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A Comprehensive Review on the Antidiabetic and Pharmacological Activities of *Syzygium cumini* (Jamun)

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Abstract: ***Jamun (Syzygium cumini), a member of the Myrtaceae family, is an angiospermous plant widely utilized in traditional Indian medicine, particularly since the Vedic period, for the management of diabetes. Although diabetes itself is not immediately fatal, it is associated with multiple systemic complications affecting organs such as the heart and kidneys. The global prevalence of diabetes has been rising, largely due to lifestyle modifications, including changes in dietary patterns. This review aims to systematically compile and analyze available information on the antidiabetic potential of Jamun. Relevant data were collected from scientific databases including Google Scholar, PubMed, SciFinder, and ScienceDirect, along with other online resources. The review highlights the plant's botanical characteristics, phytochemical composition, and pharmacological properties, with a particular focus on its antidiabetic effects. In the context of Ayurvedic medicine, Jamun is described as having acrid, astringent, carminative, digestive, refrigerant, diuretic, and sweet-sour properties. Ethnomedicinally, it has been employed in the treatment of a wide range of conditions, including fever, piles, leucorrhea, wounds, gastrointestinal disorders, dental issues, and skin diseases. Various parts of the plant are traditionally used to manage ailments such as arthritis, asthma, bowel spasms, dysentery, flatulence, obesity, stomach pain, urinary disorders, and notably, diabetes. Phytochemical investigations have identified numerous bioactive compounds in Jamun, including anthraquinones, alkaloids, cardiac glycosides, catechins, flavonoids, glycosides, steroids, phenolic compounds, saponins, and tannins. Mechanistically, Jamun has been shown to modulate key metabolic pathways by activating signaling molecules such as AKT, PPARα, and PPARγ, thereby enhancing glucose and lipid metabolism. Additionally, it suppresses the expression of genes and proteins associated with gluconeogenesis and lipid synthesis, including FoxO-1, PGC-1α, ACC1, SREBP-1c, Scd1, KDEL receptor, and GPR98. Overall, contemporary scientific evidence supports the traditional use of Jamun in the management of diabetes and other disorders. Further research may facilitate its integration into modern therapeutic strategies and advance its role in translational medicine.***

Keywords: Syzygium cumini, Diabetes mellitus, Antidiabetic activity, Phytochemicals, Medicinal plants, Glucose metabolism

I. INTRODUCTION

Diabetes mellitus is a chronic metabolic disorder characterized by hyperglycemia resulting from defects in insulin secretion, insulin action, or both. The increasing global prevalence of diabetes is largely attributed to lifestyle changes, including dietary habits and reduced physical activity. Medicinal plants have gained attention as alternative therapeutic agents due to their safety and efficacy [1,4]. *Syzygium cumini*, commonly known as Jamun or Indian blackberry, has been traditionally used in India for the treatment of diabetes since ancient times. It is widely distributed in tropical and subtropical regions and has been recognized for its diverse pharmacological properties [1,6].



Figure of Jamun Fruit (*Syzygium cumini)*

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Angiosperms represent approximately 80% of all extant green plants on Earth, comprising an estimated 300,000–400,000 species. These plants synthesize a wide range of secondary metabolites, many of which possess significant pharmacological properties and are widely utilized in drug development, contributing substantially to human healthcare. The use of herbal medicines and natural products in medical practice dates back over 5,000 years, with early documentation found in the *Atharva Veda*, which describes around 50 plant species employed in the treatment of various human ailments [18,22].

Among medicinal plants, *Syzygium cumini* (L.) Skeels, commonly known as Jamun, holds considerable importance. It belongs to the family Myrtaceae and is also referred to by several botanical synonyms, including *Eugenia jambolana*, *Syzygium jambolanum*, and *Myrtus cumini*.

In English, it is commonly called Indian blackberry, black plum, Java plum, and jambolan, among others. The species is indigenous to the Indian subcontinent and exhibits extensive linguistic diversity in its vernacular nomenclature across different regions and languages [822].

Approximately 400–500 varieties of Jamun have been identified globally, although only a limited number produce fruits suitable for human consumption. Beyond its edible value, the plant has notable agricultural and economic significance: its foliage is used as livestock fodder, and its durable wood is employed in the manufacture of agricultural tools, construction materials, and railway sleepers [9-21].

II. PHYTOCHEMICAL COMPOSITION

The therapeutic potential of *S. cumini* is attributed to its rich phytochemical profile. Various studies have identified the presence of:

1) Flavonoids (quercetin, kaempferol, myricetin)
2) Phenolic compounds (ellagic acid, caffeic acid)
3) Alkaloids (jambosine)
4) Glycosides (jambolin)
5) Tannins and saponins
6) Anthocyanins

These compounds contribute to antioxidant, anti-inflammatory, and antidiabetic activities [1,6].

III. TRADITIONAL AND ETHNOMEDICINAL USES

In Ayurvedic medicine, *S. cumini* is described as astringent, digestive, diuretic, and carminative. Different parts of the plant—including seeds, bark, leaves, and fruits—are used to treat various ailments such as:

1) Diabetes mellitus
2) Diarrhea and dysentery
3) Stomach disorders
4) Dental and skin diseases
5) Asthma and inflammation

The seeds are particularly valued for their hypoglycemic properties [3,5].

IV. BOTANICAL DESCRIPTION OF JAMUN

Jamun (*Syzygium cumini*) is classified scientifically as follows: Kingdom Plantae, Subkingdom Viridiplantae, Infrakingdom Streptophyta, Division Tracheophyta, Subdivision Spermatophytina, Infradivision Angiospermae, Class Magnoliopsida, Superorder Rosanae, Order Myrtales, Family Myrtaceae, Genus Syzygium, Species cumini.

Native to the Indian subcontinent, Jamun grows abundantly in India, Bangladesh, Pakistan, Sri Lanka (Ceylon), Myanmar, and Madagascar. It thrives in well-drained, deep, loamy soils and is also cultivated in Israel, the USA, and the West Indies for its fruits and timber [8,11–13]. The tree reaches full maturity in about 40 years.

Jamun typically grows up to 100 feet (30 m) tall, with a trunk diameter of 2–3 feet (0.6–0.9 m) and a canopy spread of up to 36 feet (11 m). The branches emerge from low on the trunk, with bark that is initially discolored, becoming smooth and light grey higher up. The lower bark is rough, cracked, and loose.

The leaves are opposite, elliptical to oblong, 8–10 inches long and about 4 inches wide. Young leaves are pink, while mature leaves are leathery, glossy, dark green above, lighter underneath, with a yellowish midrib and a characteristic turpentine scent.

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Jamun flowers appear in clusters of 10–50 or more, usually between March and April. Each cluster measures 1–4 inches (2.5–10 cm) long, with flowers that are round to oblong and funnel-shaped. Individual flowers are about 12.7 mm wide and 4 mm long, initially greenishwhite and maturing to rose-pink, with 4–5 petals united into a small disk and a toothed calyx [6,8,11,14].

After flowering, the fruits develop and ripen between June and July. Raw fruits are green, turning light to dark purple or black when fully mature. They are round to oblong, measuring 1/2–2 inches (1.2–5 cm) long and 1–2.8 cm wide, with a sweet-sour taste that can color the tongue purple. The seeds are oblong, whitish-purple when fresh, and turn brown upon drying [6,8,11,12,14,15].



Figure of Jamun Flower (Syzygium cumini)

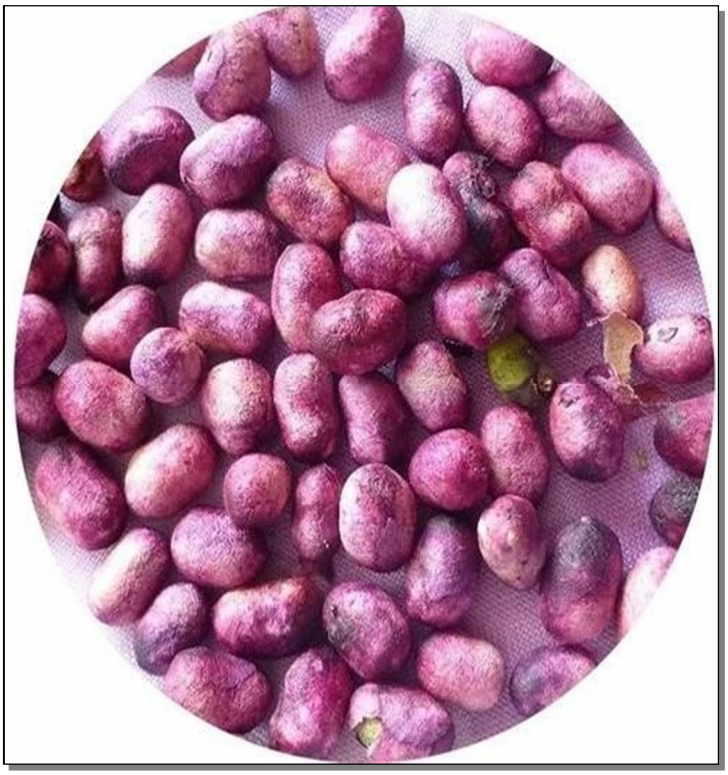


Figure of Jamun seeds (Syzygium cumini)

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Figure of Jamun Leaves (Syzygium cumini)



Figure of Jamun stem (Syzygium cumini)

V. ANTIDIABETIC ACTIVITY

A. *Mechanisms of Action*

The antidiabetic activity of *S. cumini* is mediated through multiple mechanisms:

- Inhibition of carbohydrate-digesting enzymes such as α-amylase and α-glucosidase
- Enhancement of insulin secretion and sensitivity
- Reduction of glucose absorption
- Modulation of key metabolic pathways

Studies have shown that *S. cumini* extracts inhibit enzymes involved in carbohydrate metabolism, thereby reducing postprandial hyperglycemia.

1) Inhibition of carbohydrate-digesting enzymes

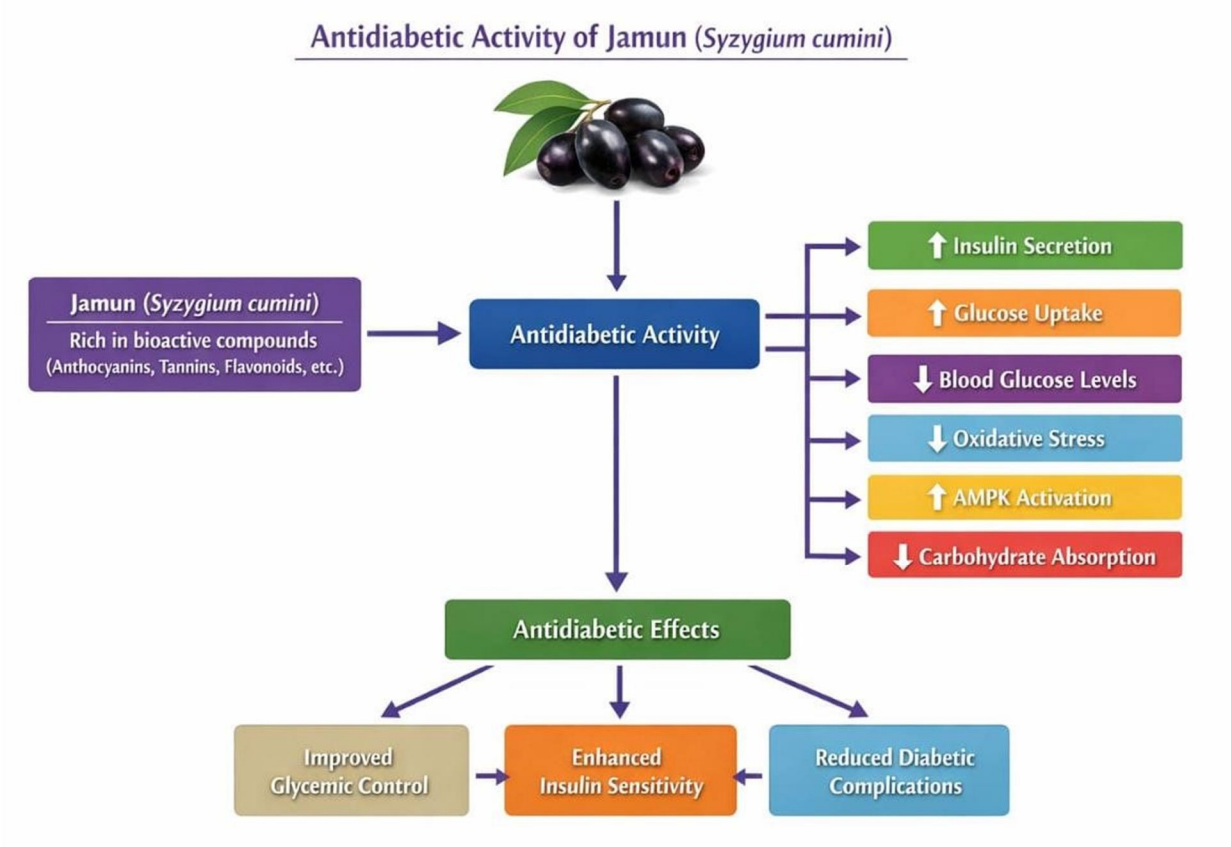
Phenolic compounds present in the seeds act as potent inhibitors of α-glucosidase. This reduces the breakdown of complex carbohydrates into glucose, thereby slowing glucose absorption after meals [21-22].

2) Anti-glycation and antioxidant effects

- Seed-derived phenolics significantly reduce the formation of advanced glycation end products (AGEs), showing effects comparable to or even better than synthetic agents like aminoguanidine.
- Extracts from jamun seeds also neutralize reactive oxygen species (ROS), enhance the activity of antioxidant enzymes such as SOD, catalase, and glutathione peroxidase, and restore reduced glutathione levels in tissues.
- These combined actions help protect pancreatic β-cells from oxidative damage, thereby delaying the progression of diabetic complications.

3) Enhancement of insulin secretion and β-cell protection

Preclinical studies in diabetic animal models demonstrate a significant increase in plasma insulin levels, along with improved glucose tolerance and enhanced glycogen storage following jamun treatment [22].



B. Role of Bioactive Compounds

Active compounds such as jambosine and jambolin are reported to regulate blood glucose levels by inhibiting starch-to-sugar conversion. Flavonoids and phenolics also contribute to improved insulin function and antioxidant defense.

C. Experimental and Clinical Evidence

Numerous in vitro and in vivo studies have demonstrated the hypoglycemic effects of *S. cumini*. Extracts from seeds, leaves, and fruits have shown significant reductions in blood glucose levels in diabetic models. These findings validate its traditional use as an antidiabetic agent [1,8].

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VI. OTHER PHARMACOLOGICAL ACTIVITIES

Apart from its antidiabetic effects, *S. cumini* exhibits several other biological activities:

1) Antioxidant
2) Anti-inflammatory
3) Antimicrobial
4) Gastroprotective
5) Hepatoprotective

These activities further enhance its therapeutic value and potential for drug development [1-8].

VII. SAFETY AND TOXICITY

Studies suggest that *S. cumini* is generally safe when used in recommended doses. However, excessive consumption may lead to hypoglycemia. Further clinical studies are required to establish standardized dosage and long-term safety [4-9].

VIII. FUTURE PERSPECTIVES

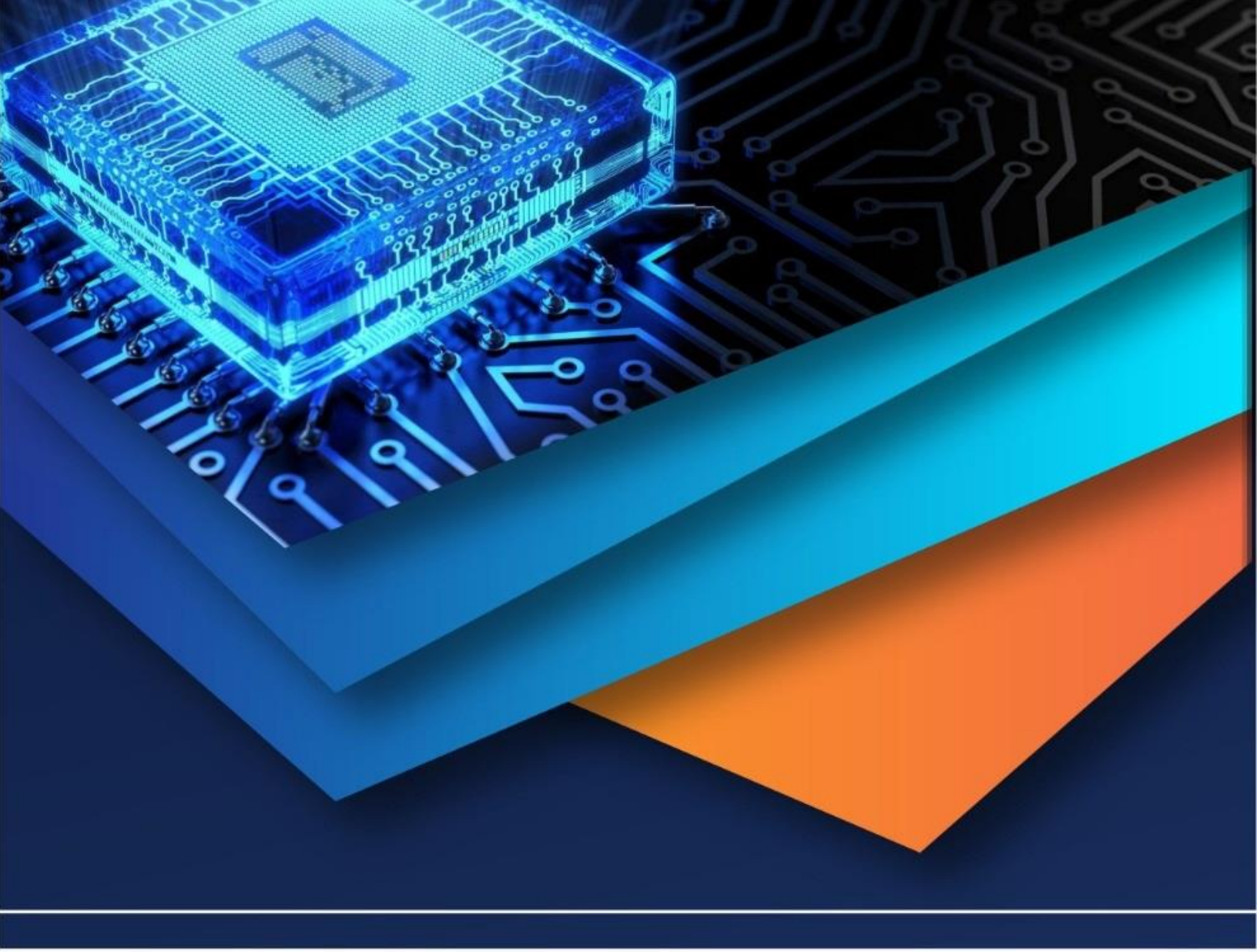
Despite extensive traditional use and promising experimental data, more clinical trials are needed to validate the efficacy and safety of *S. cumini* in humans. Advanced research focusing on isolation of active compounds and molecular mechanisms could facilitate its integration into modern medicine.

IX. CONCLUSION

Syzygium cumini is a valuable medicinal plant with significant antidiabetic potential. Its rich phytochemical composition and multiple mechanisms of action support its traditional use in diabetes management. Continued research may lead to the development of novel plant-based therapeutic agents.

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