



A Review on Critical role of Jamun (*syzygium cumini L.*) seed powder and its Fruits in Food and Medicinal Sectors

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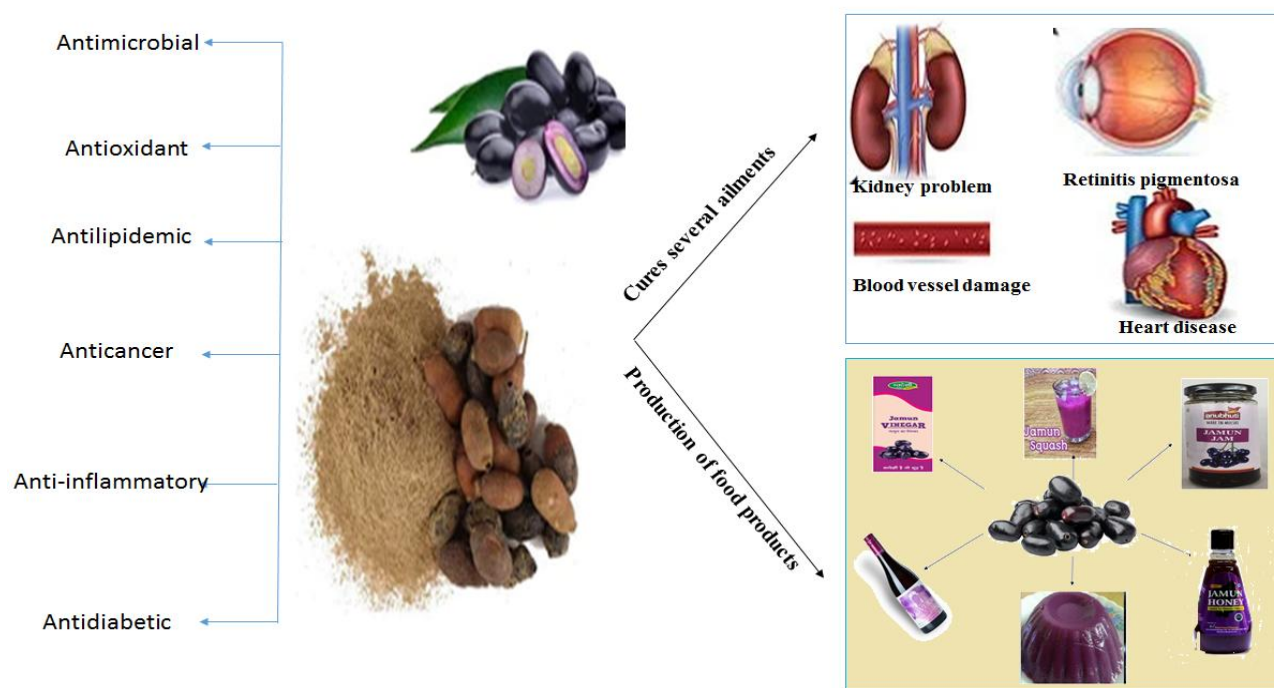
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ABSTRACT

Jamun is a nature gifted medicinal plant have played a vital role in the treatment of divergent diseases such as diabetes, ulcer, digestive problem, diarrhoea, and heart disease. Also, the combination of nutritional, bioactive, and phytochemical constituents of this plant utilized for reducing the blood pressure and to prevent cancer. The present review explores the overview of jamun seed and fruit and how they are employed as therapeutics for diabetic patients through the investigation of pharmacological activities of jamun in previously reported literatures. The value-added products of jamun seed powder and fruits like biscuits, cakes, millets, jam, honey, coffee, cheese and health drinks respectively for mankind were also discussed. These valuable goods are mainly utilized by diabetic patients. The intention of this review is to provide a critical role of jamun seed and fruits in medicinal field as well as food industry by the way of analyzing the existing data.

Keywords: Jamun seed powder; Pharmacological Activities; Diabetes Mellitus; Jamun fruit; Value-added products

Graphical Abstract



1. Introduction

Jamun plays a vital role in medicinal field, belongs to the *Syzygium* genus, *cumini* species and family of *Myrtaceae*. Various synonyms of jamun are Jambul, Jambolan, Black plum, Blackberry, Malabar plum etc. (Prachi Agarwal et al. 2019; Munmun Joshi et al. 2019). World Health Organization (WHO) recommended this plant as a safe drug since jamun is used in the treatment of various diseases (Veeram Anjali et al. 2017). Jamun is a very tall and tropical evergreen tree endemic to the Indian subcontinent. Though, the growth of jamun trees is found scattered throughout the other subtropical regions like South America, Africa, Madagascar, Thailand, Philippines etc. (Deepti Katiyar et al. 2016). India comes seventh largest plum producer in the world with 2,51,389 tonnes production per year based on data from the Food and Agriculture Organization Corporate Statistical Database (FAOSTAT). In India, the major

producer of jamun is Maharashtra followed by Uttar Pradesh, Tamilnadu, Gujarat and others (Shashikant S. Patil et al. 2012). Jamun trees grow up to an altitude of 50 feet and have a large shade. The Taxonomical arrangement of Jamun with their parts are described (Prachi Agarwal et al. 2019) in the Fig. 1.



Fig. 1 Taxonomical classification of Jamun and other parts

The bark of the jamun looks like scaly and darkish brown in colour. It is mainly used in tanning of leather as well as conserving the fishing nets (Veeram Anjali et al. 2017). The appearance of their leaves is oblong, glassy, leather like texture and fibroid in nature. The flowers are white in

colour and have stalkless, good aroma and filmy layered petals. It can grow annually during the month of March to April. Mostly their flowers are structured in a bundle and develops up to a diameter of 6m. The fruiting process starts after 2 months of flowering stage and mostly they are found in clusters. Generally, jamun fruits ripens during the month of April to July (Ahmad Nadeem et al. 2019; Kshirsagar RB et al. 2019). Jamun tree can be developed over a wide variety of soils. However, a deep loam and well-drained soil are required to keep the moisture content for excellent growth with a higher yield. For a good quality fruit, the soil should have a pH ranging from 6.5 to 7.5 with saltiness and swampy conditions. It was first reported in biomedicine in the century of mid-nineteenth through the investigation of diabetes mellitus (Prachi Agarwal et al. 2019).

All the parts of jamun are having a medicinal value due to the presence of bioactive compounds and nutritional value. These bioactive compounds having a properties like antioxidant, antifungal, anti-bacterial, & pharmacological properties. Hence, many countries implemented this plant not only in homeopathy practice but also employed in Unani, and Ayurveda to treat as well as prevent several ailments such as diabetes, heart disease, ulcer, retinitis pigmentosa, cancer, and diarrhoea (Yogendra Singh et al. 2019; Gajera HP et al 2017; Munmun Joshi et al. 2019).

The fabulous benefits of the jamun in human make it new research for reducing the financial burden on the Indian health care system are as follows:

- Purifies the blood and regulate the blood glucose level
- Maintain the normal urination and sweating
- Stimulates the liver function

- Rectify indigestion, and
- Act as a coolant (Kalse SB et al 2016; Vora A et al. 2019; Desai GB et al. 2019)

The bioactive compounds and nutritional value of the plant parts and their uses are enlisted in

Table

1.

Table 1 Numerous constituents of the various parts of Syzygium Cumini and its medicinal uses.

S.No	Parts of the plant	Nutritional Constituents	Chemical Constituents	Bioactive constituents	Medicinal uses	Reference
1.	Seed	Moisture, crude fat, proteins, fibres, vitamins, minerals, carbohydrates,	Polyphenols, tannins, and some metals such as zinc, chromium, vanadium, potassium and sodium.	Hexahydroxydiphenoyl glucose and its isomer hexahydroxydiphenic acid, 1-galloylglucose,	Diabetes, liver disorder, cardiovascular problem, allergies, viral infection, inflammation, and gastric ulcer diseases. Used as a paste if body burns.	Vora A et al. 2019; Yogendra Singh et al. 2019
2.	Leaves	-	Aliphatic alcohols, betulinic acid, crategolic acid, phenolic compounds such as	Myricetin 3-o-4''-acetyl- α -L-rhamnopyranoside, sitosterol, Quercetin, Myricetin, tocopherol	Dysentery, inflammation, haemorrhoids.	Yogendra Singh et al. 2019; Munmun Joshi

			ferullic acid, catechin.			et al. 2019
3.	Fruits	Carbohydrates, fats, proteins, minerals, Sugar, Non-reducing sugar,	Mallic acid, oxalic acid, citric acid, anthocyanins, tannins, chlorogenic acid	Anthocyanins, Gallic acid, delphinidin-3-gentiobioside and malvidin-3-lamaribioside, petunidin-3-gentiobioside, riboflavin	Diarrhoea, spleen and diuretic diseases, diabetes, stomach infections, strengthening of teeth.	H. P. Gajera et al 2017 ; Amol Changdeo Dagadkhair et al. 2017
4.	Stem bark	-	Betulinic acid, tannins, ellagic acid.	Beta-sitosterol, Friedelin, Myricetin, Kaempferol, di-dimethyl-5-hydroxypinoresinol, di-demethoxy- pinoresinol, pinoresinol and 4'-methyl-5'-hydroxypinoresinol	Digestive problem, astringent, bronchitis, asthma, and ulcers. Remove the impurities from blood.	Amol Changdeo Dagadkhair et al. 2017
5.	Flower	-	Kaempferol, Oleanolic	Eratelgic acid, Flavonoids	-	Amol

			acid, isoquercetin, quercetin, ellagic acid.	such as Eugenia-triterpenoid A, Eugenia-triterpenoid B, acetyl oleanolin acid		Changdeo Dagadkhair et al. 2017
6.	Roots	-	Isohamnetin-3-O-rutinside, flavonoid glycosides	Myricetin-3-O-glucoside, myceritin -3-O-robinoside.	-	

2. Jamun Seed

Jamun seed comprises an appropriate of phenolic compounds such as anthocyanins, gallic acid, tannins, steroids, flavonoids and therefore they are having a good anti-oxidant activity (Mushtari Akter Marufa et al. 2019; Sidana S et al. 2022). In Unani, their seed kernel is termed as Khasta Jamun. It has been acknowledged to be the good medicine for diabetes as it decreases the glucose level & urea in blood and cholesterol & triglyceride levels in serum. It is not only beneficial for the persons suffering from diabetes but also for treating the digestive problem. Jamun seed powder alters the inhibitory activity of many enzymes like α - amylase, sucrose, & α - glycosidase on carbohydrate metabolism and glucose homeostasis (Kalse SB et al 2016; Vora A et al. 2019). The jamun seed powder (JSP) was prepared by the procedure as follows: The seed and fruit pulp of jamun is first separated using pulper. Then the seed is washed in fresh water and dried in tray dryer at 60° C for 48 hours. After achieving the complete drying of seed, is subjected to pulverize for fine powder with a desired particle size (Yogendra Singh et al. 2019; Kshirsagar RB et al. 2019). Shikha Pandhi & Amrita Poonia (2013) studied the screening of jamun seed using various extraction methods such as Soxhlet extraction, Ultrasound-assisted extraction and Microwave-assisted extraction methods. They predicted both qualitative and quantitative analysis of alkaloids, phenols, flavonoids, proteins & amino acids presence in jamun seed powder which was prepared by extraction methods, using respective analytical tests. Besides, they found that the maximum yield of 11.65 for JSP was obtained by Microwave-assisted extraction than Soxhlet and Ultrasound-assisted extraction methods.

Ambika Chauhan & Intelli (2015) reported that 100gm of JSP contains 70.5gm of moisture content, 8.2gm of protein, 16.2gm of crude fiber, & 12.8gm of iron respectively. Kshirsagar RB et al. (2019) investigated the physico-chemical & nutritional properties of jamun

seed. They determined the mineral composition such as iron, calcium, magnesium, phosphorus, potassium & zinc and proximate composition include moisture, carbohydrate, crude fiber, fat, protein, & ash of JSP respectively. Furthermore, they found that the fat soluble vitamin A and water soluble vitamins like niacin, ascorbic acid as 3, 0.069, & 0.21 mg/100g for JSP.

2.1 Jamun Seed Powder in Diabetes

Diabetes or diabetes mellitus is a metabolic syndrome wherein the endocrine system, carbohydrates, fats and protein are not metabolized resulting in deficiency of insulin secretion i.e. hypoglycemia. India ranked second with over 77 million people had diabetes. In 2019, National diabetes and diabetic retinopathy survey reported that the prevalence of diabetes for males was 12% and for females for 11.7%. Majority of individuals under the category of Type II diabetes resulting in several complications like cardiovascular diseases, cataracts, eye problem, neuropathy, kidney and liver damage. These long-term complications are associated with the leading cause for morbidity and mortality (Vora A et al. 2019; Eswarappa G & Somashekar RK 2020). Jamun seed contains the most important alkaloids such as Jamboline, glycoside and antimellin which is greatly helpful to diabetes by reducing or halting the diastatic conversion of starch into sugar (Mahpara Safdar et al. 2006; Wasswa et al. 2019). Also, jamun seed and fruit holds the property of antihypercholesterolemia and helps to reduce the cholesterol and triglyceride levels in the blood. Many researchers investigated the antihyperlipidemic activity of jamun seed powder and fruits through the examination in diabetes rats. Vora A et al. (2019) investigated the execution of aqueous extract of jamun seed and oral hypoglycaemic drug sitagliptin (SITA) at the dosage ratio of 4:1 mg/Kg in streptozotocin induced diabetic rats for 28 days and studied the pharmacodynamic and pharmacokinetic interaction between them. From the study, they concluded that the jamun seed with a low level of SITA resulting in blood glucose

level rather than individual jamun seed or SITA which was analyzed by pharmacodynamic study. Besides, the combination of these drugs was significantly improved the kidney and liver functions. Besides, they have many antioxidants as well as bioactive compounds helps to prevent different metabolic diseases. Kandan Prabakaran & Govindan Shanmugavel (2017) evaluated the phytochemical bioactive compounds and invitro anti-diabetic activity of Syzygium cumini seed extract. Their study showed that the appreciable amount of flavonoid and steroid is present in the jamun seed which having an antidiabetic properties. The summary of literatures reported regarding the evaluation of pharmacological activities using jamun seed powder is presented in

Table

2.

Table 2 Summary of literatures reported regarding the evaluation of pharmacological activities using Jamun seed powder

S.No	Examination of Pharmacological activities	Source	Remarks	Reference
1.	<ul style="list-style-type: none">• Cardio protective activity	Isoproterenol induced myocardial infraction in albino rats	<ul style="list-style-type: none">• Investigated the methanolic extract of JSP on cardio protective effect against isoproterenol induced myocardial injury in rats.• Result showed that isoproterenol significantly increased the activities of enzymes in serum and decreased in heart tissues.	Mastan SK et al. 2009
	<ul style="list-style-type: none">• Antihyperlipidemic activity	High cholesterol fed diet rats	<ul style="list-style-type: none">• Result showed that serum cholesterol, triglycerides, low density lipoproteins, atherogenic index were decreased and increased the high density lipoproteins	Modi Dikshit et al. 2009

S.No	Examination of Pharmacological activities	Source	Remarks	Reference
			and their ration in hyperlipidemic rats.	
	<ul style="list-style-type: none"> Antihyperlipidemic activity 	Alloxan induced mild and severely diabetic rabbits	<ul style="list-style-type: none"> Supplemented the ethanolic extract of JSP on mild diabetic and severely diabetic rabbits for 21 days and treated with sephadex LH 20 chromatography. Result emanated that serum total cholesterol, triglycerides, high density lipo protein cholesterol and their ratio were significantly improved. 	Suman B Sharma et al. 2011.
	<ul style="list-style-type: none"> Antidiabetic activity 	Alloxan induced mild and severely diabetic rabbits	<ul style="list-style-type: none"> JSP was significantly decreased the glycosylated hemoglobin and increased the plasma insulin level in rabbits. Liver and muscle glycogen content were 	Suman Bala Sharma et al. 2009

S.No	Examination of Pharmacological activities	Source	Remarks	Reference
			increased in both mild and severely diabetic rats.	
	<ul style="list-style-type: none"> Antihyperglycemic activity 	Type II Diabetic patients	<ul style="list-style-type: none"> 2g of JSP was supplemented to 30 years type II diabetic patients for 60 days and analyzed the significant reduction of blood glucose level. Also observed the post prandial blood glucose level. 	Neha Ayya et al. 2015
	<ul style="list-style-type: none"> Antidiabetic activity 	Isoproterenol-induced myocardial infarction in rats	<ul style="list-style-type: none"> Revealed that JSP has high inhibitory effect on α-amylase of 95.4%. Suggested that JSP have an excellent anti-diabetic activity through the examination of phytochemical constituents such as 	Kandan Prabakaran & Govindan Shanmugavel 2017

S.No	Examination of Pharmacological activities	Source	Remarks	Reference
			flavonoids, glycosides, steroids, tannins etc.	
	<ul style="list-style-type: none"> Antihyperglycemic activity 	Male Sprague Dawley rats	<ul style="list-style-type: none"> Evaluated the potential of both jamun seed and fruit's ethanolic extracts against hyperglycemia. Serum glucose and insulin levels were monitored and depicted the blood glucose level. Regulated the insulin level in hypoglycemic rats. 	Ahmad Raza et al. 2017
	<ul style="list-style-type: none"> Pharmacodynamic activity Pharmacokinetic 	Streptozotocin induced diabetic rats	<ul style="list-style-type: none"> The combination of JSP & hypoglycaemic drug sitagliptin (SITA) reduced the blood glucose level. 	Vora A et al. 2019

S.No	Examination of Pharmacological activities	Source	Remarks	Reference
	activity		<ul style="list-style-type: none"> Also improves the kidney, liver functions & lipid parameters 	
	<ul style="list-style-type: none"> Antidiarrheal activity Antimicrobial activity Spasmolytic activity 	Carbachol induced rats	<ul style="list-style-type: none"> Ethanol extract of JSP inhibited the phase contractions induced by carbochol induced rats due to the presence of phenols, steroids, alkaloids. 	Monteiro FS et al. 2020
	<ul style="list-style-type: none"> Antidiabetic activity Antihyperlipidemic activity 	Patients with Type II diabetes Milletus.	<ul style="list-style-type: none"> Group A patients who have taken 10g/day JSP powder for 90 days. FGP and PP were decreased with increasing the days. Group B patients who have taken the same amount of placebo powder for 90 	Sidana S et al. 2022

S.No	Examination of Pharmacological activities	Source	Remarks	Reference
			days. FGP and PP were increased with increasing the days.	

JSP = Jamun seed powder, FGP = Fasting Plasma Glucose, PP = Post-prandial Plasma

2.2 Jamun Seed Powder in Food Products

Jamun seed powder is not only used as a medicine but also used to prepare different nutritionally enriched bakery products such as cakes, cookies, & biscuits in order to improve the quality and quantity of nutrients like carbohydrates, fiber content, and protein respectively (Mushtari Akter Marufa et al. 2019; Kalse SB et al 2016) . These products are specially made for diabetic patients in which it reduces the postprandial blood sugar level. Abinaya Kannan & Yamuna Devi Puraikalan (2013) developed the cookies using different proportions of JSP such as 5%, 10%, & 15% and evaluated the organoleptic properties like colour, appearance, flavour, viscosity, and taste.

Among the JSP concentrations, 10% of the powder produced cookies have a high nutritional value. Desai GB et al. (2018) prepared the nutritionally enriched multigrain cookies using combinations of refined wheat flour (RWF), finger millet flour (FMF),

and JSP. They reported that the prepared cookies have a good nutraceutical (pharmaceutical & nutrients) value with the proportion of 75% RWF, 10% JSP, & 15% FMF respectively. JSP prepared the biscuits when combined with finger millet and maida using traditional creamy method was described by Kalse SB et al (2016). They determined the length, width, thickness, density, calorific value & textural properties of biscuits respectively. Their results revealed that 81% maida, 9% JSP & remaining 10% finger millet contributed the acceptable combination for biscuit preparation with good colour, taste and flavour, were evaluated by sensory analysis treatment. Mushtari Akter Marufa et al. (2019) evaluated the nutritional and functional properties of JSP which was extracted from fresh jamun. Further, they developed the cakes by incorporating different proportion combination of JSP and wheat flour and then predicted the chemical composition such as moisture, protein, ash, fat, carbohydrate and energy respectively. Their results revealed that the proportion of 10% JSP & 90% wheat flour contributed the most acceptable one for good cake preparation which was evaluated by sensory analysis. Apart from the preparation of cookies, JSP used on bleached cotton fabric at different concentrations of bacterial strains such as staphylococcus aureus & streptococcus agalactiae to evaluate its antibacterial activity against some gram positive & gram-negative strains, was attempted by Subrata Das et al. (2018). Also, the zone of inhibition (ZOI) was measured at various concentration of jamun extract and showed that 24mm ZOI for 77% streptococcus agalactiae strain and 18mm ZOI for 55% staphylococcus aureus strain.

3. Jamun Fruit

Jamun fruit comprises of five major compounds of glycone anthocyanidins such as Delphinidin (Dp), Cyanidin (Cy), petunidin (Pt), peonidin (Pe), and Malvidin (Ma). Apart from that, it has many beneficial compounds such as carotene, riboflavin, thiamine, niacin, calcium, phosphorus, iron and sugar which is mainly used for enteralgia, scurvy, ulcer, liver problems, and flatulence problems. The presence of these compounds possesses anti-oxidant, anti-inflammatory, antidiabetic, and antimicrobial activity in fruit (Farrukh Aqil et al. 2014). The antimicrobial activity and cytotoxicity of ethanolic extract of jamun fruit against staphylococcus aureus & S. epidermidis (gram positive), pseudomonas aeruginosa (gram negative) and yeast of candida SP & Cryptococcus neoformans was studied by Ketylin F. Migliato et al. (2010). They noticed that the minimum inhibitory concentration (MIC), Minimum bactericidal concentration (MBC), & minimum fungicidal concentration (MFC) values were remarkably the same for all the microorganisms. In addition, the cytotoxicity index of the dried extract was evaluated with the concentration of 400µg/ml. Gajera HP et al. (2017) evidenced that small fruit has higher antidiabetic activity and antioxidant compared with the larger one through the investigation of methanolic extract of jamun fruit. Besides, inhibitor on porcine pancreatic α -amylase (IC_{50}) was low in small fruit. Depending upon the geographical conditions such as fruit pulp content, seed weight, & its diameter, the fruit size is divided in to two: small & big. The small size fruit named as *Kaatha Jamun*, is rounded in shape and has sweet to taste whereas the big one called as *Ras Jamun*, is oval in shape and has a combination of sweet and sour to taste (Manjeshwar S. Baliga et al. 2013). The phenolic compounds such as anthocyanins, tannins, & acids are very low in small size pulp and it's vice versa in big size one. The fully ripe fruit is deep purple or black in colour due to the greater amount of anthocyanin present in the fruit (Deepti Katiyar et al. 2016; Navnidhi Chhikara et al.

2018). An immature (raw) fruit is greenish yellow in colour and has a lesser amount of ellagitanins, flavonoids, gallic acid and ellagic acid.

Isanaia Maria De Carvalho Tavares et al. (2016) predicted the 74 different phenolic compounds in Jambolan fruit such as 9 anthocyanins, 9 flavonols, 19 flavanonols, 8 flavan-3-ol monomers, 13 gallotannins & 13 ellagitannins and some proanthocyanidins, gallic and ellagic acids through the analysis of high performance liquid chromatography with a diode array detection coupled with an electrospray ionization mass spectrometry (HPLC-DAD-ESI-MS/MS). They further reported that the skin of the jamun fruit contains a larger amount of proanthocyanidins, gallotannins & ellagitanins. The same study was carried out by the same authors (Tavares Isanaia Maria de Carvalho et al. 2017) in 2017 in which the dehydrated powder was formed by foam mat drying method. Their result emanated that the dehydration temperature had an antagonistic effect on anthocyanin of juice and 70°C was the most suitable the dehydration temperature without affecting the nutritional quality of the jamun juice. Jamun fruit becomes astringent due to the presence of gallic acid and tannins. Besides, 59 wt% of mallic acid and a small amount of oxalic acid is present. In addition, jamun fruit contains several principal sugar components such as glucose, fructose, mannose, & galactose. These phytochemical and nutritional constituents present in the fruits depends on the maturation of the fruit pulp, atmospheric conditions, cultivation practices, and post-harvest handling and processing. Besides, jamun fruit is used to make jam, jellies, wine, preservatives, cheese, toffee, health drinks, and squashes (Yogendra Singh et al. 2019; Amol Changdeo Dagadkhair et al. 2017). Raisins of jamun are utilized for ulcer, diabetes, and acidity problems. The vinegar or syrup produced from jamun fruit is an excellent remedy for spleen enlargement and chronic diarrhea. Jamun honey is used to cure kidney disorder & seasonal problems and regulates the blood glucose level. If the

children consume the jamun fruit juice mixed with goat milk resulting in sudden relief of diarrhea (Mahpara Safdar et al. 2006; Amol Changdeo Dagadkhair et al. 2017).

Fig. 2 shows the several food products formed from jamun fruit which is publicized in the market.



Fig. 2 shows the various kinds of food products of jamun fruit.

Shashikant S. Patil et al. (2012) produced the red wine from jamun fruit and analysed the alcoholic content of wine by varying the concentration of total soluble sugars (TSS) and *saccharomyces Cerevisiae* yeast level during fermentation process. They reported that the wine had a maximum amount of 8.22 % alcohol at the optimum conditions of 8.18% TSS and 10 % yeast. Furthermore, there was no significant changes in colour and clarity of wine if further addition of yeast. Swaminathan Santhalakshmy et al. (2015) probed the effect of inlet temperature ranging from 140°C to 160°C on the physicochemical properties like moisture content, water activity, bulk density, hygroscopicity, powder morphology, and glass transition temperature of spray dried jamun juice powder. They found that at higher inlet temperatures, the moisture content of the juice powder was increased and affected the powder colour. Furthermore, at lower inlet temperature, the particle surface was smoother while at higher temperature, the particle was spherical in shape with shrinkage which was analyzed by scanning electron microscopy (SEM). Nitra Nuengchamnog and Kornkanok Ingkaninan (2009) identified the antioxidant compounds include a mixture of hydrolysable tannins and fruit acids, anthocyanins, malvidin-3-o-p-coumaroyl glycoside in jamun fruit wine using the analysis of high liquid performance chromatography (HPLC) coupled on-line to a radial scavenging detection system and mass spectrometry (MS).

Conclusion

Many reviews are conducted earlier explored on pharmacological potential of jamun such as antidiabetic, antioxidant, antihyperglycemic, therapeutic activities etc. whereas the present review is aimed at discussing the jamun, their applications in medicinal as well as in food sectors. The presence of antioxidant and bioactive compounds of jamun seed aids to prevent the morbidity

and mortality among diabetic people and reducing the side effects of synthetic drugs for several ailments. Besides, the jamun fruit contains several phenolic compounds include 9 anthocyanins, 9 flavonols, 19 flavanonols, 8 flavan-3-ol monomers, 13 gallotannins & 13 ellagitannins, having a great ability to cure or prevent many diseases like enteralgia, scurvy, ulcer, liver problems, flatulence problems and cancer. In addition, this review highlighted the discussion of valuable goods that are produced from both jamun seed powder and fruits and their benefits in human. To conclude, a multifarious health benefits of jamun plant and their parts will provide a great support to the health care system around the globe.

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