E-ISSN: 2663-1067
P-ISSN: 2663-1075
NAAS Rating: 4.74
www.hortijournal.com
IJHFS 2025; 7(4): 01-10
Received: 02-02-2025
Accepted: 07-03-2025

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Syzygium cumini (Jamun): A comprehensive exploration of its nutritional and medicinal attributes

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DOI: https://www.doi.org/10.33545/26631067.2025.v7.i4a.280

Abstract
This is study explores the medicinal properties of Syzygium cumini (jamun), emphasizing its antioxidant and antidiabetic potential. Ethanolic and aqueous extracts of jamun pulp exhibit significant antidiabetic effects, demonstrating dose-dependent hypoglycaemic activity in animal models by lowering blood glucose levels and increasing plasma insulin, suggesting pancreatic β -cell regeneration. The fruit's extract also shows potent antioxidant activity, reducing lipid peroxidation and enhancing enzymatic and non-enzymatic antioxidants, positioning jamun as promising natural agent against oxidative stress related disorders. Toxicological assessment confirms the safety of jamun seeds with no mortality observed in acute and sub-acute oral toxicity studies clinical trials and Type-I and Type-II diabetes patients show favourable outcomes with jamun seed powder, though mild side effects such as nausea and diarrhoea are reported. These findings highlight jamun's therapeutic potential, advocating for further research to elucidate its mechanism for diabetes management and broader health benefits.

Keywords: Antioxidant, antidiabetic, hypoglycemic, plasma insulin, pancreatic β-cells, oxidative stress

Introduction
Jamun (Syzygium cumini (L.) Skeels) is a regional fruit-bearing tree in India, known by various colloquial names such as, jambul, java plum, black plum and Indian blackberry [1]. This diminutive and delicate fruit is associated with the category of underutilized crops, primarily because of lack of organized cultivation practices [2]. Notably, jamun exhibits extreme perishability, which spoils quickly under room temperature [3].
Historically, jamun fruits played a significant role in traditional medicine, addressing different type of disease and physiological imbalances [4]. The natural distribution of jamun extends to Thailand, the Philippines, and Madagascar. Moreover, successful introductions have facilitated its cultivation in several other tropical nations, including the West Indies, California, Algeria, and Israel. Jamun (Syzygium cumini) trees exhibit sporadic distribution across tropical and subtropical regions of India, with additional occurrences in select areas of the lower Himalayan ranges, reaching elevations of up to 1600 meters [5]. Notably, this tree has been extensively cultivated and has successfully naturalized in the Philippines, where its introduction is believed to date back to prehistoric times. The transfer of jamun seeds from the Philippines to Florida facilitated its establishment as an ornamental plant [6].
California, particularly in the vicinity of Santa Barbara, provides an ideal environment for the growth of jamun trees. Historically, these trees were extensively planted in Southern Florida. Despite prolific fruiting, local consumption remains minimal in Hawaii [6]. Overall, jamun is prevalent in tropical and subtropical regions worldwide. Easily produced in swampy places where other fruits fail to establish, it's among the hardest fruit crops [8]. On the west coast of India, nevertheless, it grows well in laterite soils with good drainage. It thrives in soils that are black cotton and sandy loam as well. According to [6], it also grows on region with shallow groundwater level, degraded ground, and ravines. It thrives in subhumid region with 500 mm or less of yearly rainfall. For jamun to flower and set fruit, dry weather is necessary. Early rains are thought to be advantageous for healthy fruiting and color development in subtropical regions [6]. A significant producer of jamun is India. Nevertheless, enormous amounts of jamun-which could be utilized for processing-are lost

due to rain or during the sorting and grading process in order to meet quality criteria for the fresh fruit export market. There is 0.5 MT of wasted jamun in India alone. All Jamun growing regions have a significant amount of marketable surplus fruit that is available; these must be processed and turned into products with additional value [9]. The tree yields fruit once per year, and the early purple berries eventually turn black and have a bitter-sweet flavor. Because of its versatility in handling different kinds of soil and different patterns of rainfall, jamun offers unexplored economic potential and creative product creation.

Chemical profiling of jamun fruit

Phytochemicals

Seeds: According to [10, 11], the plant's seed have been found to contain substances like jambo sin, gallic acid, ellagic acid, corilagin, 3,6-hexahydroxy diphenoylglucose, 1-galloylglucose, 3-galloylglucose, quercetin, β-sitosterol, and 4,6 hexahydroxydiphenoylglucose.

Bark on Stems: The bark on the stems, as reported by contains [11], the following constituents: friedelin, friedelan-3-α-ol, betulic acid, betulinic acid, kaempferol, gallic acid, myricetine, β-sitosterol gallotannin, ellagitannin, β-sitosterol-D-glucoside and ellagic acid.

Flowers: The flowers of this plant, according to [10], contain kaempferol, myricetin, isoquercetine, quercetin, ellagic acid, and oleanolic acid.

Fruit pulp

Delphindin, petunidin, anthocyanins, and malvidin-Di glucosides [10, 12, 13].

Leaves: Betulinic acid, mycaminose, B-sitosterol crategolic (maslinic) acid, n-hepatcosane, n-hentriacontance n-nonacosane, noctacosanal, n-triacontanol, n-dotricontanol, quercetin, myricetin, myrictrine, and the flavonol, glycosides myricetin 3-O-(4"-acetyl)-α Lrhamnopyranosides [10, 14].

Essential oils: 1, 8-cinele, geranyl acetone, pinocarvone, α-myrtenal, eucarvone, muurolol, α-terpeneol, and myrtenol [15, 17].

Medicinal prespective of jamun

Seeds: Jamun seeds exhibit antioxidant properties and have been researched for their antioxidant properties in diabetes and anti-inflammatory effects in rats. These seeds also possess antibacterial qualities, potentially reducing the risk of gastroenteritis and skin cancer [16, 17].

Bark on Stems

The bark of jamun, primarily composed of tannins and carbohydrates, has been traditionally employed to treat dysentery [18].

Flowers and Leaves

The flowers and leaves contain bioactive compounds, including quercetin, myricetin, and ellagic acid. These constituents contribute to jamun's free radical scavenging, antibacterial, antifungal, and antimicrobial properties [17].

Overall Therapeutic Benefits

Jamun demonstrates efficacy in managing diabetic mellitus, ulcers, and nitric oxide scavenging. Additionally, it exhibits anti-HIV activity and radioprotective effects.

Fig 1: High density planting, B: Flowering of Jamun plant, C: Fruiting at approachable height, D: Fruits in Bunch, E: View of seed and fruit. Source [19]

The jamun fruit comprises of a high amount of raffinose, glucose, fructose, citric acid, mallic acid, gallic acid, petunidin-3-gentiobioside, malvidin-3-laminaribioside, and cyanidindiglycoside, among other sugars and sugar derivatives. It contains minerals like copper, sodium, potassium, calcium, phosphorous, iron, and zinc; water-soluble vitamins such as ascorbic acid, thiamine, and niacin; carbohydrates like glucose, mannose, sucrose, maltose, fructose, galactose, and mannose; and free amino acids like alanine, asparagine, tyrosine, glutamine, and cysteine, according to [20, 21, 22].

Fruit Composition: Hinging on the kind and region, jamun fruit varies in size and characteristics. The content of pulp (68.75-86.59%), seed weight (1.3-2.36 g), length (2.22-4.51 cm), weight (4.8-17.6 g), and diameter (1.66-3.04 cm) of the

fruit vary greatly [26]. The contents of a newly plucked fruit's edible section, measured in grams: Amounts: 85.9 grams of moisture; 0.15 grams of ether extract; 0.3 grams of crude fiber; 0.129 grams of nitrogen; 0.32 grams of ash; 8.3 mg of calcium; 16.2 mg of phosphorus; 1.62 mg of iron; 0.004 mg of carotene; 0.008 mg of thiamine; 0.009 mg of riboflavin; 0.009 mg of niacin; 0.290 mg of total ascorbic acid. The Jamun fruit has the following characteristics: its specific gravity is 1.0184; its total acidity (as acetic acid) is 5.33 per 100 cc; its volatile acidity (as acetic acid) is 5.072 per 100 cc; its fixed acidity is 0.275% as citric; its total solids are 4.12 per 100 cc; its ash is 0.42; its alkalinity is 32.5 (N/10 alkali); its nitrogen is 0.66131; its total sugars are 0.995; reducing sugars are 0.995; non-volatile reducing sugars are 0.995; alcohol is 0.159% by weight; its oxidation value (KMnO4, 186.4); its iodine value is 183.7; and its ester value is 40.42.

Chemical composition of Jamun

Proximate analysis

Table 1: Represents the value of proximate analysis

Serial. No.	Component	Value
1.	Moisture	83.70-85.80 g100 g^{-1}
2.	Protein	1.4 ± 0.7 g100 g^{-1}
3.	Fat	0.6 ± 0.2 g100 g^{-1}
4.	Fiber	0.6 g100 g^{-1}
5.	Ash	0.32 g100 g^{-1}
6.	Carbohydrate	14.00 - 16.00 g100 g^{-1}
7.	Maltose	210 mg g^{-1}
8.	Sucrose	95.5 mg g^{-1}
9.	Fructose	57.5 mg g^{-1}
10.	Galactose	52.5 mg g^{-1}
11.	Glucose	20 mg g^{-1}

Source: [24]

Vitamins

Table 2: Represents the value of vitamins

1.	**Ascorbic acid**	**30 mg100 g^{-1}**
2.	Riboflavin	0.06 mg100g^{-1}
3.	β-Carotene	50 mg100 g^{-1}
4.	Thiamine	0.12 mg100g^{-1}

Source: [24]

Minerals

Table 3: Represents the mineral contents in jamun.

1	**Copper**	**0.07 mg 100g^{-1}**
2	Magnesium	49.8 mg 100g^{-1}
3	Iron	0.15 mg 100g^{-1}
4	Zinc	0.28 mg 100g^{-1}
5	Sodium	3.5 mg/100g^{-1}
6	Calcium	21.5 mg 100g^{-1}
7	Phosphorus	18.5 mg 100g^{-1}

Source: [24]

Food value of one hundred grams of edible Jamun fruit

The following is the nutritional content of jamun per 100 grams of edible portion:

- Moisture content ranges from 83.7 to 85.8 grams.
- Protein content varies between 0.7 and 0.129 grams.
- Fat content ranges from 0.15 to 0.3 grams.
- Crude fiber is present in the range of 0.3 to 0.9 grams.
- Carbohydrates constitute 14.0 grams.
- Ash content is between 0.32 and 0.4 grams.
- In terms of mineral content:
- Potassium is present at 55 milligrams.
- Copper content is 0.23 milligrams.
- Sulphur content is 13 milligrams.
- Chlorine content is 8 milligrams.
- Calcium ranges from 8.3 to 15 milligrams.
- Magnesium is at 35 milligrams.
- Phosphorus ranges from 15 to 16.2 milligrams.
- Iron content varies between 1.2 and 1.62 milligrams.
- Sodium is at 26.2 milligrams.
- Vitamins and other components include:
- Vitamin A is present at 810 IU.
- Thiamine content ranges from 0.008 to 0.003 milligrams.
- Riboflavin is in the range of 0.009 to 0.01 milligrams.
- Niacin content is between 0.2 and 0.29 milligrams.
- Ascorbic acid (Vitamin C) ranges from 5.7 to 18 milligrams.
- Folic Acid is at 3 milligrams.
- (Note: The source of this information is cited from[8,19]

Essential oils in jamun

According to [2] 82% of all essential oils are found in jamun leaves. Jamun leaf contains significant essential oils, including guaiol, β-caryophyllene, α gurjeuene, and aromadendrene [Table 3]. α-murolol, terpeneol, eucarvone, myrtenol, α-myrtenal, α-cadinol, geranyl acetone, and pinocarveolessential oils are present in jamun pulp.

According to [27], caryophyllene oxide has anti-mycobacterial effects, whereas the essential oil β-Caryophyllene found in jamun leaves has anti-inflammatory qualities.

Table 4: Represents the essential oil in jamun leaf and pulp

Sr. no	Jamun leaf		Jamun pulp	
1.	cis-Ocimene	0.90	α-Cadinol	4.6
2.	trans-Ocimene	0.50	Pinocarvone	4.4
3.	γ-Terpinene	0.09	trans-Pinane	3.8
4.	DL-Limonene	4.04	Geranyl acetone	5.6
5.	o-Cymene	0.54	Myrtenal	5.8
6.	α-Terpinene	0.81	Muurolol	6.4
7.	β-Pinene	0.16	α-Terpineol	8.9
8.	Camphene	0.09	Myrtenol	8.3
9.	β-Myrcene	0.30	Eucarvone	6.6
10.	Hexanal	0.21	Pinocarveol	15.1
11.	Aromadendrene	6.62	Bornyl acetate	1.2
12.	β-Guaiene	0.70	Carvone	1.4
13.	Caryophyllene alcohol	0.11-3.90	para-Cymen-8-o1	2.7
14.	α-Copaene	0.56	cis-Carveol	2.2
15.	β-Elemene	0.31	Limonene oxide	1.8
16.	δ-Elemene	0.44	δ-Cadinol	3.5
17.	β -Caryophyllene	6.96-16.00	β-Pinene	0.7

Source: [35, 34, 36].

Therapeutic value of compounds found in seeds and fruits

Alpha-Pinene

- Medical Importance: Exhibits gastroprotective and antiulcerogenic effects induced by ethanol and indomethacin in mice.
- Reported by [37]

Cynadin

- Medical Importance: Demonstrates anti-tumorigenic properties.
- Reported by [38]

Quercetin

- Medical Importance: Possesses antioxidant and antiviral applications.
- Reported by [39]

Cisocimene

- Medical Importance: Exhibits antimutagenic properties.
- Reported by [40]

Beta-bisqbolal

- Medical Importance: Displays anti-inflammatory, anticancer, and antiviral effects.
- Reported by [41]

Therapeutic effects of jamun pulp and seed

Antioxidants

Many studies have investigated the antioxidant properties of jamun pulp using *in vitro* tests such as DPPH, super-oxide radical, hydroxy radical, and lipid peroxidation. These include research conducted using aqueous skin extract, aqueous-methanolic, ethanolic, and methanolic pulp extract, respectively, by [42, 43, 44, 45]. However, using the ABTS, FRAP, and β-carotene bleaching experiment [46] further demonstrated the antioxidant capacity of pulp [47]. Conducted an *in vitro* investigation utilizing the thiobarbituric acid assay to evaluate the effectiveness of pulp-isolated anthocyanins in preventing lipid peroxidation caused by iron sulphate in liver, brain, testes of rat. In streptozotocin-induced diabetic rats [35] examined into an aqueous extract of jamun pulp's *in vivo* anti-oxidant potential [48].The study demonstrated that jamun pulp is a unique source of antioxidant in biological systems by reporting a substantial rise in glutathione per-oxidase levels, catalase, super oxide dis-mutase, glutathione-S-transferase, and reduced gluta- thione within liver tissue. Antioxidants delay the procedure of ageing and manage free-radicals, which cause several ailments. Several *in vitro* experiments utilizing alcoholic seed extracts have shown this capability. The extracts may have different actions, such as chelating ferric ions, a transition metal catalyst, and trapping free-radicals like hydroxyl, superoxide, DPPH, lipid peroxide, and nitric oxide [44, 49]. The prevention of self-oxidation in linoleic acid and β-carotene has been reported, which supports the trapping mechanism [28]. It was discovered that the concentration-dependent anti-oxidant ability of the seed extract against super-oxide radical is six times greater than Trolox [49].

Antidiabetic

Thus far, research on animals has been conducted to illustrate the antidiabetic characteristics of jamun pulp. This relevant aqueous extract feature was initially demonstrated by [52] in diabetic rats induced by streptozotocin. According to [48] derived from outcome of this rat study, oral administration of the aqueous extract produced a significant dose-dependent decrease in blood glucose level with a commensurate improvement in body weight. In diabetic rats given alloxan, [50] noted that administering the ethanolic extract orally resulted in a positive impact on blood glucose levels. After streptozotocin was used to induce diabetes in rabbits [51] investigated the anti-diabetic properties of an aqueous and ethanolic extract derived from pulp of jamun. The results demonstrated significant hypoglycaemic activity 30 minutes after oral administration. Moreover, they mentioned that when compared to the usual medication, tolbutamide, which has a dosage of 100 $mgkg^{-1}$weight of body, the extract at 300 and 200 $mgkg^{-1}$ weight of body exhibits outcomes that are equivalent. Additionally, the liver

and kidney of diabetics induced by alloxan showed no harmful effects from the aqueous extract of S. cumini pulp [51].

[52, 51] Suggested that the extract's ability to augment insulin production from cultivated Langerhans cells in a controlled system accounts for its hypoglycaemic impact. Numerous people with lifestyle disorders such as diabetes are beginning to show signs of interest in alternative medical systems such as Ayurvedic, Unani, and others. In these medical systems, jamun seeds are frequently given to manage diabetes [53]. The anti-diabetic properties of jamun seed have also been supported by several pharmacological investigations. Research conducted by [54, 55] demonstrated a notable decrease in the blood glucose levels of rats with induced diabetes when they were administered jamun seed. Various scientists have investigated the extracts' efficacy using various solvents on various animal models. Studies on rats with alloxan-induced diabetes[51,56,57,58] streptozotocin-induced diabetes [59,60,44,45,46] and fructose-induced model [47] have all been successfully conducted. The study conducted by [38] examined the potential of ethanolic extract from jamun seeds to mitigate alloxan-induced diabetes in rabbits. Clinical studies involving human subjects have also been incorporated in the study82-84 [49, 50, 51] Pharmacological research have shown that the use of powdered jamun seeds as well as their ethanolic [54], methanolic [31], ethyl acetate [41, 45], and aqueous [42, 47] extracts can be taken orally [31] or injected intraperitoneally. The seeds present minimal harm to individuals when utilized in the alternative medicine systems outlined above. The toxicological investigations [41] conducted on rats using water extract, ethyl acetate, and methanol extracts have demonstrated no mortality with sub-acute and acute oral toxicity. Clinical trials on human subjects with Type-1 (Refs. 83, 84 [50]) and Type-2 (Ref. 82 [49]) diabetes have shown that oral intake of jamun seed powder produces successful outcomes with no adverse effects. However, [51] reported five in5ividuals who experienced adverse effects, including nausea, diarrhoea, and epigastric discomfort, which may have stemmed from consuming a large amount.

[48] Suggested that jamun seeds' direct insulinotropic action is the likely mechanism behind their anti-diabetic effects. Numerous investigations that conclude that the impact is a raised plasma insulin level following dosage administration have also supported this distinction [46, 56, 57]. In 2010, Singh, Gupta, Gohil, and colleagues hypothesized that an increase in blood insulin levels might have an impact on the repair of pancreatic β-cells, which when injured, decrease insulin output.[58] discovered that chloroform extract has the ability to stimulate islet neogenesis in both outside the body and within the living organism investigations, supporting the regeneration of β-cells. The reducing effectiveness of starch hydrolysing enzymes, such as α-amylase, pancreatic amylase, and α-glucoamylase, has also been shown as an antidiabetic effect of seed extracts [59, 60, 61]. Key enzymes for glycolysis and gluconeogenesis are activated and inactive, according to Sharma *et al.*'s strategy for preserving carbohydrate homeostasis. Additionally, in a way reliant on phosphatidylinositol 3-kinase, the extract stimulates glucose transport in cell culture. Mycaminose, a deoxyaminosugar, was discovered by [74] in the alcohol's powdered seed extract. In streptozotocin-induced diabetic rats, they observed the hypoglycemic impact of this amino sugar at a dosage of 50 $mgkg^{-1}$ body weight. Research has demonstrated that jamun seeds also inhibit diabetic-induced secondary pathogenesis, such as weight loss [62], neuropathy, gastropathy, diabetic cataract [63], and kidney damage [31]. According to [52]the seed also lessens oxidative stress caused by hyperglycemia by raising glutathione levels, activating catalase and superoxide dismutase, and subsequently lowering lipid peroxidase levels. Jamun seeds may therefore be viewed as a unique therapeutic tool for the management of diabetes.

Antimicrobial

[87] Reported that the extract from jamun seeds was effective as an antibacterial agent against a variety of bacteria, including Salmonella dysenteriae, Sh. Shiga, Sh. boydii, Sh. Flexneriae, Sh. Sonnie, Escherichia coli, Salmonella typhi B, Sal. typhi B-56, and Klebsiella species. According to [65] anti-bacterial properties against a variety of Gram +ve and Gram -ve microorganisms. As per [15] the seeds' methanolic extract exhibits a wide range of antibacterial activity against A. hydrophila, V. cholera and B. subtilis. Minimum bactericidal concentrations (MBC) and minimum inhibitory concentrations (MIC) of the extract range from 1.5-12.0 and 1.5-16.0 mg/mL. According to Mathur *et al.*, (2011), this extract is also harmful to Pseudomonas aeruginosa with Proteus vulgaris. The antibacterial properties of an ethanolic extract were reported by [16] against three Gram -ve bacteria (K. pneumonia, P. aeruginosa, and E. coli) and two Gram +ve bacteria (S. aureus and E. faecalis). They found that the MIC for E. coli, P. aeruginosa, and E. faecalis was 6.25 $mgmL^{-1}$when compared to conventional antibiotics, whereas it was 3.13 mg/ml for S. aureus and K. pneumonia. The seed's alcoholic extract has the ability to stop E. coli from growing, but it doesn't have bactericidal properties [68, 59]. According to Chandrasekaran and Venkatesalu, The aqueous and methanolic extracts of jamun seeds have the ability to suppress dermatophytic fungus, including Microsporum gypseum, Tricophyton rubrum, T. mentagrophytes, and Candida albicans [69]. According to reports, the methanolic extract exhibiting antifungal activity against Aspergillus niger.

Anti-inflammatory

In line with several studies [69] jamun seed extract has an anti-inflammatory impact on carrageenan-induced oedema. Using methanol and ethyl acetate extracts, [71] have shown an anti-inflammatory effect on q rats' paw oedema. [71] Comparing the treated group to the control group, swallowing of the methanolic and aqueous extracts at 250 mgkg-1 decreased body wt. 48.29% and 68.85% of the oedema, whereas conventional prescription diclofenac sodium at 100 $mgkg^{-1}$ body weight reduced by 75.08%. In addition, with lower doses (120 $mgkg^{-1}$ body weight), a noteworthy decrease in the oedema paw volume was also seen. Chloroform extracted from jamun seeds has the power to minimize oedema caused by carrageenan, kaolin, and other mediators [70]. A persistent form of inflammatory joint illness is arthritis. jamun seed's methanolic extract has been shown by [71] to have a strong antiarthritis effect. Researchers discovered a direct correlation between the amount of extract administered orally to rats and the prevention of Freund's complete adjuvant-induced arthritis, and usual method. The antiarthritic effect of extract of methanol on adjuvant-induced arthritis in rats has been presented by [72].

Therapeutic role of Jamun in medicine

Table 5: Therapeutic Role of Jamun in Medicine

Name of chemicals	Plant Part Used	Reported by
Antimicrobial	Leaf's Ethyle acetate extract	[77]
Hypo-lipidemic	Seed ethanolic extract can lower blood levels of triglycerides, LDL, and total serum cholesterol/high density lipoprotein cholesterol ratio.	[73]
Cardio-protective	Methanolic extracts of Jamun seeds.	[74]
Hepatoprotective	On rat hepatocytes, jamun peel extract inhibited oxidative damage produced by carbon tetra chloride. rats developed poisoning from paracetamol.	[75]
Anti-cancerous	Pulp of jamun	[76]
Antibacterial	Jamun pulp	[77]
Immunomodulatory	Jamun seed's methanolic extract	[76]
Anti-diabetic	Jamun seed's extracts in various solvent	[40,74]
Anti-oxidant	Gall extract of leaf	[78]
Anti-fungal	Bark of tree	[79]

Food potential of jamun

Fresh jamun tastes delicious with a dash of salt. Due to its extreme perishability and seasonal availability, jamun must now be preserved, either as it is or as processed products made from it. Recent conceptual breakthroughs about functional food-that is, advantages to health derived itself from the food-are prompting a number of research studies. According to information gleaned from the GNPD, which can be accessed at http://www.gnpd.com, several Jamun products have already been launched for sale, reached on November 2, 2011).

Jamun powder: Only a few of Indian food companies have introduced powders with health claims that use jamun as an ingredient.[80] recently published the outcomes of a scientific research on the safeguarding of jamun in form of powder. The powdered form was kept at 25±2°C and 90% relative humidity in glass containers. Three factors were tracked: stickiness, color, and moisture content. The shelf-life of greater than 300 days was anticipated. 2011 saw the publication in GNPD of a single dried whole black plum product, branded as Bom Preco by Wal-Mart, Brazil.

Fresh jamun

In a recent endeavor, [86] employed a 35 µm-thick polypropylene film with one or two 0.3 mm diameter holes produced on the film surface to increase the fresh jamun's shelf life using differential MAP. The film was then stored at 5°C and 75% R [86]. In compared to a fresh sample, 64% of the anthocyanins in a film with one perforation were preserved well, representing a satisfactory retention of both subjective and objective qualitative measures. Additionally, the fruits' satisfactory microbiological quality after 23 days of storage in this film under the appropriate circumstances suggested that it might be used for long-term preservation. There is one product on the shelf in the Chinese market that offers fresh jamun to be eaten as a snack. The product uses citric acid, salt, preservatives and white sugar on pack label.

Jamun juice: Industries have promoted jamun juice for its positive health benefits, both pure and in combination with other drinks. It was created using an enzymatic process to produce clarified jamun juice, which could be kept at ambient temperatures for up to six months without turbidity or sedimentation [81]. According to Shahnawaz and Sheikh, jamun juice that had been stored for four months at 32°C had altered from purple red hue to a muddy red tint, most likely due to anthocyanin degradation [82]. Subsequently, researchers looked into fluid dynamics for upsizing and reported with pH 3.77, TSS of 18.1°Brix, and 94.5% moisture content that had a viscosity of 25226 poise [82].

Jamun wine

Saccharomyces cerevisiae was employed by [83] to standardize the making of wine, and depending on the cultivar, 10.93 to 11.23% ethanol was produced [83]. Furthermore, they discovered that when pectic enzyme was used as a pre-treatment for the pulp (0.25%) and the finished product was aged for six months, the wine had improved sensory acceptance. The final wine's reducing sugar and tannin level decreased concurrently with a minor rise in acidity and ethanolic content due to the enzyme treatment. S. cerevisiae var bayanus was used in a different work by Chowdhury and Ray to ferment fruit of jamun, resulting in wine of jamun with 6 percent ethanol and a decent anthocyanin concentration (60 mg100 mL^{-1}) [84]. The technique was traditional, but it was somewhat altered to maintain pH and TSS levels before adding culture. Cane sugar and tartaric acid were used for this purpose. Although the sensory panel approved the beverage, it was not as good as samples of commercial wine of grapes [85]. Investigated the impact of jamun pulp content in broth and the aging process that followed on the final product's physicochemical characteristics and sensory quality129. They claimed that the wine made from a 1:1 pulp dilution had the highest overall sensory acceptability, optimal TSS, ethanol level, and acidity. All of these investigations accept jamun as a fermentable substrate and promote the growth of related products. 2011 saw the 10% alcohol content Sapporo Black Plum Liqueur introduced by Sapporo Breweries Ltd. in Japan. The technique was traditional, but it was somewhat altered to maintain pH and TSS levels before adding culture. Cane sugar and tartaric acid were used for this purpose. Although the sensory panel approved the beverage, it was not as good as samples of commercial grape wine [85]. Investigated the impact of pulp of jamun content in broth and the aging process that followed on the final product's physicochemical characteristics and sensory quality. They claimed that the wine made from a 1:1 pulp dilution had the highest overall sensory acceptability, optimal TSS, ethanol level, and acidity. All of these investigations accept jamun as a fermentable substrate and promote the growth of related products. Sapporo Black Plum Liquor with 10% alcohol content has been launched by Sapporo Breweries Ltd, in 2011.

Other products

Indian food companies manufacture and sell vinegar and jamun chips. Additionally, jamun pulp is being introduced to the global food market sector in range of different edible products, like yoghurt & biscuits. With further research and development, jamun may be able to maintain its position as a functional meal while maintaining its health advantages. Other product may include jamun jam, jamun syrup, jamun snack bar and jamun ice-cream.

Conclusion

The study offers convincing evidence of Syzygium cumini, sometimes referred to as jamun, having antidiabetic qualities. The study draws attention to the notable hypoglycemic response that several animal models showed after oral treatment of distinct jamun extracts. According to the study, a rise in plasma insulin levels may be responsible for these antidiabetic benefits, which may also point to a possible regenerative impact on pancreatic ß-cells. Additionally, the study suggests that seed extracts have inhibitory effects on enzymes that hydrolyze starch, which may be a factor in their antidiabetic qualities. The study also highlights how resilient the jamun tree is, highlighting how it can grow in a range of soil types and climates and being a productive crop in many areas. The study also emphasizes the necessity of more research to completely comprehend the underlying processes underlying the reported antidiabetic benefits. This may open the door to the creation of more potent treatment approaches that make use of jamun and other natural resources to control diabetes.

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