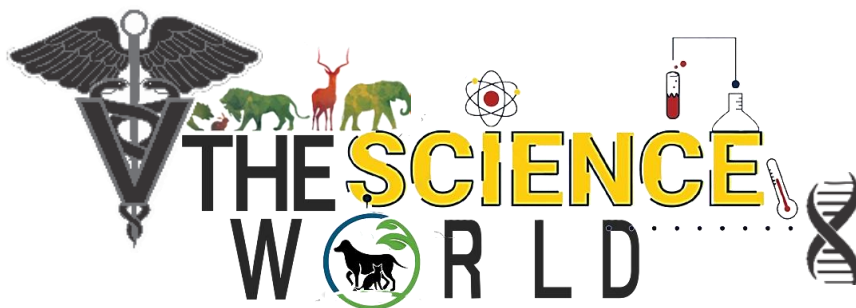




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Jamun Seed: A Natural Functional Food for Diabetic Wellness

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INTRODUCTION

Jamun (*Syzygium cumini* (L.) Skeels) is a polyembryonic species of the Myrtaceae family grown for its fruit, timber, and ornamental values. The tree is relatively drought tolerant and is mostly grown in deep loam and well-drained soil in many tropical and sub-tropical region. It is native to India, Myanmar and Sri Lanka, and was later introduced to Himalayan Asia, China, Eastern Australia, and the Southeast Asian islands. Country ranks second in the production of *S. cumini* with a contribution of nearly 15.4 per cent to the world's total annual output of 13.5 million tons. In India, Maharashtra leads the production followed by Gujarat. Jamun fruits are small, usually oval-shaped with a pink purple to blue black colour when completely ripe with a subtly sweet, astringent, and sour flavour, and a firm seed inside (Tak *et al.*, 2022). The blossoms are important source of honey from *Apis dorsata* in North India. Three triterpenoids are reported to be present in the flowers namely acetyl oleanolic acid, eugenia-triterpenoid A and eugeniatritetrapenoid B. Jamun flowers also contain ellagic acid and the flavonoides; isoquercitrin, quercetin, kaempferol and myricetin. The average pulp recovery from the Jamun fruits is around 50 per cent, while the peels and the seeds account for the rest 50 per cent. Fruit has 83 per cent moisture, 0.3 per cent fat, 0.9 per cent crude fibre, 0.7 per cent protein, 14 per cent carbohydrate and 0.4 per cent ash. (Kumar *et al.*, 2023). The fleshy component of the pericarp contains sterols and small quantity of essential oil and major components appears to be triterpenohydroxy acid and oleanolic acid. Jamun fruits are a rich source of iron, sugars, mineral, carbohydrate, anthocyanin and Oxalic acid, tannic acid, gallic



acid and the major secondary metabolites responsible for the astringency taste of seed as well as pulp. The high level of antioxidant and polyphenolic compounds present in the jamun pulp and seeds are reported to possess free radical scavenging as well as anti-inflammatory activities, which have a number of reported human health benefit. Jamun fruit is highly perishable and is also processed in variety of products including the beverages, jams, jellies, vinegar, wines and squashes. Although the fruit pulp is extensively utilized, the substantial quantity of seeds is generated as by-product during fruit consumption and processing. This creates an opportunity for the recovery and utilization of jamun seeds as a source of nutritionally valuable and biologically active compounds (Singh *et al.*, 2011)

Jamun (*Syzygium cumini* L. Skeels) has a long history of use in traditional medicinal systems including Ayurveda, Unani and Siddha because of the high concentration of phytochemicals in them. Different parts of plant, particularly the fruit, seed, bark and leaves have traditionally been utilized for managing various health conditions. The seeds have received particular attention in traditional practice because of their perceived usefulness in the management of disorders associated with elevated blood glucose. The traditional importance of jamun seeds has subsequently stimulated the scientific investigation into their phytochemical composition and biological properties. Studies have identified phenolic compounds, flavonoids and other secondary metabolites in the seeds, with gallic acid and ellagic acid reported among important phenolic constituents. The antioxidant activity of jamun seed extracts has also been associated with their phenolic and flavonoid content (Kumar *et al.*, 2022).

Previous research indicates that polyphenolic constituents found in *Syzygium cumini* (jamun) fruit and seeds may interfere with the activity of carbohydrate-hydrolysing enzymes, particularly α -amylase and intestinal α -glucosidase. These enzymes are involved in the breakdown of complex carbohydrates and starch into smaller sugars that can subsequently be absorbed, and their inhibition may therefore help reduce the postprandial increase in blood glucose. As α -amylase and α -glucosidase are established targets in the management of type 2 diabetes, naturally occurring plant polyphenols have attracted considerable interest as potential sources of bioactive compounds for glycemic management. Studies on jamun seeds have reported appreciable antioxidant activity and inhibitory effects on carbohydrate-digesting enzymes, which have been associated with their rich polyphenolic composition (Arivalagan *et al.*, 2021)

Nutritional composition of Jamun Seed

Jamun seeds are rich source of nutrients containing carbohydrates (89.68%), protein (4.68%), fiber (1.21%), fat (1.28%), calcium (135.86%), iron (4.2%), and ash content (3.13%)



with significant amounts of iron, potassium and relatively low volumes of fat and cholesterol. The seeds also have substantial amounts of dietary fiber and appreciable quantities of anthocyanins, chlorophyll, phytosterols, amino acids, vitamin C, vitamin B complexes (thiamine, riboflavin, folic acid), essential oil, albumin and fats. Fatty acid profiling of the seeds reveals the presence of lauric, myristic, palmitic, stearic, oleic, linolenic, malvalic, and sterculic acids as predominant fatty acids. Phytoconstituents of seed kernels are mainly gallic acid, corilagin, 1-galloyl glucose, 33-galloyl glucose, 6-hexahydroxy diphenoyl glucose, ellagic acid, β -sitosterol, quercetin, 4,6 hexahydroxydiphenoyl glucose. Jamun seeds exhibit various functional qualities including anti-cancer, antioxidant, anti-diabetic, anti-microbial and cardiovascular protection (Kumar *et al.*, 2023).

Carbohydrates

Carbohydrates constitute the major nutritional component of jamun seeds. Among the digestible carbohydrates, starch is considered the predominant fraction with reported concentration ranging from approximately 23 to 60 g per 100g dry matter. In contrast, soluble sugars occur at relatively low concentrations, generally within the range of 0.1-1.4g per 100g. It also contains the substantial amount of non-digestible carbohydrate fraction, particularly dietary fibre. The fibre fraction is nutritionally important because dietary fibres can influence gastrointestinal function and may contribute to the modulation of intestinal microbiota and carbohydrate and lipid metabolism (Tak *et al.*, 2022)

Proteins:

Protein constitutes up to approximately 8 per cent of seed dry matter, whereas considerably higher values have been reported when the seed were analyzed on a fresh matter basis. Free amino acids have also been detected in jamun seeds. The glycoprotein present in seeds exhibits hypoglycemic activity and is thus used in the treatment of diabetes mellitus. Researchers have shown that Jamun Seed waste from fruit processing units is a sustainable and environmentally friendly source for the production of specific antioxidant peptides (Tak *et al.*, 2022).

Lipids

The total lipid content of jamun seed is low (below 1.5 g/100 g). It has a remarkably high amount of monounsaturated fatty acids 292.79 mg per 100 g. The saturated fatty acids (SFA) account for 50 per cent and unsaturated fatty acids (UFA) including monounsaturated fatty acids and polyunsaturated fatty acids for 14 per cent and 36 per cent of total fatty acids, respectively. Among SFA, lauric acid (12:0; 2.8%), myristic acid (16:0; 31.7%), palmitic acid (16:0; 4.7%), and stearic acid (18:0; 6.5%) were determined. Oleic acid (18:1 n-9; 32.2%),



linoleic (18:2 n-6; 16.1%), and epoxy and cyclopropanoid fatty acids, such as malvalic (1.2%), sterculic (1.8%), and vernolic (1.3%) acids, were also found in the fatty acid profile of jamun seed oil. A low content of lipids and a high content of dietary fiber make the nutritional value of jamun seed low, reaching only 267 kcal/100 g which can be considered nutritionally beneficial in the context of the current global problem of overweight and obesity in humans (Tak *et al.*, 2022).

Micronutrients

Jamun seeds contain a high amount of minerals and ascorbic acid content. The mineral profiling varies with the different soil nutrition and climatic conditions. The predominant mineral in jamun seeds is potassium (606.46 mg/100g), followed by calcium (135.86 mg/100g), magnesium (111.60 mg/100g), sodium (43.9 mg/100 g), iron (4.20 mg/100 g), copper (2.13 mg/100 g), chromium (1.40 mg/100 g), zinc (0.46 mg/100 g), and manganese (0.40 mg/100 g). In addition to minerals, ascorbic acid has been detected in jamun seeds, although reported concentrations differ markedly among investigations. Along with the remarkable mineral profile, Jamun seed also have appreciable vitamins including ascorbic acid (1.84–35.75 mg/100 g) and pantothenate and niacin (0.09 mg/100 g) among water-soluble vitamins and retinol 3 IU per 100g among the fat-soluble vitamins (Kumar *et al.*, 2023).

Bioactive Compounds

Jamun seeds are rich in bioactive compounds with significant economic potential. The bioactivity of jamun seed is related to the presence of phenols, flavinoids steroids, alkaloids, triterpenoids, tannins and saponins. The major phytochemicals reported in seed kernels include gallic acid, corilagin, ellagic acid, β -sitosterol, quercetin, 1-galloyl glucose, 33-galloyl glucose, 6-hexahydroxy diphenoyl glucose, and 4,6 hexahydroxydiphenoyl glucose. The seeds possess antidiabetic potential due to the presence of phenolics and glycosides, which prevent starch from converting into sugar and help avert diabetic complications such as cataracts and neuropathy. Pharmacological research has demonstrated that the seeds exhibit antibacterial, anti-inflammatory, antioxidant, cardioprotective, anticancer, and antidiarrheal properties (Ahmed and Ejaz, 2025).

Health-Promoting Applications as a Food Ingredient

Nutritional constituents of Jamun Seeds are optimum for baking goods with a low glycemic value and high digestibility with health benefits for liver function. Jamun Seed powder has a low-to-medium protein content, high dietary fiber content, and calcium, thus forming a good blend with whole wheat flour for functional cookies, biscuits, and cakes. Fortification of jamun-based ready-to-drink with the Jamun Seed powder enhanced its



antioxidant related constituents, resulting in increase in the total phenolic content, flavonoid content and carotenoid content (Kumar *et al.*, 2022).

Potential Health Benefits

1. **Antidiabetic Potential:** One of the most extensively investigated properties of jamun seeds is their antidiabetic activity. Bioactive constituents present in seeds inhibit the α -amylase activity which slows down starch digestion, influence the carbohydrate metabolism and glucose regulation. Jamboline has been reported as one of the glycosidic constituents associated with the antidiabetic effects of jamun seeds.
2. **Anti-hyperlipidemic and Anti-hypercholesterolemic Potential:** The presence of several bioactive compounds in jamun seeds helps to regulate the blood lipid profile. The extract was also reported to decrease the total cholesterol-to-HDL cholesterol ratio, LDL cholesterol levels, and the activity of 3-hydroxy-3-methyl-glutaryl-coenzyme A (HMG-CoA) reductase, an important enzyme involved in cholesterol biosynthesis.
3. **Antioxidant Potential** Jamun seeds are the valuable sources of phenolic compounds, including gallic acid, ellagic acid, ferulic acid and quercetin, which contribute to their antioxidant activity. In particular, extracts from indigenous black jamun landraces from the Gir forest region of India showed significant antiradical activity against DPPH radical.
4. **Anti-Inflammatory Activity:** Jamun seeds have demonstrated anti-inflammatory potential, which is attributed partly to their phenolic and other bioactive constituents. Jamun seed extract may suppress inflammatory responses and reduce marker associated with acute and chronic inflammation.
5. **Antimicrobial Activity:** Jamun seeds have been investigated as a source of natural antimicrobial compounds. The extract of jamun seeds exhibited the antibacterial potential against multidrug resistant human bacterial pathogens (Tak *et al.*, 2022).

Conclusions and Future Perspectives

Jamun Seed represents a promising and underutilized source of bioactive compounds with a considerable potential for the nutraceuticals and functional food applications. The jamun seed extract and their bioactive constituents may have particular relevance to the metabolic health, especially glucose and lipid metabolism. Its richly- varied composition of bioactive compounds and reported antidiabetic along with their antioxidant, anti-inflammatory, cardiometabolic and antimicrobial potential activities provide a scientific basis for further investigation. Also, as a potential source of nutrients (carbohydrates, proteins, lipids, vitamins



and minerals) researchers have established a role for jamun seed as a health promoting and food ingredient (Kumar *et al.*, 2022).

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