollen viability	90-94%
Length of style (mm)	8.2-8.37 mm
Width of gynoecium (mm)	3.1-3.5 mm
Anthesis	5.30-7.30 am and 4.00-7.00 pm
Anther dehiscence	5.30 am-9.30 am
Stigma receptivity	One day prior to anthesis and remained receptive upto 2 to 4 days after anthesis

Food uses

Good quality jambolan juice is excellent for sherbet, syrup and squash. In India, the bottled drink prepared by cooking the crushed fruits for 5 to 10 minutes at 140°F, pressing out the juice, combining it with sugar and water and adding citric acid and sodium benzoate as a preservative. Jambolans of good size and quality, having a sweet or sub acid flavor and a minimum of astringency, are enjoyable raw and may be made into tarts, sauces and jam (Patil *et al*., 2012).

Uses in traditional medicine

Traditionally the jambul fruits, leaves, seeds, and bark are all used in ayurvedic medicine. The bark contains tannins and carbohydrates, accounting for its long-term use as an astringent to combat ailments like dysentery. A glycoside in the seed (jamboline) is considered to have anti -diabetic properties. Jamun fruit seeds and pulp have been reported to serve various purposes in diabetic patients, such as lowering blood glucose levels and delaying diabetic complications, including neuropathy and cataracts. Jamun is most often recognized as an adjuvant therapy in type-2 diabetes (Swami *et al*., 2012).

Jamun seeds are reported to be a rich source of ellagitannins (ETs), including corilagin, 3,6-hexa hydroxyl diphenoyl glucose and its isomer 4,6-hexahydroxy diphenoyl glucose, 1- galloylglucose, 3-galloylglucose, gallic acid, and ellagic acid (EA). Jamun fruit reduces the sugar in the blood and is very good in the control of diabetes. Its seeds contain Glucoside, Jamboline and El-lagic acid, which are reported to have the ability to check the conversion of starch into sugar, in case of excess production of glucose. Various traditional practitioners in India use the different parts of the plant for treating diabetes, blisters in mouth, cancer, colic, diarrhea, digestive complaints, dysentry, piles, pimples and stomach ache (Benherlal and Arumughan, 2007: Chaudhary and Mukhopadhyay, 2012).

Jamun is most often recognized as an adjuvant therapy in type-2 diabetes. This has been traced not only to its anthocyanin-rich, dark-purple fleshy pulp, but also to its seeds, which have been most studied for their antidiabetic principles. When alloxan induced diabetic rats were fed with Jamun seed extract, the blood glucose, blood urea, serum cholesterol and serum triglyceride levels were found to decrease significantly. Jamun fruit reduces the sugar in the blood and is very good in the control of diabetes (Swami *et al*., 2012).

Medicinal properties

Jamun has promising theraupeutic value due to its various phyto-constituents and pharmacological properties. It is a good source of iron apart from being the source of other minerals, sugars and phytochemicals (Singh *et al*., 1967). The fruit is a rich source of anthocyanins, pectin, phenols and protein. Seed contains an alkaloid jambosin and aglycoside, jambolin or antimallin, which reduces or stop diastatic conversion of starch into sugars. The volatile oil from the jamun seeds can be extracted and used

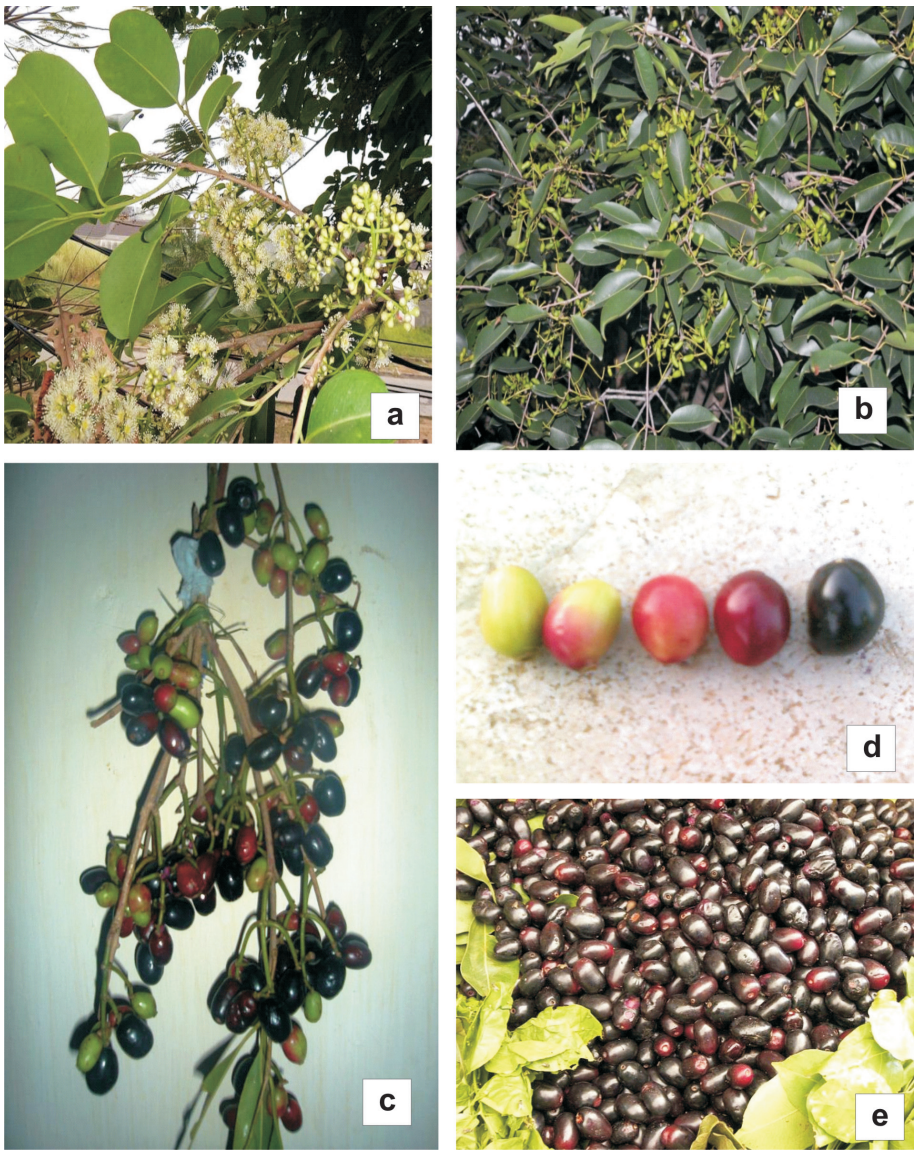

Fig. 1. Flowering to fruit ripening. a) Full bloom of panicle b) View of unripe fruits c) View of ripe and unripe fruits in the panicle d) Stages of fruit ripening e) View of ripe fruits.

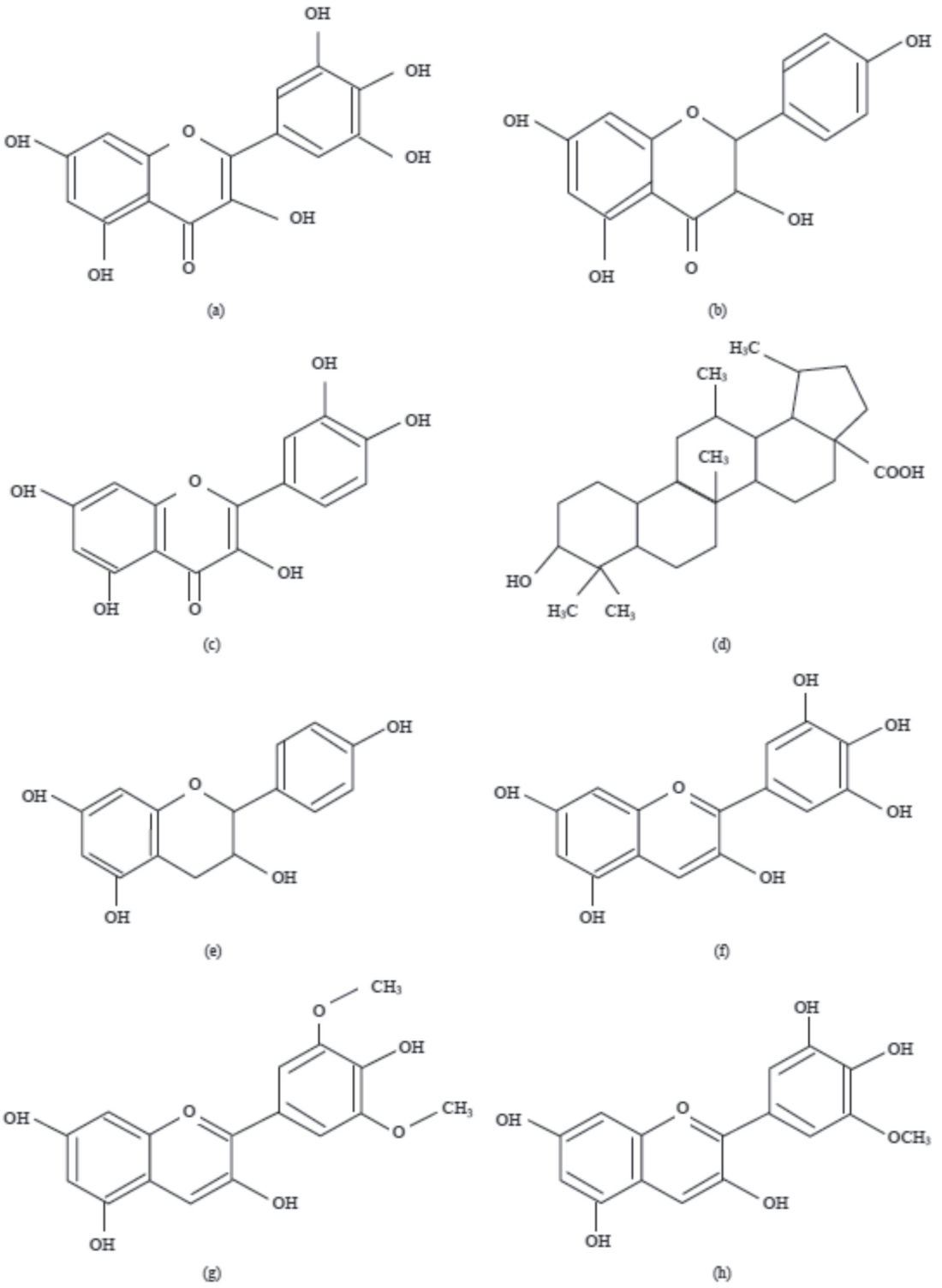

Fig. 2. Structures of phytochemicals in Jamun reported to be of use in the treatment of Cancer. (a) Myricetin; (b) Kaempherol; (c) Quercetin; (d) Betulinic; (e) Anthocyanin; (f) Delphinidin; (g) Malvidian; (h) Petunidin (Swami *et al.*, 2012).

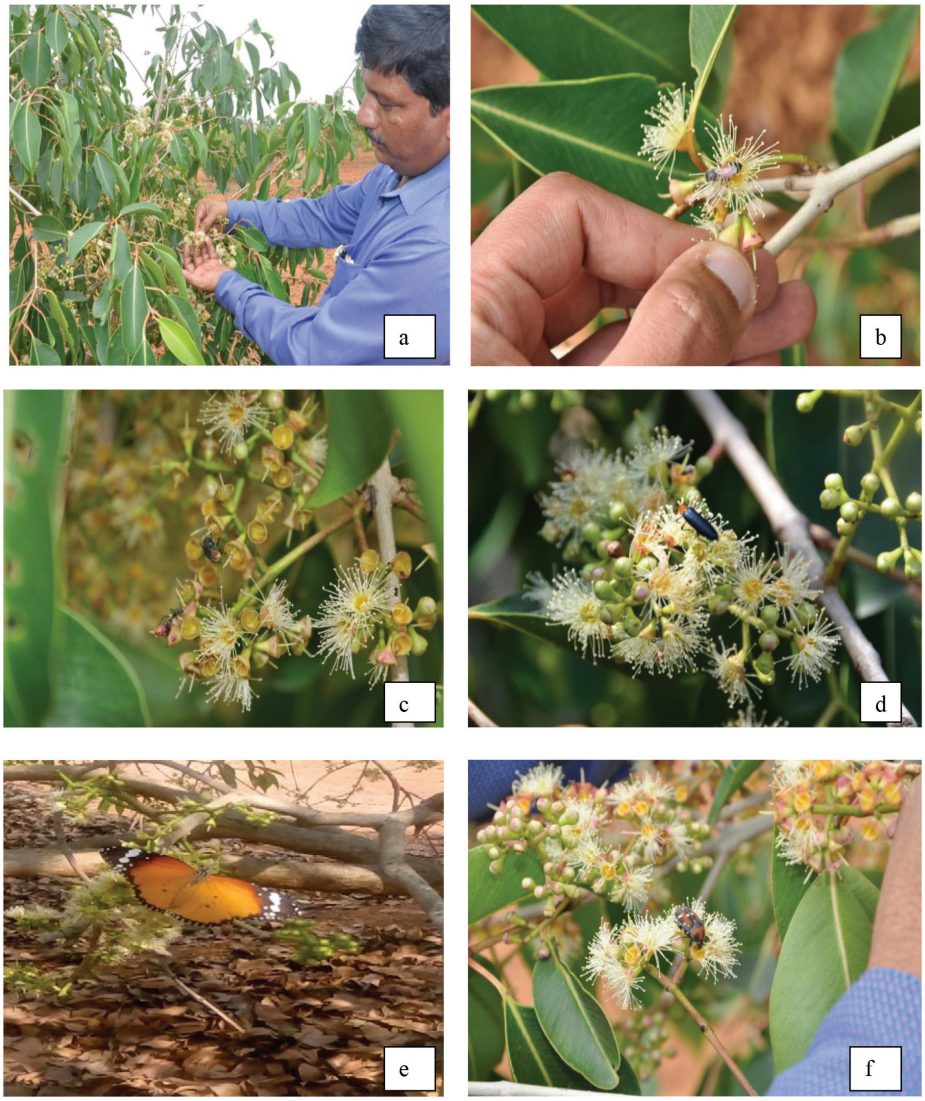

Fig. 3. Pollinators associated with *S. cumini* at flowering a) Recording of pollinator visitation b) *Apis florea* F. c) *Chrysomya sp.* d) *Cantheridaesp* e) *Danaus chrysippu* L .f) *Oxycetonia versicolor* F.

Table 3. Types of phytochemicals present in jamun plant.

Sl.No.	Plant part	Chemical present
1.	Seeds	Jambosine, gallic acid, ellagic acid, corilagin, 3 , 6 - hexahydroxy diphenoylglucose, 1-galloylglucose, 3-galloylglucose,quercetin, β-sitoterol, 4.6 hexahydroxydiphenoyglucose.
2.	Stem bark	Friedelin, friedelan 3 α -ol, betulinic acid, β-sitosterol, kaempferol, β-sitrosterol-Dglucoside, gallic acid, ellagic acid, gallotamin and ellagitanmin and myricetine
3.	Flower	Oleanolic acid, ellagic acids, isoquercetin, quercetin, kampferol and myricetin
4.	Fruit pulp	Anthocyanins, delphinidim, petunidin, malvidin-diglucosides
5.	Leaves	ß sitosterol, betulinic acid, mycaminose, crategolic, (maslimic) acid, n-hepatcosame, n-nonacosame, n-hentriaconrame, nactocosamol, n-triacontanol, n-dotricontanol, quercetin, myricetin, myricitrin and the flavonol glycosides myricetin 3-O-(4″-acetyle) α -Lrhamnopyranosides.
6.	Essential oils	α -terpeneol, myrtenol, eucarvone, muurolol, α-myrtenal, 1,8-cineole, geranyl acetone, α-cadinol and pinocarvone.

as an effective medicine against diabetes, heart and liver troubles. The antioxidant activity of jamun fruit has been attributed to its total phenolic compounds including anthocyanins. Glucose and fructose are the principal sugars in the ripe fruits, with no trace of sucrose. In recent years, jamun fruits are becoming popular due to their rich medicinal properties particularly for the antidiabetic properties. The medicinal value is due to the presence of malic acid, oxalic acid, gallic acid and tannins. The fruits are rich sources of anti-oxidant compounds, including flavonoids, phenolics, carotenoids and vitamins, which are all considered beneficial to human health, for decreasing the risk of degenerative diseases by reduction of oxidative stress and for the inhibition of macromolecular oxidation (Ayyanar and Subash-Babu, 2012).

Jamun timber is used for making furniture and agricultural implements. The plant tops are used to cure skin diseases as it has excellent anti-fungal properties. The leaves are used in the treatment of liver cirrhosis, hepatitis, infective hepatitis, liver enlargement, jaundice and other ailments of liver and gall bladder. Leaves fried in cow ghee are used as a curry to treat dry cough.

There is a very high anthocyanin content in *S. cumini* fruits which attributes to its antioxidant and free radical scavenging activity. These pigments can be a good source of natural food colourants for the food processing industries. Fruit bark decoction shows antiplasmodial activity. Plant steroids are known to be important for their cardiotonic activities and also possess insecticidal and antimicrobial properties. They are also used in nutrition, herbal medicine and cosmetics (Maren *et al*., 2014).

The juice of the ripe fruit, or a decoction of the fruit, or jambolan vinegar, may be administered in India in cases of enlargement of the spleen, chronic diarrhoea and urine retention. Water-diluted juice is used as a gargle for sore throat and as a lotion for ringworm of the scalp. Jambolan juice and mango juice, half and half, quench thirst in diabetics. Studies in the earlier decade have also shown that Jamun possess antineoplastic, radioprotective and chemopreventive effects all of which are useful in the prevention and treatment of cancer (Koley *et al*., 2011). The stages from flowering to fruit ripening are indicated in Fig. 1.

Phenology and pollination

Studies on reproductive biology which included phenology, pollination and breeding system is essential in jamun, which is of considerable socioeconomic importance. Knowledge of the phenology of a particular crop is important for its correct management. The period for panicle emergence was recorded from 3rd week of February and continued till 2nd week of March The tree canopy had 5-13

Table 4. Phytochemicals along with reported radio protective activities in jamun plant.

Sl.No.	**Agent**Phytochemicals	radio protective effects & the mechanisms operating
1.	Olenolic acid	1) Inhibits the growth of ascitic tumors and enhance the recovery of hematopoietic system in irradiated mice
2.	Quercetin	1) Protected yeast cells from γ -radiation damage by reducing DNA damage; 2) Effective in protecting against γ -radiation - induced DNA damage to the human peripheral blood lymphocytes in vitro (10^4, and plasmid DNA). The protective mechanisms were mediated by the antioxidant and inhibition of lipid peroxides 3) Intraperitoneal administration of quercetin 100 mg-kg/kg for 3 consecutive days before and/or after irradiation prevented radiation induced DNA damage in WBC of mice. Pronounced effects ere when querecetin was administered before radiation.
3.	Gallic acid	1) Inhibits radiation - induced damage to DNA and lipid peroxidation in both vitro and in vivo conditions
4.	Ellagic acid	1) Protects yeast cells from ã -radiation - Induced damages by reducing DNA damage 2) Inhibitsã -radiation induced lipid peroxidation in a concentration - dependent manner in vitro 3) Enhance the cytotoxic effect of radiation in nenoplastic cells (Ehrlich ascites ascities carcinoma and Hela) by inducing free radicals, reducing antioxidant enzymes and alternating the mitochondrial potential, but protects the normal cells (splenic lymphocytes) to tumor-bearing mice against the radiation damage.

panicles per shoot, having relation with the direction of shoot. The total flowering phase culminating in fruit set and ripening lasted for 119 to 126 days, with long phase of flower bud initiation and lasted 45-50 days. In jamun flowering panicles, large amount of pollen grains are released from numerous anthers. Pollens are tricolporate (triangular pattern in centre of grain), fertile and 15-20 µm in size, creamish-white in colour. Pollen is typically oblate and triangular in polar view. The pollen viability is about 90-94 per cent and the stigma receptivity is one day prior to anthesis, remained receptive upto 2 to 4 days after (Table 2) anthesis (Anju Bajapai *et al.*, 2012*).* The associated pollinators of *S. cumini* at flowering period are indicated in Fig. 3.

Conclusion

Jambul is widely used by the traditional medicinal systems for the treatment of various diseases especially diabetes and related complications. The effect of Jamun and its phytochemicals should also be investigated for its chemo preventive effects. Studies should also be undertaken on understanding which of the phytochemicals are responsible for the observed results and their mechanism of action. The plant is an important source of pharmaceutically active compounds and should be integrated into the agro forestry systems. More over the plant support a lot of pollinator as well as native bee fauna which should be studied in depth in future.

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