International Journal of Research in Pharmacy and Pharmaceutical Sciences
www.pharmacyjournal.in
ISSN: 2455-698X
Received: 17-03-2023, Accepted: 02-04-2023, Published: 17-04-2023
Volume 8, Issue 2, 2023, Page No. 25-32

A review on pharmacognosy and pharmacology of *Syzygium cumini* leaf

Chaithra N[1*], Manoj R V[1], S P Keerthy[2]
[1] Department of Pharmaceutics, Sarada Vilas College of Pharmacy, Mysore, Karnataka, India
[2] Assistant professor, Department of Pharmacognosy, Sarada Vilas College of Pharmacy, Mysore, Karnataka, India

Abstract
Syzygium cumini (L.) Skeels sometimes referred to as the Java plum, black plum, jamun, or jambolana, is an evergreen tropical tree belonging to the family Myrtaceae. Jamun is a popularly used medicinal herb in Ayurveda. Despite the fact that it has several medicinal properties, there is some published research on the pharmacognostic characterisation and physicochemical examination of its leaves. Macroscopy, microscopy, powder microscopy, physicochemical analysis and preliminary phytochemical screening were the methods used for pharmacognostic characterisation. The microscopic analysis revealed helpful characteristics for the identification of *Syzygium cumini (L.)* Skeels leaf. Transverse section revealed the presence of a single layer of wavy epidermal cells with striated cuticle, palisade beneath the upper epidermis in the lamina region, a layer of sphaeraphide in the lamina region, collenchyma above and below the upper epidermis in the midrib region, Xylem and phloem in center, Sclerenchyma in between vascular bundle and collenchyma in midrib region. The lower epidermis has anisocytic stomata. Through powder microscopy, spiral vessels, calcium oxalate crystal sheaths in the lamina, fibre fragments, and bordered pitted reticulate vessels were seen. According to physical and chemical composition studies, Total ash was found to be 3.1%, acid insoluble ash was 0.7%, alcohol soluble and water-soluble extractive values were found to be 10.96% and 12.32% respectively. A phytochemical examination found sugar, lipid, glycoside, saponins, phenols, flavonoids, tannins, and steroids in the leaf. The study creates the initial report on pharmacognostic traits and a physicochemical characteristic that may be helpful for plant identification and authentication. This review will generate the data to justify the use of this plant in a variety of ayurvedic applications. It is effective in the treatment of diabetes mellitus, inflammation, ulcers and diarrhoea. Preclinical studies have also revealed that it has chemoprotective, radioprotective, and antineoplastic properties. The current review has been designed to describe the existing data on traditional and medicinal uses of the *Syzygium cumini* leaf.

Keywords: *Syzygium cumini*, Jamun leaf, phytochemicals, pharmacognosy, microscopy

Introduction
Syzygium cumini (L.) SKEELS, often known as jambolan, Java plum, black plum, or Jamun, is an evergreen tropical tree in the flowering plant family Myrtaceae. Other names for S. *cumini* include Calyptranthes jambolana, Eugenia jambolana LAM, Syzygium jambolana DC, and Syzygium jambolanum DC. It is reported to be widespread throughout India, with the exception of desert regions, and can be found in both wild and domesticated varieties. The evergreen Jamun plant is indigenous to India and Indonesia [4]. Due to the predominance of Jamun trees, Indian mythology refers to the Indian subcontinent as Jambudweep. It is indigenous to the Indian Subcontinent and nearby Southeast Asian countries including Myanmar, Sri Lanka, and the Andaman Islands. It may grow up to 30 metres (98 feet) in height and has a lifespan of over 100 years. It is a plant with rapid growth that many areas of the world regard to be an invasive species [2-3]. For its numerous uses, the entire plant has historically been utilised. Worldwide health organisations endorse *Syzygium cumini* as a secure medication for treating a number of ailments. The nutritional content of the entire plant is good. Despite their ethnopharmacological usage, leaves are now known to provide a wide range of medicinal benefits due to presence of many phytoconstituents. The leaves are used to treat leucorrhoea, stomach ache, dermopathy, fever, and constipation, as well as to restrict blood discharges in the faeces and minimise radiation-induced DNA damage [5]. Pharmacognostic and Physicochemical evaluation of medicinal plants is required for identification, detection of adulteration, and quality assessment, which is directly related to efficacy. The quality assessment of medicinal plants is critical in order to justify their acceptability in the current day. One of the primary issues confronting the herbal sector is the lack of strict quality control criteria for natural products. A study of the literature found that there are just a few studies on the Pharmaco0.gnostic evaluation of *S. cumini* leaf. As a result, a complete investigation on pharmacognostic standardisation and pharmacological activities of *S.cumini* leaf was conducted in accordance with API and WHO standards/guidelines for medicinal plants [7].

Pharmacognosy of jamun leaf
Active constituents of *Syzygium cumini* leaf
The different parts of Jamun have been subjected to isolation and characterization of various types of phytochemicals, including the flavonoids, phenolic acids, terpenes, tannins and anthocyanins. The leaves of Jamun were found to contain betulinic acid, crategolic acid, n-dotricontanol, n- hentriacontane, n-hepatcosane, mycaminose, myricetin, myricitrin, myricetin 3-O-(4″-acetyl)- α-L- rhamnopyranosides, n-nonacosane, quercetin, β-sitosterol, noctacosanol, n-triacontanol, triterpenoids, tannins, eicosane, octacosane and octadecane[23-24].The essential oils from Jamun leaves showed the presence of α-cadinol, geranyl acetone, muurolol, α-myrtenal, pinocarvone, pinocarveol, a-terpeneol, myrtenol, eucarvone, cineole, alloocimene, α-bornyl acetate, α-pinene, 2-β-pinene, caryophyllene, caryophyllene oxide, L-limonene, α-humulene, α-terpineol and α-terpineolene [20, 22].

Materials and methods

Plant material

In Pune, Maharashtra, India, on the campus of the Regional Ayurveda Institute for Fundamental Research, *Syzygium cumini* (L.) SKEELS, leaves of the plant were collected. The Flora database was used to identify and authenticate the plant material [8]. Additionally, plant material was matched to the herbarium specimens kept in the Institute's herbarium. A plant specimen herbarium was created and placed with a voucher specimen number in the herbarium department of the RAIFR, Pune.

Powder preparation

Shade dried leaves were made into powder using grinding mill; powder is passed through #60 sieve and kept in an airtight container for further analysis [9].

Macroscopic and organoleptic evaluation

The image of the leaf of *S. cumini is* shown in figure 1. The detail of macroscopic characters and organoleptic characters are shown in figure 1. The description of macroscopic studies is as follows [10]

Shape: Oblong-oval or elliptic

Size: leaf is 5-18 cm long and 2.5 to 8 cm wide, stalk 0.7-2.2 cm long

Apex: Blunt or tapering to a point.

Margin: Entire Base: Slightly unequal

Colour: Upper surface and the lower surface of the fresh leaf is dark green and light-green respectively. The upper surface and the lower surface of the dried leaf are brownish green and light brown respectively.

Stalk: Slender and light yellow in fresh while brown in dried leaves

Odour: Turpentine like.

Taste: Slightly astringent.

Touch: Leather like [11].

Fig 1

Microscopic characterization

It only entailed powder microscopy, which was done by turning dry materials into coarse powder. The adaptable digital microscope, Deno Capture 2.0 version 142D, was used to take a photomicrograph of a powder investigation. A leaf's freehand portions (T.S.) were cut out and stained with phloroglucinol before being exposed to hydrochloric acid. The adaptable digital microscope Deno Capture 2.0 version 142D was used to take microphotographs. At 4X and 10X, the images were taken [10, 11].

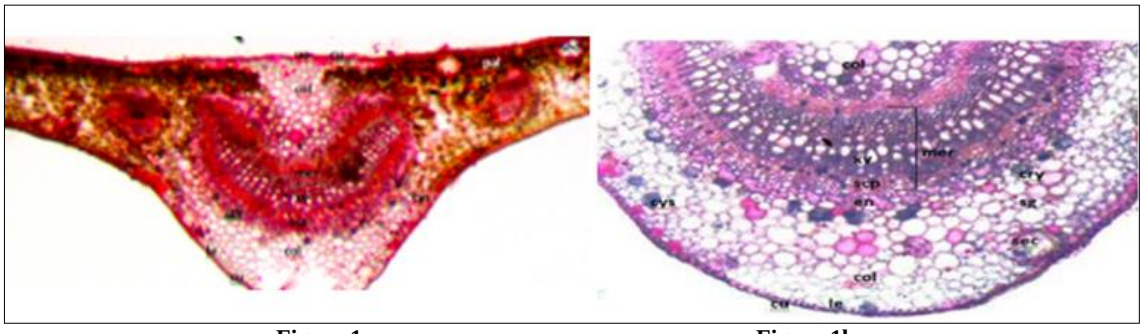

Figure 1a **Figure 1b**

Figure 1a: TS of leaf (dorsiventral) passing through midrib at 4X

Upper epidermis (ue) covered with cuticle, followed by single-layered, elongated palisade layer (pal), disrupted by secretory canal (sec), and spongy cells, disrupted by vascular bundle (vb) with centrally located meristele (mer) forming an arc with lignified xylem (xy) toward upper surface and arranged in radiating bands spreading towards lower surface, protoxylem (cu) [5].

Figure 1b: TS of Leaf passing through midrib lower region at 10X

Upper collenchyma (col), centrally placed meristele (mer) i. e. forming an arc having lignified xylem (xy) towards upper surface arranged in radiating bands spreading towards lower surface, protoxylem pointing towards upper surface and phloem bands at lower side, vascular bundle covered with sclerenchyma Tous pericycle bands (scp) and below to that endodermis, lower collenchyma showing deposition of crystal sheath (cry), starch grain(sg), cystolith (cys) and secretory canal (sec), single layered lower epidermis (le) covered with cuticle (cu) [6].

Microscopic studies

Figure 2 depicts the various anatomical properties revealed by a powder under a microscope. Below are descriptions of the characters that were noted [10].

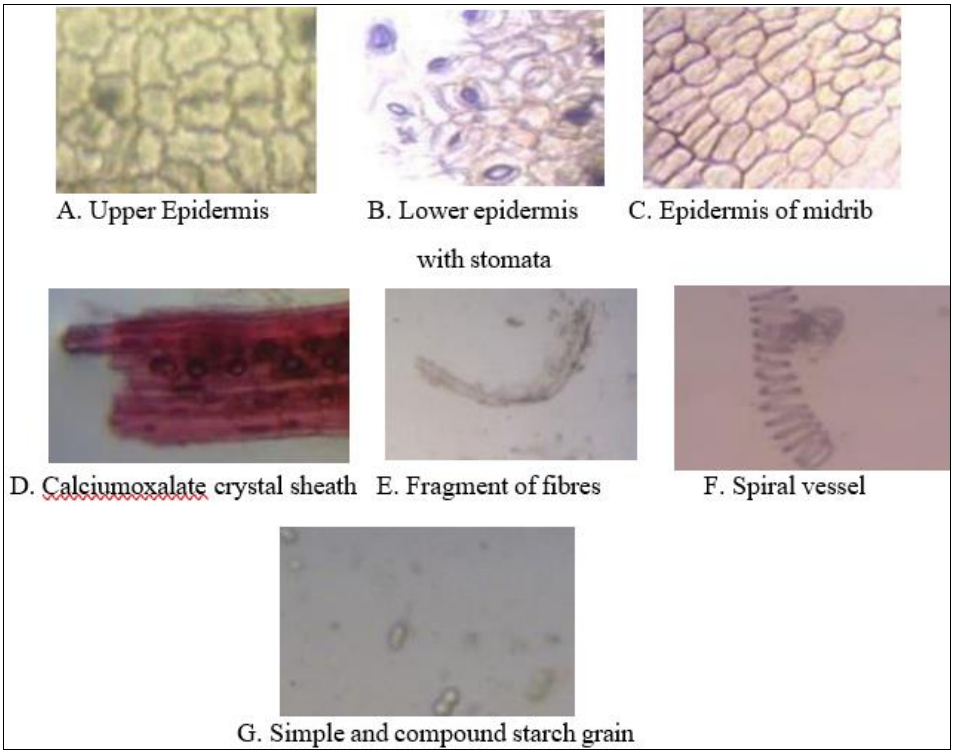

Fig 2: Powder microscopy of *Syzygium cumini* (L.) at 10X

Physicochemical study

Total Ash value

Air dried plant samples weighing 5 grammes each were weighed separately and burned at 450^0 in a muffle furnace. It was weighted and cooled to make ash. Calculations were made to determine the amount of ash in the air-dried samples [19].

Acid Insoluble Ash Value

The whole ash from the study was heated in 25 ml of diluted hydrochloric acid for five minutes. On separate sheets of ashless filter paper, the insoluble residues were collected, and they were then hot water cleaned. The leftovers were then set on fire, allowed to cool, and then stored for desiccation. Weighted residues were recovered, and percentages of insoluble acid ash pertaining to air-dried leaf samples were computed.

Water soluble Ash value

The resulting ash was heated in 25 ml of distilled water for 5 minutes. The soluble material was gathered, cleaned with hot water, set on fire, and weighed. It was computed and recorded what percentage of the air-dried sample was water-soluble ash [19, 20].

Extractive Value

Separately, 5 g of air-dried powdered leaf samples were macerated for 24 hours with 100 ml of methanol and 100 ml of water. The filtrate was removed from each flask, stored for drying, and weighed. Regarding the air-dried powder, it was estimated what percentage of various soluble extractive values there were [18].

Determination of % moisture

A flat-bottomed plate that had already been pre-weighed was filled with around 10 g of sample. Weights for the leaf sample and the empty dish were recorded separately. The oven's temperature was set at 100°C to maintain the sample loaded dish within. After 4 hours, the dish was removed, cooled in the desiccators, and reweighed. The dish was returned to the oven for another three hours, and after cooling, a new weight was taken. Until the steady reading was achieved, this procedure was repeated. The following formula was used to calculate the % moisture content [18].

%Moisture = (Weight of fresh sample-Weight of sample after drying)/Weight of fresh sample *100

Physicochemical parameters

Results obtained from physicochemical contents such as loss on drying, total ash, acid insoluble ash, water and alcohol soluble extracts are depicted in Table 1 [5].

Table 1

S. No	Parameters	Result
1	Loss on drying	5.26%
2	Total Ash	Should not be more than 3.1 %
3	Acid insoluble ash	Should not be more than 0.7 %
4	Water soluble extractive	Should not be less than 12.32%
5	Alcohol soluble extractive	Should not be less than 10.96%
The data depicted in table is mean of three sample.		

Preliminary phytochemical screening

Materials and methods

Collection of plant material

The Department of Dravyaguna at the Institute of Post Graduate Ayurved Education and Research (IPGAER), Kolkata, identified the leaves of Syzygium cumini (family: Myrtaceous), which were taken from the medicinal plants garden. India's Sanjay Gandhi Botanical and Zoological Garden is located in Patna, Bihar [12].

Preparation of plant extracts

The Fresh leaves were cleaned under running water to remove dust, and leaf samples were left in the sun for seven days to dry. In order to powder the dried materials for use in phytochemical analysis research and pharmacognostic research, no. 40 and no. 120 mesh sieves were used. The granules were stored in airtight plastic bottles. The residue was extracted with ethyl acetate and methanol using cold percolation after the powder was extracted with hexane and filtered. For additional phytochemical study, extracts were collected and employed [12, 13].

Phytochemical screenings

The leaf extracts of syzygium cumini were analysed for the presence of alkaloids, glycosides, triterpenoids, saponins, steroids, flavonoids, tannins and carbohydrates according to standarad methods [14].

Test of alkaloids

(Mayer's test). 60 ml of distilled water was used to dissolve 1.36 g of mercuric chloride, and 10 ml of water was used to dissolve 5 g of potassium iodide. Using distilled water, these two formulations were combined and diluted to a volume of 100 ml. A few drops of the reagent were added to 1 ml of the acidic aqueous solution of samples. Formation of white or pale precipitate showed the presence of alkaloids [15]. OR An orange-brown precipitate that formed after adding 2 ml of diluted hydrochloric acid to the 5 ml of extract and treating it with Dragondroff's reagent indicated the presence of alkaloids [16].

Test of carbohydrates (Molisch's test)

2 ml of the samples' aqueous extract was added to a test tube along with 2 drops of freshly made 20% alcoholic alpha-naphthol solution (Molisch's reagent), which was then thoroughly shaken. The presence of carbohydrates was then determined by carefully adding an excess of alkali solution to 2 ml of concentrated H2SO4 that was carefully poured along the side of the test tube [15].

Test of flavonoids

5 to 10 drops of diluted HCl, together with a little amount of Zn or Mg, were added to a test tube holding 0.5 ml of the alcoholic extract of the samples. The solution was then heated for a short period of time. Flavonoids were present when the colour was reddish pink or filthy brown. OR 2 ml of the extract was combined with a few drops of diluted NaOH. A yellow solution that turns colourless showed the presence of flavonoids [16].

Test of glycosides

A small amount of extracts were dissolved in 1ml water and then aqueous sodium hydroxide was added. Formation of a yellow color indicated the presence of glycosides [16].

Test of steroids (Salkowski's test)

Two ml of chloroform were used to dissolve about 100 mg of dry extract. To create a lower layer, sulfuric acid was carefully introduced. The presence of a steroidal ring was shown at the interface by a reddish-brown tint [16].

Test of saponins

A drop of sodium bicarbonate was added in a test tube containing about50 ml of an extract. The mixture was shaken vigorously and kept for 3 minutes. A honey comb like froth was formed and it showed the presence of saponins.

Test of resins

After gently heating and dissolving 2 ml of chloroform or ethanolic extract in 5-10 ml of acetic anhydrite, the mixture was cooled before the addition of 0.5 ml of H_2SO_4. Bright purple colour was produced to indicate the presence of resin.

Test of phenols (Ferric chloride test)

One millilitre of the extract's alcoholic solution, two millilitres of distilled water, and a few drops of 10% aqueous ferric chloride solution were then added. Phenols could be detected by the formation of blue or green colour.

Test of tannins (Lead acetate test)

In a test tube with roughly 5 ml of an aqueous extract, a few drops of lead acetate 1% solution were added. The presence of tannins is indicated by the precipitation of a yellow or red colour.

Test of proteins (Biuret's test)

1 ml of hot extract was added 5-8 drops of 10% (W/V) copper sulphate solution in attest tube. A red violet color indicated the presence of protein [15-16].

Table 2: Phytochemical screening of *S. cumini* leaf extracts.

Phytoconstituent	n-Hexane	Acetone	Chloroform	Methanol
Alkaloids	+	+	+	+
Carbohydrate	-	-	-	+
Flavonoids	-	-	-	+
Glycosides	-	+	-	+
Phenols	-	+	-	+
Proteins	-	+	+	-
Resins	-	-	-	+
Saponins	-	-	-	+
Steroids	-	+	+	+
Tannins	-	+	-	+

'+' Indicates presence of phytoconstituents

'-' Indicates absence of phytoconstituents

Results of phytochemical screening

The phytochemical screening was performed with the acetone, chloroform, methanol and n- hexane extracts of the leaves of *S. cumini*. Glycosides, phenols, proteins, steroids and tannins were detected in the acetone extract; alkaloids, proteins and steroids from chloroform extract; alkaloids, carbohydrates, flavonoids, glycosides, phenols, resins, saponins; and tannins from the methanol extract; and only the alkaloids were detected from the n-hexane extract (Table2) [17].

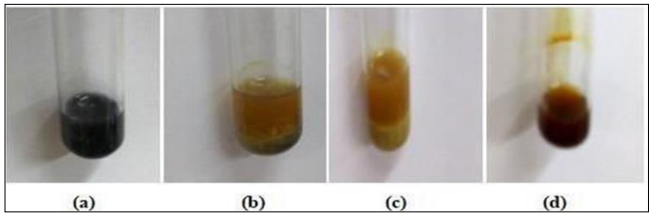

Fig 3: Showing "+" results of (a) Presence of Phenols (b) Presence of Tannins (Gelatin test)

(c) Presence of Flavonoids (Lead acetate test) (d) Presence of Alkaloids (Wagner's Test).

Pharmacological studies

Anti- diabetic activity

The anti-diabetic properties of jamun are mentioned in the Ayurvedic Pharmacopeia; jamun has been used as a blood sugar-controlling remedy for more than 130 years. Additionally, the antidiabetic action of Jamun has been studied in a number of preclinical animal models, which have shown hypoglycemic effects for the various Jamun constituents. Adenosine deaminase and glucose levels in diabetes patients' serum have both been shown to be decreased by aqueous Jamun leaf extract [25].

Male Sprague-Dawley rats with alloxan-induced diabetes have been shown to have lower serum glucose levels when treated with aqueous and methanol extracts of Jamun's root, stem bark, leaves, and seeds [26].

Anti-Allergic activity

The *Syzygium cumini* is having the anti-allergic effect is due to the inhibition of mast cell degranulation and of histamine and serotonin effects where as the inhibition of esonophil accumulation in the allergic pleurisy model. Briton studies showed that this plant skeels shows antiallergic effect.

In mice that have received injections of the mast-cell degranulator C48/80 or ovalbumin (OVA) to cause anaphylactic edema, the antiallergic activity of aqueous leaf extract of Jamun has been studied. The edema was observed to be reduced by treatments using different dosages of jamun leaf extract [27-28].

Anti-inflammatory activity

According to some reports, jamun acts as an anti-inflammatory, lowering both acute and long-term inflammation. In tests using carrageenan, histamine, and serotonin to elicit rat paw oedema and cotton pellets to create rat granuloma, it was discovered that the methanol extracts of Jamun leaves also reduced acute and chronic inflammation [29]. In another study, it was shown that the Jamun leaf's essential oils prevented rat eosinophils from migrating, suggesting that the leaf has anti-inflammatory properties [30]. Indomethacin-induced inflammatory alterations in mice have also been shown to be decreased by the aqueous leaf extract by lowering the enzymes nitric oxide synthase (iNOS), tumour necrosis factor-alpha (TNF), and cyclooxygenase (COX) [38]. In BALB/c mice that have undergone intravenous infection with Mycobacterium bovis Bacillus Calmettte-Guerin, the essential oils from the Jamun leaf have been shown to reduce chronic granulomatous inflammation [31]. The flavonoid fraction of Jamun has been reported to alleviate inflammatory response in human lymphocytes, monocytes and neutrophils against the hepatitis B vaccine [32].

It has a potent anti-inflammatory activity without any side effect to gastric mucosa and other systems also.

Antibacterial activity and antifungal activity

Bacteria can enter the body through an opening in your skin, such as a cut or a surgical wound, or through your airway. in order to overcome such infections antibacterial agents are used.

One such activity was seen using ethanolic extracts of *Eugenia jambolana* against gram positive and gram-negative organisms. Essential oils extracted from the Jamun leaves have been reported.

Bacillus sphaericus, Staphylococcus aureus, Escherichia coli, Pseudomonas aeruginosa, and Salmonella typhimurium have all been documented to be resistant to the antibacterial effects of essential oils isolated from jamun leaves [20]. In addition to Enterococcus faecalis, E. coli, Kocuria rhizophila, Neisseria gonorrhoeae, P. aeruginosa, and Shigella flexneri, it was discovered that the hydroalcoholic extract of Jamun leaves was effective against Candida krusei and antibiotic-resistant bacterial species of P. aeruginosa, Klebsiella pneumoniae, and S.aureus[33].

Various Gram-positive bacteria, such as B. subtilis, B. cereus, and S. aureus, and Gram-negative bacteria were both effectively combated by the 70% ethanol extract of jamun leaf (including S. flexneri, P. aeruginosa and V. cholera). When compared to the pulp and seed extracts, comparison study revealed that the leaf and bark extracts were more powerful.

The essential oils from Jamun leaves and the leaf extracts in methanol and methylene chloride both displayed antibacterial activity against Gram-positive and Gram-negative bacteria, with the methanol extract outperforming the other two [34].

Cardioprotective activity

The most common cause of death worldwide is cardiovascular disease, and the many Jamun extracts have been tested for their cardioprotective efficacy in a variety of preclinical settings. In hypertensive rats, the hydroalcoholic extract of Jamun leaves, given orally at a dose of 0.5 g daily for 8 weeks, has been shown to lower blood pressure [44]. According to the combined results of these preclinical and clinical model investigations, Jamunleaf also acts as cardioprotective agent.

Hepatoprotective activity

Administration of aqueous leaf extract of Jamun to albino rats for 7 days prior to carbon tetrachloride treatment has been found to show hepatoprotective activity. the activity was confirmed by the alleviation of enhanced levels of aspartate aminotransferase and alanine aminotransferase compared to control rats which were treated with carbon tetrachloride alone [36].

Radioprotective activity

Every person and animal are regularly exposed to ionising radiation from cosmic sources, air and space travel, and medical procedures. Ionizing radiation is harmful and poses a number of risks to health, including the development of cancer and diseases of the heart, lungs, liver, kidney, and reproductive systems. This makes it necessary to look for pharmaceutical treatments that can guard against ionising radiation's harmful effects. Jagetia and coworkers assessed the radioprotective efficacy of Jamun leaf and seed extracts as early as 2002[37]. Prior to exposure to 3 Gy of radiation, the scientists treated human peripheral blood cells with various doses of 1:1 DCM-MET) leaf extract. They discovered protection through a reduction in DNA damage as micronuclei, which happened in a concentration-dependent way.

Mice were given 50 mg/kg of 1:1 DCM-MET leaf extract before being exposed to various doses of - radiation in order to study the impact of Jamun leaf extract on radiation-induced DNA damage. Animal spleens that had undergone radiation treatment had their cells isolated, grown, and used to determine the amount of DNA damage in cytochalasin B-blocked binucleate splenocytes. The mice were shielded from radiation-induced DNA damage by the jamun leaf extract, which prevented the creation of radiation- induced micronuclei [42].

Antioxidant activity

Free radical scavenging experiments have demonstrated the antioxidant activity of several Jamun components. Furthermore, nitric oxide (NO) free radical scavenging activity has increased in response to the concentration of the Jamun leaf and seed extracts [39]. Free radicals such as hydroxyl (OH), superoxide (O2), and DPPH have been discovered to be scavenged by the aqueous extract of Jamun fruit skin [40].

The leaf extract's DPPH radical scavenging and ferric-reducing power (FRAP) in methanol extract and its portion of ethyl acetate, chloroform, n-hexane and water were assessed. The most effective fraction for scavenging FRAP and DPPH radicals was determined to be ethyl acetate [41].

The *in vitro* scavenging capacity of a 1:1 dichloromethane and methanol (DCM-MET) extract of Jamun leaves was examined. The jamun extract was discovered to scavenge OH free radicals in a dose- dependent manner, with 350 g/mL having the most effect. Additionally, this extract reduced the production of O2 • radicals, with 250 g/mL having the highest impact. The maximum effect was obtained with 80 g/mL for both radicals. It similarly equally suppressed DPPH and ABTS+ free radicals [42]

Conclusion

The *Syzygium cumini* also known as the jamun plant contains a diverse assortment of secondary metabolites i.e., alkaloids, flavonoids, terpenoids, steroids, tannins, saponins and reducing sugars that play a vital role in preventing various diseases. The antidiabetic, anti-inflammatory, antiviral, anti- bacterial, anti-analgesia, anti-oxidant, anti-abortifacient of the various parts of plants is due to the presence of diverse secondary metabolites. The phytochemical analysis of the plants is also important for the novel drug development for the treatment of various diseases. The present study compares different methods for phytochemicals extraction. It also reveals various medicinally important bioactive compounds present in jamun leaf and justifies their use as a conventional medication for treatment of different diseases. Further purification, identification, and characterization of the bioactive chemical constituents would be our priority in future studies. Efforts should be geared up to exploit the biomedical applications of this leaf due to the presence of a certain class of phytocompounds for their full usage.

Further phytochemical and clinical research should be done on this traditional medicinal plant for the discovery of safer drugs. Studies should also be on understanding which of the phytochemicals are responsible for the observed beneficiary effects. Although most of the studies of *Syzygium cumini has* shown antidiabetic with its possible mechanism of action and delaying complications of diabetes, have been conducted but detailed research on isolation of bio actives through clinical trials followed by standardisation is seriously required to know the potential of plant. Most of the pharmacological work was carried out on seeds of *Syzygium cumini* but the pharmacological potential of *Syzygium cumini* leaf is also required to be explore.

The body of literature makes it abundantly evident that jamun has a variety of therapeutic benefits, and more research is required to see whether these benefits extend to its full potential for treating some of the most significant modern-day illnesses. Its therapeutic success seems to be a long way off despite the abundance of studies that suggest it has potential as an anti-diabetic. Despite the fact that jamun fruits are eaten, thorough research on the fruit's toxic effects in conjunction with other pharmacologic agents is still required in order to realise its full clinical potential. Last but not least, Jamun's teratogenic effects have not been researched, indicating the urgent necessity to look into this matter in depth.

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