Jamun: an underutilized fruit with untapped potential

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Introduction

Jamun (*Syzygium cumini* L.), often called the Indian blackberry or Java plum, is a tropical evergreen tree belonging to the Myrtaceae family. It is indigenous to the Indian subcontinent and it is found broadly across South Asia and Southeast Asia (Ayyanar & Subash-Babu, 2012). People also mention it as *Syzygium jambolanum* and *Eugenia cumini*. Other familiar names include Jambul Indian Blackberry Black Plum Java Plum Jamblang and a few more, depending on the place. Jamun is typically harvested during the monsoon period, and honestly the harvesting window is rather brief, it may run around 30–40 days, only. The fruit itself is dark purple, with an oval shape. Usually the fruit is fleshy, and there is a hard seed inside. The tree fruits once in a year, while the berries have a sweetish sour kind of flavour.

For ages it has been used inside regional eating routines as well as in traditional medicine, since it is thought to offer nutritional support along with many therapeutic advantages (Ayyanar & Subash-Babu, 2012). What most folks eat day after day is basically the pericarp, that is, the part with pulp and peel together. Then the seed, which is about 25 percent of the whole fruit weight, is normally discarded after eating, so it ends up as post consumption waste.

(Source: google)

Fig. 1. Jamun fruits

(Source: google)

Fig. 2: Jamun seeds

Nutritional composition of the Jamun

The nutritional composition of jamun varies depending on the cultivar, stage of maturity, and growing conditions; however, reported values indicate that the fruit is a nutrient-rich, low-calorie food with a high moisture content ranging from 83.7 to 85.8 g per 100 g of edible portion. It provides approximately 60 kcal of energy and contains 14.0–15.6 g of carbohydrates, 12.7 g of total sugars, 0.7–0.8 g of protein, 0.15–0.30 g of fat, 0.3–0.9 g of crude fibre, and 0.32–0.70 g of ash. Jamun also contains essential minerals, including 8.3–19 mg calcium, 15–35 mg magnesium, 15–16.2 mg phosphorus, 55–79 mg potassium, 14–26.2 mg sodium, 0.19–1.62 mg iron, and 0.23 mg copper per 100 g of edible portion. In addition, it provides small amounts of vitamins such as vitamin A (3–8 IU), thiamine (0.006–0.03 mg), riboflavin (0.009–0.012 mg), niacin (0.20–0.29 mg), pantothenic acid (0.160 mg), vitamin B_6 (0.038 mg), vitamin C (5.7–18 mg), and folic acid (3 μg). The fruit primarily contains fructose and glucose as its major sugars, while malic acid is the predominant organic acid responsible for its characteristic sweet-astringent taste.

Bioactive composition of jamun

Jamun is notable not only for its nutritional value but also for its exceptional phytochemical profile, which supports its functional characteristics and potential as a nutraceutical. Many bioactive substances, such as phenolic compounds, flavonoids, anthocyanins, tannins, phenolic acids, carotenoids, terpenes, and other phytochemicals, are abundant in the pulp, peel, and seeds. Cultivar, geographic origin, maturation stage, and processing conditions all affect the kind and concentration of these chemical compounds.

Table 1: Bioactive composition of jamun fruits

Ascorbic acid (mg/100g)	21.48
Anthocyanins (mg/100g)	185.35
Total Tannin (mg/100g)	168.24
Total Phenols (mg GAE/100g)	2133.50
Antioxidant activity (%)	95.81

(Source: Suradkar NG et. al., 2017)

Phenolic compounds are, in general, the most common kind of phytochemicals. The seeds are, somehow, an extraordinarily high source of natural antioxidants, which is shown by the reported total phenolic content, that ranges from 221.83 to 1348 mg gallic acid equivalents (GAE)/100 g in the pulp and 4500 to 5670 mg GAE/100 g in the seeds. These phenolics are vital for scavenging reactive oxygen species and protecting biomolecules against oxidative damage.

Anthocyanins, reported at about 29.7–47.7 mg/100 g, are mostly behind jamun's distinctive deep purple, to black look. The main anthocyanin pigments in jamun are cyanidin derivatives, including delphinidin-3,5-diglucoside, petunidin-3,5-diglucoside, malvidin-3,5-diglucoside, cyanidin-3,5-diglucoside, peonidin-3,5-diglucoside, and the diglucosides of

malvidin, petunidin, and cyanidin. These pigments show strong antioxidant activity as well as offering that attractive color.

Jamun contains flavonoids at levels which fall between 29.45 and 36 mg quercetin equivalents (QE)/g in the pulp and between 29.45 and 208 mg QE/g in the seeds. The main flavonoids consist of quercetin and myricetin and kaempferol and syringetin and laricitrin and myricetin-3-O-glucoside and quercetin-3-O-glucoside and myricetin-3-O-pentoside. These substances contain antioxidants which also help to reduce inflammation in the body.

The fruit contains multiple phenolic acids which include gallic acid and ellagic acid and ferulic acid and caffeic acid and chlorogenic acid and p-coumaric acid and ellagitannins such as corilagin. Tannins which exist in large amounts within the seeds create the typical astringent flavor of jamun while they boost its antioxidant properties. The fruit contains carotenoids and phytosterols (β-sitosterol) and volatile terpenes which include α-terpineol and β-myrcene and trans-ocimene and cis-ocimene to create its scent and biological effects. The seeds contain jambosine along with other seed phytochemicals which scientists have linked to glucose metabolism during traditional studies.

Phytochemicals present in jamun interact with each other to exhibit a range of biological activities. These activities include antioxidant, antidiabetic, anti-inflammatory, antimicrobial, antihyperlipidemic, cardioprotective, hepatoprotective, gastroprotective, neuroprotective, and potential anticancer effects. Due to this diversity of phytochemicals and the biological activities they exhibit, jamun is considered to be a promising source of natural antioxidants and bioactive ingredients for the development of functional foods, nutraceuticals, and natural health products.

Health Benefits and Functional Potential of Jamun Fruit and Seeds

Jamun (*Syzygium cumini L.)* is a fruit that has been traditionally recognized for its health benefits. Jamun is used in various traditional medicinal systems like Ayurveda, Unani, Siddha and Homeopathic and in Sri Lankan and Tibetan medicinal system of alternative and complementary medicines. The history of the medicinal usage of jamun is marked by its prescribed usance by Charkha and Sushruta for curing many diseases like diarrhoea, obesity, vaginal discharge, menstrual disorders, haemorrhage, etc.

There is increasing scientific evidence that supports the use of jamun as a functional food. The health benefits of jamun are attributed to the various phytochemicals found in the fruit, including anthocyanins, phenolics, flavonoids, tannins, phenolic acids, and other bioactive compounds. These compounds are found in the jamun's pulp, peel, and seeds. The compounds found in jamun exhibit antioxidant, anti-inflammatory, antimicrobial, antidiabetic, and other pharmacological activities.

Antioxidant Activity

The antioxidant activity of jamun fruit and seeds is due to the phenolic compounds, flavonoids, anthocyanins, gallic acid, ellagic acid, and tannins that are present in the fruit. These phytochemicals are known to reduce oxidative stress in the body by scavenging free radicals and protecting the cells from oxidative damage. Jamun seeds have a significantly higher concentration of phenolic compounds compared to the jamun pulp, which makes them a valuable source of natural antioxidants that can be used in functional foods and nutraceuticals.

Antidiabetic Potential

One of the most extensively investigated biological activities of jamun and its seeds is its antidiabetic potential. The seeds of jamun have traditionally been used for managing glycaemia in diabetics. Compounds such as phenolic compounds, flavonoids, tannins, ellagic acid and jambosine have been identified as the bioactive compounds in the seeds that contribute to regulating blood glucose in diabetic patients. Studies have also revealed the ability of jamun to inhibit enzymes that hydrolyse carbohydrates, thus contributing to glycaemic control in diabetics. However, more clinical studies are required to investigate the efficacy of jamun in managing diabetes.

Anti-inflammatory Activity

The phenolic and flavonoid compounds of jamun have been implicated in the anti-inflammatory activity of the fruit. Compounds like quercetin, myricetin, ellagic acid and anthocyanins have been reported to exhibit anti-inflammatory activity by reducing oxidative and inflammatory responses in the body.

Cardioprotective Potential

Jamun contains various phytochemicals that are rich in antioxidants. These phytochemicals contribute to the cardioprotective potential of jamun by reducing oxidative stress in the body and supporting lipid metabolism. The flavonoids and phenolic compounds in jamun have been reported to improve the antioxidant defence mechanisms in the body and protect the lipids in the blood from oxidative modifications, especially the low-density lipoprotein (LDL) oxides. LDL oxides are associated with cardiovascular risks.

Antimicrobial Activity

Extracts of jamun fruit and its seeds have exhibited antimicrobial activity against various bacterial and fungal species. The presence of phenolic compounds, flavonoids, and tannins in these extracts contributes to their antimicrobial

properties. These compounds disrupt the structure and growth of the microbes. The antimicrobial properties of jamun suggest its potential for use as a natural antimicrobial agent in foods and nutraceuticals.

Digestive Health Benefits

The fibre present in the pulp of jamun fruit can benefit the digestive system. The fibre promotes proper functioning of the intestines and aids in the regularity of bowel movements. The tannins in jamun fruit and its seeds provide astringent properties to the fruit. These tannins have been associated with benefits to the gastrointestinal system.

Hepatoprotective Potential

Studies have indicated the potential of jamun's extracts to protect the liver. The antioxidant constituents of jamun, such as phenolic compounds and flavonoids, are responsible for this potential. These compounds protect the liver from oxidative injury by reducing lipid peroxidation and increasing the antioxidant defences of the body.

Potential Anticancer and Neuroprotective Activities

Bioactive compounds present in jamun, particularly anthocyanins, flavonoids, and phenolic acids, have demonstrated potential anticancer and neuroprotective activities in experimental models. These effects are associated with modulation of oxidative stress, inflammatory responses, and cellular signalling pathways. However, further well-designed clinical studies are necessary to validate these protective effects in humans.

Nutraceutical Potential of Jamun Seeds

Jamun seeds, traditionally considered an underutilized by-product, have gained significant interest as a potential source of functional ingredients due to their high levels of phenolic compounds, tannins, dietary fibre, and other bioactive constituents. Seed powder and extracts are being explored for their incorporation into functional foods, beverages, and nutraceutical formulations owing to their antioxidant potential and possible role in supporting glucose metabolism. Jamun seeds have an immense potential as antimicrobial, antioxidant, gastroprotective, antidiabetic, Hypolipidemic, Cardioprotective, Immunomodulatory, radioprotective agents etc.

Post harvest losses of jamun fruits

Though Jamun has many health benefits, it is highly perishable in nature and suffers from the heavy losses after harvest particularly during the postharvest handling. The fruit can be stored for few days (1-2 days) at normal temperature whereas it can be stored for 3 weeks at 85 – 95 % when precooled and packed into perforated polythene bags. It is necessary to process the fruits into different value-added products by employing different methods of fruit preservation. Jamun fruits are processed in to different fermented and non-fermented beverages. Besides that, good quality jelly, jam, leather, wine can be prepared.

Value Addition Opportunities for Jamun

Jamun offers multiple avenues for value addition through its transformation into functional foods, nutraceutical ingredients, and natural additives that harness its rich anthocyanin and phenolic profile. Strategic utilization of both primary fruit fractions and processing by-products can convert this underutilized resource into a portfolio of high-value, health-oriented and eco-conscious products.

Functional Food and Beverage Products

Jamun pulp and juice can be processed into ready-to-serve (RTS) beverages, squash, syrup, and jam, which serve as convenient carriers of bioactive compounds such as anthocyanins and phenolics. These jamun-based products generally show good sensory acceptability during storage, with total soluble solids, pH, and total sugars increasing over time, while acidity, total phenolics, and anthocyanin contents gradually decline. Such data on physicochemical and bioactive changes provide a basis for optimizing formulation, processing conditions, and storage regimes to retain functional quality, thereby elevating jamun from a seasonal fruit to a year-round value-added commodity.

Nutraceuticals and Bioactive Ingredient Extraction

The high concentration of anthocyanins and diverse phenolic compounds in jamun fruit, particularly in the peel and seed, enables the development of nutraceutical ingredients and standardized extracts. Recent work has optimized green extraction techniques, such as ultrasound-assisted enzymatic extraction, to obtain anthocyanin-rich extracts with high total anthocyanin content, phenolics, and strong antioxidant activity, suitable for application in dietary supplements and functional formulations. These concentrated extracts, formulated as powders, capsules, or liquid concentrates, allow jamun bioactives to be positioned in the nutraceutical market targeting oxidative stress, glycemic control, and cardiometabolic health, thereby substantially enhancing its economic value.

Natural Colorant and Clean-Label Additive

The intense purple coloration of jamun, attributable to its anthocyanin profile (including cyanidin, delphinidin, peonidin, pelargonidin, petunidin, and malvidin derivatives), confers a strong potential as a natural food colorant. Anthocyanin-rich extracts from jamun can be incorporated into beverages, confectionery, dairy products, and bakery items as biocolorants, addressing consumer demand for clean-label, synthetic dye-free products while simultaneously contributing antioxidant functionality. Stabilization strategies such as pH control, co-pigmentation, and encapsulation can

further improve the technological performance of jamun anthocyanins, enabling their commercialization as high-value natural additive ingredients.

Jamun-Enriched Processed Foods

Beyond simple preserves and beverages, jamun can be integrated into diverse processed foods, including yogurts, ice creams, bakery fillings, snacks, and health drinks, to deliver both sensory appeal and health benefits. Such jamun-enriched formulations tap into its documented pharmacological activities particularly antidiabetic, antihyperlipidemic, and antioxidant effects and support the development of tailored products aimed at lifestyle disease management. From a food technology perspective, this integration enables product differentiation in competitive markets and contributes to repositioning jamun from a traditional fruit to a modern functional ingredient in mainstream food systems.

By-Product Utilization and Sustainability

Another way to add value to jamun products is to utilize the residues from jamun processing. These residues contain dietary fibre and bioactive compounds. These by-products can be converted into antioxidant powders or fiber-rich ingredients. These ingredients can be added to bakery goods, cereal products, and health supplements. Utilizing these by-products can reduce waste from jamun processing and increase the sustainability of the process. Adding value to these residues also increases the attractiveness of jamun products to industry and consumers who are interested in sustainability.

Challenges in Jamun Utilization

Although jamun contains many beneficial phytochemicals and has therapeutic properties, there are challenges to the utilization of jamun. The fruit is seasonal and is usually obtained from scattered trees, which leads to inconsistency in supply and quality. There are no standardized technological protocols for processing jamun and its anthocyanin pigments. Jamun's pigments are sensitive to environmental factors and degrade during processing and storage. Jamun has a strong astringent flavor and intense color, which can be challenging to formulate for consumer acceptability. Additionally, there is a lack of clinical evidence of jamun's health benefits, a lack of regulatory information, and limited consumer awareness of jamun outside of its traditional regions, which pose challenges to marketing jamun products in other regions and in the functional and nutraceutical food markets.

Future Scope and Research Directions

There is considerable scope to expand jamun's role in food and health systems through targeted research and development. At the production level, work on improved cultivars, organized orchards, and optimized postharvest protocols could ensure consistent quality and reliable raw material supply. In processing, future efforts should optimize green extraction and stabilization techniques for anthocyanins and phenolics, scale them to industrial levels, and develop innovative jamun-based products such as low-sugar functional beverages, synbiotic dairy products, and high-fiber snacks. From a health perspective, well-designed clinical trials, toxicological studies, and bioavailability assessments are needed to substantiate antidiabetic, antihyperlipidemic, and antioxidant claims and to support regulatory approval of jamun-derived functional foods and nutraceuticals. Interdisciplinary work linking food technology, nutrition, and socio-economics could further clarify jamun's potential contribution to sustainable value chains and rural livelihoods.

Conclusion

Jamun is nutritionally rich fruit with many therapeutic benefits due to bioactive composition. However, seasonal availability and perishable nature limit its utilization. Therefore, innovative processing and value addition can help in reducing post-harvest losses and increase is commercial potency.

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