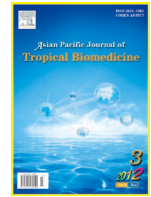




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## *Syzygium cumini* (L.) Skeels: A review of its phytochemical constituents and traditional uses

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## ABSTRACT

*Syzygium cumini* (*S. cumini*) (L.) Skeels (jambolan) is one of the widely used medicinal plants in the treatment of various diseases in particular diabetes. The present review has been primed to describe the existing data on the information on botany, phytochemical constituents, traditional uses and pharmacological actions of *S. cumini* (L.) Skeels (jambolan). Electronic database search was conducted with the search terms of *Eugenia jambolana*, *S. cumini*, jambolan, common plum and java plum. The plant has been viewed as an antidiabetic plant since it became commercially available several decades ago. During last four decades, numerous folk medicine and scientific reports on the antidiabetic effects of this plant have been cited in the literature. The plant is rich in compounds containing anthocyanins, glucoside, ellagic acid, isoquercetin, kaemferol and myrecetin. The seeds are claimed to contain alkaloid, jambosine, and glycoside jambolin or antimellin, which halts the diastatic conversion of starch into sugar. The vast number of literatures found in the database revealed that the extracts of different parts of jambolan showed significant pharmacological actions. We suggest that there is a need for further investigation to isolate active principles which confer the pharmacological action. Hence identification of such active compounds is useful for producing safer drugs in the treatment of various ailments including diabetes.

### 1. Introduction

The genus *Syzygium* is one of the genera of the myrtle family Myrtaceae which is native to the tropics, particularly to tropical America and Australia. It has a worldwide, although highly uneven, distribution in tropical and subtropical regions. The genus comprises about 1100 species, and has a native range that extends from Africa and Madagascar through southern Asia east through the Pacific. Its highest levels of diversity occur from Malaysia to northeastern Australia, where many species are very poorly known and many more have not been described taxonomically. Plants of this family are known to be rich in volatile oils which are reported for their uses in medicine<sup>[1]</sup> and many fruits of the family have a rich history of uses both as edibles and as traditional medicines in divergent

ethnobotanical practices throughout the tropical and subtropical world<sup>[2]</sup>. Some of the edible species of *Syzygium* are planted throughout the tropics worldwide.

### 2. History and distribution

*Syzygium cumini* (*S. cumini*) (L.) Skeels is one of the best known species and it is very often cultivated. The synonyms of *S. cumini* are *Eugenia jambolana* Lam., *Myrtus cumini* Linn., *Syzygium jambolana* DC., *Syzygium jambolanum* (Lam.) DC., *Eugenia djouant* Perr., *Calyptranthes jambolana* Willd., *Eugenia cumini* (Linn.) Druce. and *Eugenia caryophyllifolia* Lam. It is commonly known as jambolan, black plum, jamun, java plum, Indian blackberry, Portuguese plum, Malabar plum, purple plum, Jamaica and damson plum.

For long in the period of recorded history, the tree is known to have grown in the Indian sub-continent, and many others adjoin regions of South Asia such as India, Bangladesh, Burma, Nepal, Pakistan, Sri Lanka and Indonesia. It was long ago introduced into and became

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naturalized in Malaysia. In southern Asia, the tree is venerated by Buddhists, and it is commonly planted near Hindu temples because it is considered sacred to Lord Krishna<sup>[3]</sup>. The plant has also been introduced to many different places where it has been utilized as a fruit producer, as an ornamental and also for its timber. In India, the plant is available throughout the plains from the Himalayas to southern India.

### 3. Botany

Jambolan is a large evergreen and densely foliaceous tree with greyish–brown thick bark, exfoliating in woody scales. The wood is whitish, close grained and durable; affords brown dyes and a kind of a gum *Kino*. The leaves are leathery, oblong–ovate to elliptic or obovate–elliptic with 6 to 12 centimeters long (extremely variable in shape, smooth and shining with numerous nerves uniting within the margin), the tip being broad and less acuminate. The panicles are borne mostly from the branchlets below the leaves, often being axillary or terminal, and are 4 to 6 centimeters long. Flowers are scented, greenish–white, in clusters of just a few or 10 to 40 and are round or oblong in shape and found in dichotomous paniculate cymes. The calyx is funnel–shaped, about 4 millimeters long, and toothed. The petals cohere and fall all together as a small disk. The stamens are numerous and about as long as the calyx. Several types, which differ in colour and size of fruits, including some improved races bearing purple to violet or white coloured flesh and seedless fruits have been developed. The fruits are berries and are often obviously oblong, 1.5 to 3.5 centimeters long, dark–purple or nearly black, luscious, fleshy, and edible; it contains a single large seed<sup>[4,5]</sup>. The plant produces small purple plums, which have a very sweet flavor, turning slightly astringent on the edges of the pulp as the fruit becomes mature. The dark violet colored ripe fruits give the impression the fruit of the olive tree both in weight and shape and have an astringent taste<sup>[6]</sup>. The fruit has a combination of sweet, mildly sour and astringent flavour and tends to colour the tongue purple.

### 4. Phytochemical constituents

Jambolan is rich in compounds containing anthocyanins, glucoside, ellagic acid, isoquercetin, kaemferol and myrecetin. The seeds are claimed to contain alkaloid, jambosine, and glycoside jambolin or antimellin, which halts the diastatic conversion of starch into sugar and seed extract has lowered blood pressure by 34.6% and this action is attributed to the ellagic acid content<sup>[3]</sup>. The seeds have been reported to be rich in flavonoids, a well–known antioxidant, which accounts for the scavenging of free radicals and protective effect on antioxidant enzymes<sup>[7,8]</sup> and also found to have high total phenolics with significant antioxidant activity<sup>[9]</sup> and are fairly rich in protein and calcium. Java plums are rich in sugar, mineral salts, vitamins C, PP which

fortifies the beneficial effects of vitamin C, anthocyanins and flavonoids<sup>[10]</sup>.

#### 4.1. Leaves

The leaves are rich in acylated flavonol glycosides<sup>[1]</sup> (Figure 1A), quercetin, myricetin, myricitin, myricetin 3–O–4–acetyl–L–rhamnopyranoside<sup>[11]</sup> (Figure 1B), triterpenoids<sup>[12]</sup>, esterase, galloyl carboxylase<sup>[13]</sup>, and tannin<sup>[3]</sup>.

#### 4.2. Stem bark

The stem bark is rich in betulinic acid, friedelin, epi–friedelanol,  $\beta$ –sitosterol, eugenin and fatty acid ester of epi–friedelanol<sup>[14]</sup>,  $\beta$ –sitosterol, quercetin kaempferol, myricetin (Figure 1C and Figure 1D), gallic acid and ellagic acid<sup>[15]</sup>, bergenins<sup>[16]</sup>, flavonoids and tannins<sup>[17]</sup>. The presence of gallo– and ellagi–tannins may be responsible for the astringent property of stem bark.

#### 4.3. Flowers

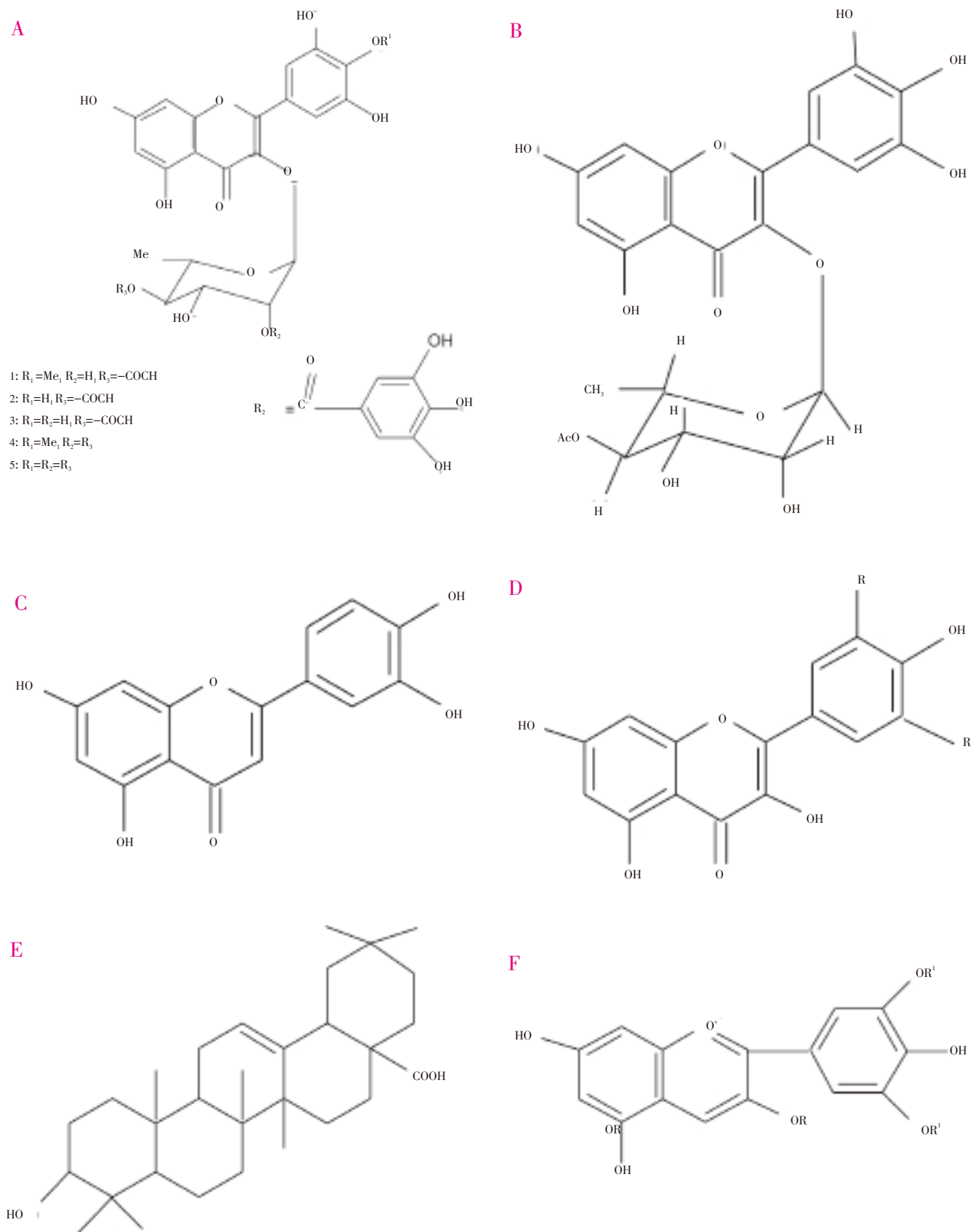
The flowers are rich in kaempferol, quercetin, myricetin, isoquercetin (quercetin–3–glucoside), myricetin–3–L–arabinoside, quercetin–3–D–galactoside, dihydromyricetin<sup>[18]</sup>, oleanolic acid (Figure 1E), acetyl oleanolic acid, eugenol–triterpenoid A and eugenol–triterpenoid B<sup>[18]</sup>.

#### 4.4. Roots

The roots are rich in flavonoid glycosides<sup>[19]</sup> and isorhamnetin 3–O–rutinoside<sup>[20]</sup>.

#### 4.5. Fruits

The fruits are rich in raffinose, glucose, fructose<sup>[21]</sup>, citric acid, mallic acid<sup>[22]</sup>, gallic acid, anthocyanins<sup>[23]</sup>; delphinidin–3–gentiobioside, malvidin–3–laminaribioside, petunidin–3–gentiobioside<sup>[24]</sup> (Figure 1F)<sup>[24]</sup>, cyanidin diglycoside, petunidin and malvidin<sup>[25]</sup>. The sourness of fruits may be due to presence of gallic acid. The color of the fruits might be due to the presence of anthocyanins<sup>[24]</sup>. The fruit contains 83.70–85.80 g moisture, 0.70–0.13 g protein, 0.15–0.30 g fat, 0.30–0.90 g crude fiber, 14.00 g carbohydrate, 0.32–0.40 g ash, 8.30–15.00 mg calcium, 35.00 mg magnesium, 15.00–16.20 mg phosphorus, 1.20–1.62 mg iron, 26.20 mg sodium, 55.00 mg potassium, 0.23 mg copper, 13.00 mg sulfur, 8.00 mg chlorine, 80 I.U. vitamin A, 0.01–0.03 mg thiamine, 0.009–0.01 mg riboflavin, 0.20–0.29 mg niacin, 5.70–18.00 mg ascorbic acid, 7.00 mg choline and 3.00 mcg folic acid per 100 g of edible portion<sup>[26]</sup>. One of the variety of jambolan found in the Brazil possesses malvidin–3–glucoside and petunidin–3–glucoside<sup>[27]</sup>. The peel powder of jambolan also can be employed as a colorant for foods and pharmaceuticals and anthocyanin pigments from fruit peels were studied for their antioxidant efficacy stability as extract and in formulations<sup>[28]</sup>.



**Figure 1.** Phytochemical constituents isolated from *S. cumini* (L.) Skeels.

A: Meamsetin 3-O-(400-O-acetyl)- $\alpha$ -L-rhamnopyranoside (1), myricetin 3-O-(400-O-acetyl-200-O-galloyl)- $\alpha$ -L-rhamnopyranoside (2), myricetin 3-O-(400-O-acetyl)- $\alpha$ -L-rhamnopyranoside (3), myricetin 40-methyl ether 3-O- $\alpha$ -L-rhamnopyranoside (4), myricetin (5); B: Myricetin 3-O-(4''-acetyl)- $\alpha$ -L-rhamnopyranoside; C: Quercetin; D: Kaempferol R=H; Myricetin R=OH; E: Oleanolic acid; F: Delphinidin-3-gentiobioside R = Gentiobiose, R' = H; Malvidine 3-laminaribioside R = Laminaribiose R' = Me.

#### 4.6. Essential oils

The essential oils isolated from the freshly collected leaf (accounting for 82% of the oil)<sup>[29]</sup>, stem, seed, fruits contain  $\alpha$ -Pinene, camphene,  $\beta$ -Pinene, myrcene, limonene, cis-Ocimene, trans-Ocimene,  $\gamma$ -Terpinene, terpinolene, bornyl acetate,  $\alpha$ -Copaene,  $\beta$ -Caryophyllene,  $\alpha$ -Humulene,  $\gamma$ -Cadinene and  $\delta$ -Cadinene<sup>[6]</sup>, trans-ocimene, cis-ocimene,  $\beta$ -myrcene,  $\alpha$ -terpineol, dihydrocarvyl acetate, geranyl butyrate, terpinyl valerate<sup>[30]</sup>,  $\alpha$ -terpineol,  $\beta$ -caryophyllene,  $\alpha$ -humulene,  $\beta$ -selinene, calacorene,  $\alpha$ -muurolol,  $\alpha$ -santalol, cis-farnesol: lauric, myristic, palmitic, stearic, oleic, linoleic, malvalic, sterculic and vernolic acids<sup>[31]</sup>. Unsaponifiable matter of the seed fat was also chemically investigated<sup>[32]</sup>.

#### 5. Medicinal properties

The bark is acrid, sweet, digestive, astringent to the bowels, anthelmintic and used for the treatment of sore throat, bronchitis, asthma, thirst, biliousness, dysentery and ulcers. It is also a good blood purifier. The fruit is acrid, sweet, cooling and astringent to the bowels and removes bad smell from mouth, biliousness, stomachic, astringent, diuretic and antidiabetic<sup>[33]</sup>. The fruit has a very long history of use for various medicinal purposes and currently has a large market for the treatment of chronic diarrhea and other enteric disorders<sup>[28]</sup>. The seed is sweet, astringent to the bowels and good for diabetes. The ash of the leaves is used for strengthening the teeth and gums. Vinegar prepared from the juice of the ripe fruit is an agreeable stomachic and carminative and used as diuretic<sup>[34]</sup> and it is also useful in spleen enlargement and an efficient astringent in chronic diarrhea.

Juice of tender leaves of this plant, leaves of mango and myrobalan are mixed and administered along with goat's milk and honey to treat dysentery with bloody discharge, whereas juice of tender leaves alone or in combination with carminatives such as cardamom or cinnamon is given in goat's milk to treat diarrhoea in children<sup>[33]</sup>. Traditional medical healers in Madagascar have been using the seeds of jambolan for generations as the centerpiece of an effective therapy for counteracting the slow debilitating impacts of diabetes<sup>[35]</sup>. The seed extract is used to treat cold, cough, fever and skin problems such as rashes and the mouth, throat, intestines and genitourinary tract ulcers (infected by *Candida albicans*) by the villagers of Tamil Nadu<sup>[36]</sup>. Jambolan fruit can be eaten raw and can be made into tarts, sauces and jams. Good quality jambolan juice is excellent for sherbet, syrup and "squash", an Indian drink.

#### 6. Uses in traditional medicine

All parts of the jambolan can be used medicinally and it has a long tradition in alternative medicine. From all over the world, the fruits have been used for a wide variety of ailments, including cough, diabetes, dysentery, inflammation and ringworm<sup>[2]</sup>. It is also an ancient medicinal plant with an illustrious medical history and has been the subject of classical reviews for over 100 years. It is widely distributed throughout India and ayurvedic medicine (Indian folk medicine) mentions its use for the treatment

of diabetes mellitus. Various traditional practitioners in India use the different parts of the plant in the treatment of diabetes, blisters in mouth, cancer, colic, diarrhea, digestive complaints, dysentery, piles, pimples and stomachache<sup>[37]</sup>. During last four decades, numerous folk medicinal reports on the antidiabetic effects of this plant have been cited in the literature (Table 1). In Unani medicine various parts of jambolan act as liver tonic, enrich blood, strengthen teeth and gums and form good lotion for removing ringworm infection of the head<sup>[38]</sup>.

The plant has been viewed as an antidiabetic plant since it became commercially available several decades ago. In the early 1960s to 1970s, some preliminary reports on the antidiabetic activity of different parts of jambolan in diabetic animals were reported. Most of these studies have been conducted using crude preparation of the plant without pointing out their chemical profile and antidiabetic action in animals is not fully understood. A number of herbal formulations were also prepared in combination with this plant available in market which showed potential antidiabetic activity and are used regularly by diabetic patients on the advice of the physicians. Different parts of the jambolan were also reported for its antioxidant, anti-inflammatory, neuropsychopharmacological, antimicrobial, anti-bacterial, anti-HIV, antileishmanial and antifungal, nitric oxide scavenging, free radical scavenging, anti-diarrheal, antifertility, anorexigenic, gastroprotective and anti-ulcerogenic and radioprotective activities<sup>[38]</sup>.

#### 7. Pharmacological actions of jambolan

Different parts of the jambolan especially fruits, seeds and stem bark possess promising activity against diabetes mellitus and it has been confirmed by several experimental and clinical studies. In the early 1960s to 1970s, Chirvan-Nia and Ratsimamanga<sup>[39]</sup>, Sigogneau-Jagodzinski *et al*<sup>[40]</sup>, Lal and Choudhuri<sup>[41]</sup>, Shrotri *et al*<sup>[42]</sup>, Bose and Sephal<sup>[43]</sup> and Vaish<sup>[44]</sup> reported the antidiabetic activity of various parts of jambolan in diabetic animals. Tea prepared from leaves of jambolan was reported to have antihyperglycemic effect<sup>[45]</sup>. The stem bark of the plant could induce the appearance of positive insulin staining cells in the epithelia of the pancreatic duct of treated animals<sup>[46]</sup> and a significant decrease in blood glucose levels was also observed in mice treated with the stem bark by oral glucose tolerance test<sup>[47]</sup>. Many clinical and experimental studies suggest that, different parts of the jambolan especially fruits and seeds possess promising activity against diabetes mellitus<sup>[7,48–53]</sup>.

Despite tremendous advancements have been made in the field of diabetic treatments, several earlier investigations have been reported from the different parts of jambolan with antioxidant<sup>[54,55]</sup>, anti-inflammatory<sup>[56–58]</sup>, neuropsychopharmacological<sup>[59]</sup>, anti-microbial<sup>[36]</sup>, anti-bacterial<sup>[60–62]</sup>, anti-HIV<sup>[63]</sup>, antileishmanial and antifungal<sup>[64]</sup>, nitric oxide scavenging<sup>[65]</sup>, free radical scavenging<sup>[66]</sup>, anti-diarrheal<sup>[67]</sup>, antifertility<sup>[68]</sup>, anorexigenic<sup>[69]</sup>, gastroprotective and anti-ulcerogenic<sup>[70]</sup>, behavioural effects<sup>[71]</sup> and radioprotective<sup>[72]</sup> activities. Besides the above, the effect of various concentrations of the leaf extracts of the plant on the radiation-induced micronuclei formation was studied by Jagetia and Baliga<sup>[73]</sup>.

**Table 1**Folk medicinal uses of *S. cumini* (L.) Skeels.

| Ethnic group used and their origin                         | Plant part used, mode of preparation, administration and ailments treated  | References |
|--|--|------------|
| Local people in southern Brazil                            | Either infusions or decoctions of leaves of jambolan in water at an average concentration of 2.5 g/L and drank it in place of water at a mean daily intake of about 1 liter are used in the treatment of diabetes.   | [74]       |
| Lakher and Pawi in North east India                        | Infusion of fruit or mixture of powdered bark and fruit is given orally to treat diabetes.<br>Juice obtained from the seeds is applied externally on sores and ulcers.<br>Powdered seeds are mixed with sugar are given orally 2–3 times daily in the treatment of dysentery.<br>The juice of leaves is given orally as antidote in opium poisoning and in centipede bite.<br>The juice of ripe fruits is stored for 3 days and then is given orally for gastric problems.<br>The juice obtained from the bark is given orally for the treatment of women with a history of repeated abortion. | [75]       |
| Local informants in Maharashtra, India                     | Fruit and stem bark are used in the treatment of diabetes, dysentery, increases appetite and to relieve from headache  | [76]       |
| Nepalese, Lepchas and Bhutias in northeast India           | Decoction of stem bark is taken orally three times a day for 2–3 weeks to treat diabetes   | [77]       |
| Native amerindians and Quilombolas in North eastern Brazil | Leaves are used in the treatment of diabetes and renal problems.   | [78]       |
| Kani tribals in Southern India                             | Two teaspoon of juice extracted from the leaf is mixed with honey or cow's milk and taken orally taken twice a day after food for 3 months to treat diabetes. Fresh fruits are also taken orally to get relief from stomachache and to treat diabetes.<br>Young leaf is ground into a paste with goat's milk and taken orally to treat indigestion.  | [79]       |
| Malayalis in South India                                   | Paste of seeds is prepared with the combination of leaves of <i>Momordica charantia</i> and flowers of <i>Cassia auriculata</i> and taken orally once a day for 3 months to treat diabetes.  | [80]       |
| Traditional medical healers in Madagascar                  | Seeds are taken orally for generations as the centerpiece of an effective therapy for counteracting the slow debilitating impacts of diabetes.   | [35]       |
| Local population in Andhra Pradesh, India                  | Shade dried seeds are made into powder and taken orally thrice a day in the treatment of diabetes.   | [81]       |
| Siddis in Karnataka, India                                 | The juice obtained from the leaves is mixed with milk and taken orally early in the morning, to treat diabetes.<br>The juice obtained from the stem bark is mixed with butter milk and taken orally every day before going to bed to treat constipation. The same recipe, when taken early in the morning on an empty stomach, is claimed to stop blood discharge in the faeces.   | [82]       |
| Rural population in Brazil                                 | Leaves of jambolan are taken orally in the treatment of diabetes.  | [64]       |
| Traditional healers in Brazil                              | Tea prepared from the infusion or decoction of leaves is taken orally to treat diabetes.   | [83]       |
| Tribal people in Maharashtra                               | The tender leaves are taken orally to treat jaundice. It was claimed that the eyes, nails and urine turned yellow. The treatment was followed for 2–3 days by adults and children as well.   | [84]       |

## 8. Conclusions

Jambolan is widely used by the traditional healers for the treatment of various diseases especially diabetes and related complications. The plant has many important compounds which confer the most of the characteristics of the plant. Most pharmacological works on diabetes were carried out with seeds but the pharmacological potential of the other parts of the plant is required to explore in detail. Similarly, not many works are there with pharmacological actions of

phytochemical constituents of jambolan. Based on these facts, the authors hope that this review highlights the role of jambolan in various treatments and recommend that further phytochemical and clinical research should be done on this traditional medicinal plant for the discovery of safer drugs.

## Conflict of interest statement

We declare that we have no conflict of interest.

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