IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

A Review on Jamun (Syzygium Cumini) Seeds: An Unexplored Source For Novel Herbal Drug Delivery System In Diabetes Management

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Abstract:

Jamun (Syzygium cumini) seeds are an unexplored natural resource rich in bioactive compounds such as polyphenols, flavonoids, saponins, and glycosides. Often discarded as waste during fruit processing, these seeds possess significant antioxidant, anti-diabetic, antiinflammatory, and anti-hyperlipidemic properties.

They are also a good source of essential nutrients including carbohydrates, proteins, lipids, minerals, and vitamins, making them suitable for use in functional and therapeutic food formulations. This project aims to explore the phytochemical profile, medicinal benefits, and nutritional potential of jamun seeds, along with evaluating their safety and acceptable intake levels. Utilizing jamun seed waste not only supports the development of value-added nutraceutical and pharmaceutical products but also promotes sustainable resource management.

Diabetes mellitus (DM) is an endocrinal disorder characterized by chronic hyperglycemia. Managing DM without side effects is a challenge till date that attracts researchers toward plantbased new products. In some studies, seeds of Syzygium cumini were found to have antidiabetic and anti-hyperlipidemic properties, attributed to saponins, glycosides, and flavonoids. Hence, it should be further explored for its benefits.

Keywords: Syzygium cumini seeds, flavonoids, anti-diabetic activity, hypoglycemic effect,Agro-waste management, Natural health supplements, dietary fibre.

Introduction to Novel Drug Delivery Systems (NDDS):

A novel drug delivery system (NDDS) refers to the advanced methods or techniques developed to deliver drugs in a controlled, targeted, and efficient manner.[1] Unlike conventional drug delivery where drugs are simply administered through tablets, capsules, injections, NDDS ensures that the drug reaches the right site at the right time and in the right concentration to achieve the desired therapeutic effect.

The main goal of NDDS is to improve the bioavailability, stability, and patient compliance of drugs while reducing side effects and dosing frequency. It transforms traditional dosage forms into smart systems capable of releasing the drug in a sustained or controlled manner. [2]

Common novel systems include liposomes, niosomes, phytosomes, nanoparticles, microspheres, transdermal patches, and microemulsions.[3] These systems protect the drug from degradation and enhance its absorption at the target site Novel drug delivery systems are not just carriers – they are intelligent vehicles that revolutionize how medicines interact with the human body, turning ordinary drugs into extraordinary therapies.

In the modern era of pharmaceutical science, NDDS bridges the gap between discovery and delivery, ensuring that innovation truly reaches the patient.

Role & Use of Herbal Plants in NDDS:

- The integration of herbal medicines with novel drug delivery systems brings together the wisdom of nature and the innovation of modern science.
- NDDS stands for novel drug delivery systems, which are advanced techniques for delivering drugs to achieve better efficacy, safety, and patient compliance than traditional dosage forms (tablets & capsules).
- Herbal seeds are also being explored in NDDS because they offer natural, biodegradable, and biocompatible materials for controlled and targeted drug delivery.
- Herbal plants are rich sources of bioactive compounds that have strong therapeutic effects, but often face problems like poor solubility, low bioavailability, and fast

metabolism. [4] To overcome these issues, the NDDS approach is used (liposome, phytosome, nanoparticle, microsphere).

• NDDS helps in protecting herbal drugs, improving absorption, controlling release, and targeting specific sites, making herbal medicines more effective and reliable it combines the power of nature with the technology of modern science. [5]

Introduction:

The jamun fruitSyzygium cumini (L.)(Synonyms: Myrtus cumini, Calyptranthes jambolana, Syzygium jambolanum, Eugenia jambolana, Eugenia cumini) belonging to the Myrtaceae family [06] is a highly perishable fruit with a very short shelf life of 1–2 days under normal conditions. It is also called as jambul, black plum, java plum, jambolan, jiwat, salam, kerian duat, and Indian blackberry . The jamun fruit is processed by industries into value-added products such as jam, wine, juice, and jellies. However, only the pulp is utilized during processing, therefore the remaining seeds and skin are discarded. As a byproduct of processing, seeds are primarily discarded. Because they account for 10–47% of the total mass of the fruit, their quantity is substantial. [07]

The generated waste causes problems for the industry and for the environment, but on the other hand, it has become a challenge for scientists. Jamun fruit waste has the potential to become a valuable byproduct and open up avenues for the scientific and research community to assist industry and farmers in generating revenue.

Fig.1 Jamun fruit

Increasing environmental concerns and government policies for waste disposal have resulted i extra financial burden to the fruit processing industries. Hence, researchers are now exploring alternative ways to utilize wastes generated from processing industries.Jamun (Syzygium cumini), commonly known as Indian blackberry or black plum, is a fruit-bearing tree widely grown across tropical and subtropical regions of Asia. The fruit is valued for its refreshing taste and nutritional richness, and it is extensively used in the preparation of juices, jellies, jams, squashes, fermented beverages, and traditional medicinal formulations. During the industrial and household processing of jamun fruits, the seeds are usually

discarded as waste, resulting in a significant amount of underutilized biomass. However, recent scientific interest has revealed that jamun seeds possess remarkable nutraceutical and therapeutic potential, making them an important yet untapped natural resource.

Jamun seeds are rich in a variety of bioactive compounds, including polyphenols, flavonoids, alkaloids, essential oils, glycosides, tannins, gallic acid, ellagic acid, and important micronutrients. [8] These components are known to exhibit several medicinal properties, such as anti-diabetic, antioxidant, anti-inflammatory, antimicrobial, anticancer, cardioprotective, and hepatoprotective activities. [9] Traditionally, jamun seeds have been used in Ayurvedic and

Unani medicine to manage diabetes, digestive disorders, and skin ailments. The presence of jamboline and jambosine—two unique alkaloids—helps regulate blood glucose levels, which makes jamun seeds particularly effective for diabetes management. [10]

Table 1 Food value per 100 g of edible portion of Jamun fruit (Nath *et al.* 2008).

Nutrient	Food value	Nutrient	Food value
Moisture	83.7–85.8g	Potassium	55mg
Protein	0.7–0.129g	Copper	0.23mg
Fat	0.15–0.3g	Sulfur	13mg
Crude Fiber	0.3–0.9g	Chlorine	8mg
Carbohydrates	14.0g	Vitamin A	80I.U.
Ash	0.32–0.4g	Thiamine	0.008–0.03mg
Calcium	8.3–15mg	Riboflavin	0.009–0.01mg
Magnesium	35mg	Niacin	0.2–0.29mg
Phosphorus	15–16.2mg	Ascorbic Acid	5.7–18mg
Iron	1.2–1.62mg	Choline	7mg
Sodium	26.2mg	Folic Acid	3mg

In addition to their medicinal benefits, jamun seeds show potential for value-added applications in various industries. They can be used to develop nutraceutical supplements, herbal formulations, functional foods, natural colorants, and bioactive powders. Recent research also highlights their suitability in pharmaceutical formulations, as well as their use as natural antioxidants for food preservation. Despite this wide potential, the seeds remain largely unexplored in commercial use due to lack of awareness, limited research, and inadequate technological development. Exploring the phytochemical composition, health benefits, and industrial applications of jamun seeds can contribute to waste reduction, economic value creation, and the promotion of sustainable utilization of natural resources. Therefore, this project focuses on understanding the nutritional, medicinal, and commercial significance of jamun seeds, aiming to highlight their role as an underexploited yet promising natural resource for future scientific and industrial advancement.[11]

Complete Information on Jamun Plant (Syzygium cumini):

Fig.2. Jamun Plant

1.Introduction:

Jamun (Syzygium cumini), commonly known as Indian blackberry or Java plum, is a tropical evergreen fruit-bearing tree belonging to the Myrtaceae family. It is widely distributed across India and other Southeast Asian countries. The plant is known not only for its delicious purple fruits but also for its significant medicinal, nutritional, and economic value. Almost

every part of the Jamun plant—including its fruit, leaves, bark, and seeds—holds great therapeutic importance and is extensively used in traditional medicine systems such as Ayurveda, Unani, and Siddha

2.Classification / Taxonomy:

- Kingdom: Plantae
- Order: Myrtales
- Family: Myrtaceae
- Genus: Syzygium • Species: Syzygium ccumini

3.Botanical Description:

a. Tree

Jamun is a large, evergreen tree that grows 10–30 meters tall and can live for more than a hundred years. It has a dense canopy, giving it an ideal shade-giving nature.

b. Leaves

- Simple, glossy, leathery, and oblong
- Dark green with a characteristic aroma due to essential oils
- Oppositely arranged

c. Flowers

- Small, greenish-white
- Mildly aromatic • Found in clusters

d. Fruits

- Oval to oblong berries
- Initially green → turn pink → deep purple → black
- Taste: sweet, slightly acidic, and astringent
- Contains one single seed [13]

4. Habitat and Distribution:

- Native to India, Sri Lanka, and Southeast Asia
- Grows best in tropical and subtropical climates
- Thrives in sunny places and well-drained loamy soil

Tolerant to water-logging, making it a hardy plant Commonly found along roadsides, fields, farms, and riverbanks

5. Propagation and Cultivation:

- Propagation Methods
- Seeds (most common)
- Grafting for improved varieties
- Growing Requirements
- Climate: Warm, humid

- Soil: Rich loamy or alluvial soil
- Water: Moderate; can resist drought
- Fertilizers: Organic manure enhances growth

6. Nutritional Value of Jamun Fruit (per 100g):

Nutrient	Amount
Energy	60-70 kcal
Carbohydrates	14-18 g
Fibre	0.5-1 g
Protein	0.7 g
Fat	0.2 g
Calcium	15-20 mg
Iron	1-1.5 mg
Vitamin C	18-25 mg
Potassium	50-70 mg

- Anthocyanins Present (gives purple color) [14]

7. Medicinal Properties:

- Jamun and its various parts have numerous bioactive compounds such as flavonoids, polyphenols, jamboline, ellagic acid, and essential oils.

- Medicinal Actions
- Anti-diabetic
- Antioxidant
- Anti-inflammatory
- Antimicrobial
- Hepato-protective
- Cardio-protective [15]

8. Uses of Different Plant Parts:

✔ Fruit:- • Eaten fresh

- Used to make juice, jam, jelly, squash, wine, and vinegar
- Rich in antioxidants

✔ Seeds:-

- Most important part medicinally
- Used in diabetes management
- Powder used in capsules, tablets, Ayurvedic medicines

✔ Leaves:-

- Used in herbal medicines
- Anti-inflammatory and antioxidant

✔ Bark:- • Astringent

- Used in diarrhea and dysentery treatments

✔ Wood:-

- Strong and resistant
- Used in making furniture, agricultural tools, and railway sleepers

9. Phytochemical Composition (Bioactive Compounds):

- Jamun seeds and fruits contain:
- Flavonoids
- Phenolic acids
- Tannins
- Alkaloids Anthocyanins

Jamboline

- Ellagic acid These compounds are responsible for antihyperglycemic, antioxidant, and therapeutic effects. [16]

10. Economic Importance:

- Fruits used in food processing industries
- Seeds used in pharmaceutical formulations
- Wood used in construction and furniture
- Increasing demand in herbal medicine market

11. Ecological Importance:

- Jamun is a long-lived evergreen tree
- Helps in soil conservation
- Provides shade and habitat for birds
- Helps purify air due to dense foliage

Jamun seeds used in diabetes management:

Diabetes mellitus is a complex metabolic disorder caused by insufficient insulin secretion or insulin dysfunction, leading to disturbances in carbohydrate, fat, and protein metabolism. It is mainly of two types: **Type I (insulin - dependent)** and **Type II (non - insulin- dependent)**, with Type II accounting for nearly 90% of cases. The disease is a major global health concern and a leading cause of mortality. The worldwide prevalence of diabetes was 2.8% in 2000 and is projected to rise to 4.4% by 2030. In India, diabetic patients are expected to increase from **31.7 million** (2000) to **79.4 million** by 2030. [17]

Although the exact pathophysiology of diabetes is not fully understood, oxidative stress, free radicals, and abnormalities in lipid metabolism are known to contribute to its complications.

Historically, diabetes has been described in ancient Greek, Arabic , and Unani literature. Scholars like **Ibn Sina** and **Zakariya Razi** recognized excessive urination, thirst, and weakness of kidneys and liver as key features of the disease.

In the **Unani System of Medicine** , several single herbs are used for diabetes manageme nt, including Gymnema sylvestre, Azadirachta indica, Tinospora cordifolia ,

and Syzygium cumini (Jamun). Among these, **Jamun (Syzygium cumini Linn.)** is widely used for its strong antidiabetic properties. Its fruits and seeds are traditionally included in

[18] formulations that help lower blood glucose levels and manage diabetic complications.

Fig.3. Jamun seed and powder

Jamun is a widely distributed medicinal tree in India. It bears purple, grape-like fruits annually, which are used for preparing jellies, beverages, and herbal medicines. The seeds contain a potent kernel that retains medicinal value for up to two years. All parts of the tree—**fruits, seeds, Leaves, and bark—**are valued in Unani medicine for their therapeutic benefits, especially in diabetes

Jamun has been traditionally used in Ayurveda for over 130 years to manage high blood sugar levels,[19] especially through its seed powder. Clinical evidence in humans shows mixed results—some patients respond well with reduced blood sugar, while others show no improvement.

Preclinical studies (mostly on animals) provide stronger support. Various extracts of Jamun seeds—aqueous, ethanol, methanol, and lyophilized forms—have demonstrated significant hypoglycaemic effects in diabetic models such as alloxan- and streptozotocin-induced rats, mice, and rabbits. These extracts were shown to:

- Lower fasting blood glucose [20]
- Improve glucose tolerance [21]
- Restore antioxidant enzymes (catalase, GPx, SOD) [22]
- Increase liver and kidney glutathione levels [23]
- Regulate metabolic proteins like PPARα and PPARγ [24]

However, some studies reported no improvement, especially when extracts lacked gummy fibres, suggesting that active components vary by preparation. [25]

Overall, while results are mixed in humans, the majority of preclinical evidence supports Jamun seeds' potential in lowering blood sugar and improving diabetic oxidative stress.

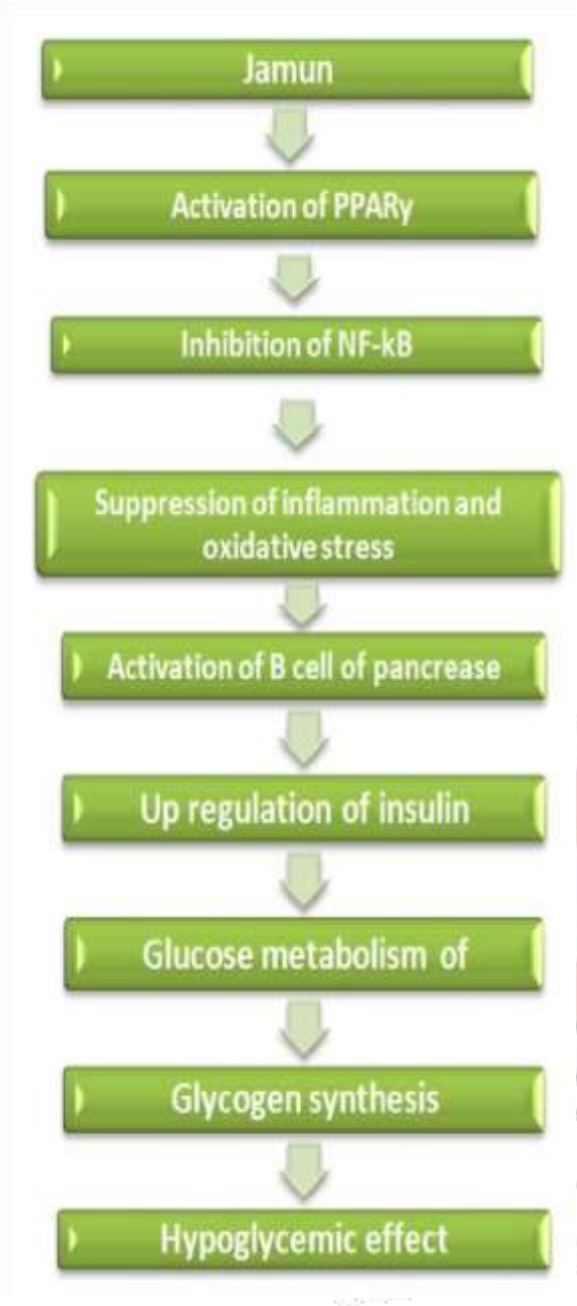
Table 1 The hypoglycaemic effect of different extracts of jamun, *Syzygium cumini* in preclinical and clinical setting

S. No.	Parts used	Extract type	Species	Reference
1	Seed	Aqueous	Rabbit Rat Mice	16 15, 17-20,23,24,34
		Powder	Humans	22,35 36,39,40
		Ethanol	Rat & Rabbit Humans	25-28,31-33 38
		Ethyl acetate Methanol	Rat and mice	29,30,37
2	Fruit	Aqueous	Rat	41-43
		Methanol		44
3	Stem	Ethanol	Rat	37,45,46
4	Leaf	Aqueous	Humans	47
		Ethanol	Rat	48

Several studies show that Jamun fruit pulp also helps reduce blood sugar in diabetic animal models, though results vary. In one Brazilian study, lyophilized fruit pulp extract did not lower blood glucose in streptozotocin-induced diabetic rats. However, other studies found that aqueous and ethanol extracts of Jamun fruit pulp did reduce blood sugar in alloxaninduced diabetic rats, with the aqueous extract being more effective. [26]

In female Wistar rats with streptozotocin-induced diabetes, the aqueous fruit pulp extract lowered serum glucose, and its combination with Cinnamon bark extract produced even stronger antidiabetic effects. More recent research also shows that methanol extracts prepared from different parts of the fruit (pulp, seed, seed coat, and kernel) demonstrate significant antidiabetic activity. [27]

Mechanism of action



Antidiabetic effect of jamun

✞ **Anti-inflammatory activity:**

The anti-inflammatory efficacy of an ethanolic extract of S.cumini bark was studied by Muruganandan et.al. Mice at doses ranging from 10–125 µg/kg.i.p. showed no signs of toxicity to extract. Without irritating the stomach mucosa, this research proved that S. cumini bark extract effectively reduced inflammation throughout all stages. [28]

✞ Antihyperlipidemic activity:

around 40% of people with diabetes mellitus, abnormalities in lipid profiles manifest as one of the disease's most common complications. Kasiappan et al. showed that the gold standard for treating hyperlipidemia in streptozotocin-induced rats was an oral dose of 100 mg/kg body weight of glibenclamide, derived from the ethanolic extract of E. jambolana-kernel. [29]

Table 2 The hypolipidemic effect of different extracts of jamun, Syzygium cumini in preclinical models

S. No.	Parts used	Extract type	Species	Reference
1	Leaf	Aqueous	Humans	47
			Rat	37
2	Seed	Aqueous	Rabbit	24
		Ethanol	Rat	27,33,38
			Mice	35
3	Fruit	Aqueous	Rat	42,
		Ethanol	Rat	38,43
			Mice	35

✞ Antispasmodic activity:

A pilot study by Dhawan et al. indicated that an ethanol-water(1:1)extract of the aerial sections had no effect on the spasms generated by guinea pig ileum compared to acetyl choline and histamine.In their study, Mokkhasmit et al. determined that guinea pig ileum was actively affected by ethanol water (1:1) with 0.01 gm per ml of dry bark. [30]

✞ Gastroprotective Activity :

Rats with stomach ulcers caused by aspirin, pylorus ligation-ethanol, or a 2-hour cold restraint stress were the subjects of an investigation by Chaturvedi et al. about the efficacy of an ethanolic extract from the seeds of E. jambolana. It is possible that Eugenia jambolana's protective effects against ulcers are the result of its actions on offensive and defensive elements simultaneously. Eugenia jambolana's antioxidant qualities are one reason for its

efficacy. [31]

✞ CNS Activity:

A number of Syzygium cuminii Linn seed extracts, fractions, and subfractions were investigated for their sedative and anticonvulsant effects by De Lima et al. Focus on the actions of mice. The hydroalcoholic

extract had a hypothermic impact and also showed anticonvulsant effects in pentylenetetrazol and maximal electroshock convulsions when taken orally. Subfractions of ethyl acetate increased the latency and duration of pentylenetetrazol's first convulsion. Some of the active components in S. cuminii have anticonvulsant effects in addition to central depressive ones. [32]

Conclusion

Jamun (Syzygium cumini) stands out as a powerful traditional medicinal plant with strong scientific potential in diabetes management. Its rich phytochemical profile—especially tannins, polyphenols, and flavonoids—supports multiple antidiabetic mechanisms, including inhibition of alpha-amylase and alpha-glucosidase, enhancement of antioxidant defenses, and modulation of key molecular pathways such as PPARα/γ and Nrf2. These actions help reduce oxidative stress, inflammation, and elevated blood glucose levels. With rising concerns over the side effects of conventional antidiabetic drugs, Jamun offers a promising, safer herbal approach. However, systematic clinical studies are still needed to validate its molecular mechanisms and establish its therapeutic value in modern medicine.

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