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Review Article

A review of the pharmacological and bioactive compounds of syzygium cumini

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ABSTRACT

The field of herbal medicine has grown rapidly in the past several years, and due to their natural origins and lower side effects, these medications are becoming more and more well-liked in both developed and developing nations. The plant known as jamun, Syzygium cumini (also called Eugenia jambolana, Syzygium jambolana, Eugenia cumini, and Syzygium jambos), is a great source of bioactive substances such flavonoids, polyphenols, antioxidants, iron, and vitamin C. The Myrtaceae family includes the essential medicinal plant known as the jamun tree, which is a tropical evergreen blooming plant that has long been utilized in Indian and other traditional remedies around the world. The majority of jamun's cultivation occurs in Asian nations like Bangladesh, Sri Lanka, India, and Pakistan. It has been used to treat a wide range of illnesses and physiological disorders since the days of ancient medicine. In terms of medicine, the fruit is said to have properties that help with hyperlipidemia, hypertension, obesity, antidiarrheal, antiallergic, antiarthritic, antimicrobial, anti-inflammatory, antifertility, antipyretic, antiplaque, radioprotective, neuropsychopharmacological, and antiulcer, hepatoprotective, antiallergic, antiarthritic, antioxidant, and various metabolic problems. This review examines the various dietary applications as well as the nutritional, phytochemical, and medicinal possibilities.

1. Introduction

Fruits are a wonderful gift from nature to humanity since they have elements that both lengthen and protect life. In addition to providing energy and vitamins, minerals, and phytochemicals, frequent fruit eating enhances physiological processes and lowers the risk of a number of diseases. An underappreciated fruit found in tropical and subtropical areas, Syzygium cumini is rich in phyto-constituents such as anthocyanins, flavonoids, steroids, and phenolics. Fruit variety, maturity level, weather, farming methods, and post-harvest handling and processing all affect how nutritious and phytochemical-rich a fruit is. The fruit's purple to black hue and great antioxidant capacity are attributed to the presence of anthocyanins.1. Different phytochemicals and antioxidants are often unstable to processing conditions such as light, pH, and heat. The most important elements in the breakdown of these bioactive and antioxidant chemicals are thermal processing techniques as boiling, steaming, and blanching at higher temperatures. Therefore, it is necessary to investigate how different processing techniques affect the stability of the bioactive chemicals. Anti-anemia, anti-microbial, anti-

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hypertensive, antioxidant, and other medical and therapeutic qualities are well known for the fruit.[1]

2. Botanical Description and Traditional Uses

Syzygium cumini (L.), also called jamun, jambul, jambolao, Java plum, Indian blackberry, and black plum, is a member of the Myrtaceae family of plants. Synonyms for Syzygium cumini (L.) include Eugenia jambolana, Syzygium jambolana, and Eugenia cuminii. The fruit is native to Pacific-Asia, which includes Hawaii, Australia, Indonesia, the Philippines, and Hawaii, as well as South Asia, which includes Pakistan, India, Afghanistan, and Myanmar. It is also grown in Florida and Kenya. The fruit is greenish as it ripens and becomes pink to dazzling crimson at maturity (Figure 1). In Asia, the jamun fruit is harvested for 30 to 40 days during the monsoon season, which runs from June to July.[2] The 1.5 to 3.5 cm fruits of S. cumini have a pleasant taste and a slight astringency.[3] Pickling, adding a little salt, and letting it stand for at least one hour can all help to lessen bitterness.[4] Fruits from S. cumini are consumed raw or cooked in chutney and jam. S. cumini juice is used to make summertime concoctions including squash, sherbet, and syrup. For preservation, the squeezed fruits are typically cooked for ten minutes and combined with water, sugar, citric acid, and sodium benzoate.[3]

Figure 1: Leaves and fruits of Syzygium Cumini.

Traditionally, S. cumini has been used as a medicinal plant. Various parts of the plant, such as bark, leaves, seeds, and fruit, have been used to treat a variety of diseases. For example, S. cumini fruit juice has been used orally to treat gastric complaints, diabetes, and dysentery.[5] S. cumini seeds have been applied externally to treat ulcers and sores, and powdered seeds with sugar have been given orally to combat dysentery.[6] Powdered seeds have been reported to be effective against diabetes.[7] S. cumini leaves were cooked in water (concentration of 2.5 g/L) and drunk daily, with 1 L being reported to be effective against diabetes.[8] The leaves' juice has been used as an antidote for opium overdose, and taking the leaves orally for two to three days has been shown to help both adults and children's jaundice.[9] The leaves of S. cumini have traditionally been used to treat dysentery, along with mango leaves, myrobalan fruit, honey, and goat milk,[10] while the bark decoction of S. cumini with water has been used to treat diabetes,[11] dysentery, increase appetite, induce sedation, and relieve headaches when taken orally.[5] A bark extract has been administered to women who experience repeated miscarriages.[6] Constipation has been reported to be treated with S. cumini bark juice and buttermilk, while blood discharge in feces has been reported to be stopped when consumed in the morning.[12]

3. Profile of Phytochemicals

S. cumini fruits are high in fiber, minerals, and vitamins. They are low in calories and fat.[2] The phytochemicals found in S. cumini include fiber, lipids, proteins, minerals, vitamins, and carbohydrates. In accordance with more recent findings, which show moisture (79.2%), protein (0.65%), sugar (7.88%), ash (1.03%), and fat (0.18%) contents on a fresh weight basis,[4] analysis of S. cumini fruits produced moisture, protein, sugar, and ash contents of 80.8, 0.81, 12.7, and 0.70% on a fresh weight basis, respectively.[13] The main ingredients of the leaf oil are octadecane (16.9%), nonacosane (9.9%), and triacontane (9.3%); other ingredients include octacosane (7.4%), hepatcosane (4.8%), hexadecanoic acid (4.2%), and eicosane (4.02%).[13–15] Furthermore, the primary components of S. cumini seeds are fatty oils, including oleic acid (32.2%), myristic acid (31.7%), and linoleic acid (16.1%). Nevertheless, trace amounts of sterculic acid (1.80%), malic acid (1.20%), lauric acid (2.80%), vernolic acid (3.00%), stearic acid (6.50%), and palmitic acid (4.70%) were found.[16] One chlorooctadecane made up the majority of the seed oil, with the remaining constituents being tetracontane, decahydro-8a-ethyl1, 1, 4a, 6-tetramethylnapahthalene, 4-(2-2-dimethyl-6-6-methylene-cyclohexene) butanol, octadecane, octacosane, heptacosane, and eicosane in the following proportions, respectively.[15] Conversely, minerals like

sodium, potassium, calcium, zinc, iron, magnesium, copper, manganese, lead, and chromium are found in leaves.[4] Zinc and boron applied topically have been shown to have significant impacts on fruit length (19.55 to 25.88 mm), seed weight (1.68 to 2.55 g), and fruit weight (10.29 to 12.88 g). Additional physicochemical characteristics, such as total soluble Zinc or boron applied topically to S. cumini fruit resulted in a modest rise in the fruit's reducing sugar content, from 6.33 to 6.64%, but no change in solids or titratable acidity.[17]Table 1 indicates that various plant parts, such as skin and pulps, seeds, flowers, bark, and leaves, have distinct and distinctive compositions, according to recent databases[18–23] An abundance of tannins contributes to the astringent flavor of S. cumini fruit, while anthocyanins give it its purple hue. Additionally, *S. cumini* was shown to have the 3, 5-diglucosides of malvidin, delphinidin, and petunidin. Peels.[18,19] Fruit pulps have been found to include bioactive substances such myricetin, gallic acid, ellagic acid, phenolic acids, carotenoids, and flavonoids, as well as their derivatives.[20,21] The flavor of the purple fruits is influenced by over thirty different chemicals, including geranyl butyrate, dihydrocarvyl acetate, and terpinyl isovalerate.[22] Further analysis of S. cumini seeds revealed the presence of β-sitosterol, gallic acid, ellagic acid, corilagin, jambosine, and quercetin.[24]

Following a recent GC-MS analysis of the essential oil extracted from S. cumini leaves, substantial concentrations of τ-cadinol and τ-muurolol were discovered, accounting for 21.4% and 12.4% of the total oil fraction, respectively.[23]

3.1. Cumini's potential for pharmacology

Many traditional medical systems, including Siddha, Tibetan, Unani, Sri Lankan, and Ayurvedic, have used S. cumini. It was used in the aforementioned systems to treat vaginal discharge, obesity, menstrual problems, diarrhea, and hemorrhage.[25] Fruit, seed, bark, leaves, pulp, skin, and other parts of S. cumini are recognized for their anti-inflammatory,[26] antioxidant[27], anticancer,[28] and antidiabetic properties.[8] There is evidence to support their hepatoprotective[29], cardioprotective[30], chemopreventive potential[31], and antipyretic qualities[32] in both animal models and many in vitro studies. Studies have shown that it is active against bacterial infections[33], diabetes[34], obesity[35], and inflammation.[32] The details of S. cumini's known pharmacological actions are provided below.

4. Antioxidant Activity

Scavenging free radicals is what antioxidants do; as a result, they lessen or prevent oxidative stress and damage. A higher phenolic content and antioxidant capability have been discovered in studies on S. cumini seeds.[36] The cardiometabolic agents known as polyphenolics are known to both boost antioxidant defense and scavenge reactive nitrogen or oxygen species. Due to the high anthocyanin content, an alcoholic extract of seeds and pulp demonstrates its ability to scavenge a variety of free radicals, including lipid peroxide, superoxide, hydroxyl, nitric oxide, DPPH (2,2-diphenyl1-1picryhydrazyl hydrate), and LOO* (lipid peroxyl radicals). The DPPH scavenging assay demonstrates that methanolic extracts of the stem, methanolic, formic acid, hydroethanolic, and dichloromethane extracts of the leaves, as well as acetone extracts[37], exhibit strong free radical scavenging action and more antioxidant activity than ascorbic acid. According to recent research, the methanolic extract's acetate fraction exhibited higher antioxidant activity than the extracts from n-hexane and chloroforms[38] and decreased the pathogenesis's oxidative stress. The seed's 50% ethanolic extract had the highest capacity to scavenge radicals.[39]

4.1. Flavonoids

Flavonoids are a class of low molecular weight, water-soluble polyphenolic chemicals that are mostly found in plants as glycosides.[40] The main flavonoids found in the fruit of S. cumini are myricetin, kaempferol, and quercetin. According to reports, the flavonoids exhibit antibacterial properties against both Gram positive and Gram negative bacteria in addition to anticancer, antiaging, neuroprotective, antineurological, anti-inflammatory, antidiabetic, and fibrocystic disease prevention properties. Research has demonstrated that the antioxidant properties of quercetin provide a strong shield against DNA damage and cancer caused by gamma radiation.[41,42] Through a caspase-3-dependent mechanism in human osteosarcoma cells, kaempferol causes apoptosis in oral cancer cell lines. This inhibits tumor development, phosphatidylinositol 3-kinase, and ceroplastic transformation.[43]

Table 1: Phytochemicals in *S. cumini.*

Plant part	Phyto-chemicals	Pharmacological uses	Refrences
Seed	Fatty acids: oleic acid, stearic acid, octadecanal, 1-monolinoleoylglycerol trimethylsilyl ether, n-hexadecanoic acid Phenolic acids: gallic acid, ellagic acid Flavonoids: quercetin Phytosterols: β-sitoterol Tannins: corilagin, 3,6-hexahydroxy diphenoylglucose, 1-galloylglucose, 3-galloylglucose, 4,6 hexahydroxydiphenoylglucose Others: 2-bromo-cyclohexasiloxane, dodecamethyl, cycloheptasiloxane, tetradecamethyl, pyrazole[4,5-b] imidazole, 1-formyl-3-ethyl-6-beta-d-ribofuranosyl, 3-(octadecyloxy) propyl ester, benzaldehyde	Antimicrobial, Antioxidant, Antilipidemic, Hypoglycemic, CNS-stimulator, Anti-inflammatory, Antihypertensive Menorrhagia	44–46
Leaves	Alkanes: n-heptacosane, n-nonacosane, n-hentriacontane, noctacosanol, n-triacontanol, n-dotricontanol Terpenoids: betulinic acid, maslinic acid, α-pinene, camphene, globulol, caryophyllene, δ-cadinene, β-eudesmol, β-pinene, γ-cadinene, α-terpineol, camphor, humulene 6,7-epoxide, cubeban-11-ol, α-muurolene, epicubenol, α-copaene, viridiflorene, guanine, β-bourbonene, terpinen-4-ol, endo-borneol, levoverbenone Flavonoids: quercetin, myricetin, myricitrin, flavonol glycosides, myricetin 3-O-(400-acetyl)-α L-rhamnopyranosides Phytosterols: β-sitosterol.	Antibacterial Anti-inflammatory Antioxidant Antifungal	23,44,47
Stem bark	Terpenoids: friedelin, friedelan-3-α-ol, betulinic acid Phytosterols: β-sitosterol, β-sitosterol-D-glucoside Phenolic acids: gallic acid, ellagic acid Tannins: gallotannin, ellagitannins Flavonoids: kaempferol, myricetin	Anti-helmintic Antioxidant Anti-inflammatory Anti-diabetic Antifungal activity	44,45

Continued on next page

Table 1 continued

Pulp and Skin	Anthocyanins: delphinidin-3,5-O-digalactoside, delphinidin-3,5-O-diglucoside, delphinidin-3-O-glucoside, petunidin-3,5-O-digalactoside, petunidin-3,5-O-diglucoside, petunidin-3-O-glucoside, cyanidin-3,5-O-digalactoside, cyanidin-3-O-glucoside, peonidin-3,5-O-digalactoside, peonidin-3,5-O-diglucoside, malvidin-3,5-O-digalactoside, malvidin-3,5-O-diglucoside, malvidin-3-O-glucoside Flavonols: myricetin-3-O-glucuronide, myricetin-3-O-galactoside, myricetin-3-O-glucoside, myricetin-3-O-rhamnoside, myricetin-3-O-pentoside, laricitrin-3-O-galactoside, laricitrin-3-O-glucoside, syringetin-3-O-galactoside, syringetin-3-O-glucoside,Flavanonols: DHQ-dihexoside-1, DHQ-dihexoside-2, DHQ-dihexoside-3, MDHQ-dihexoside, MDHQ-dihexoside, DHM-dihexoside-1, DHM-dihexoside-2, DHM-dihexoside-3, DHM-dihexoside-4, DHM-dihexoside-5, DHM-dihexoside-6, MDHM-dihexoside-1, MDHM-dihexoside-2, MDHM-dihexoside-3, MDHM-dihexoside-4, MDHM-dihexoside-5, MDHM-dihexoside-6, DMDHM-dihexoside-1, DMDHM-dihexoside-2, DMDHM-dihexoside-3, liquiritigenin Flavan-3-ols: catechin, epicatechin, gallocatechin, epigallocatechin, epicatechin 3-O-gallate, catechin 3-O-gallate, epigallocatechin 3-O-gallate, gallocatechin 3-O-gallate Tannins: galloyl-glucose, 3galloyl-glucose-1, 2galloyl-glucose, 3galloyl-glucose-2, 3galloyl-glucose-3, 3galloyl-glucose-4, 4galloyl-glucose-1, 4galloyl-glucose-2, 5galloyl-glucose-1, 5galloyl-glucose-2, 5galloyl-glucose-3, 6galloyl-glucoside-1, 6galloyl-glucoside-1, castalagin, vescalagin, (2) HHDP-glucose-1, (2) HHDP-glucose-2, G-(2) HHDP-glucose-1, (2) HHDP-glucose-2, (2) G-HHDP-glucose-1, (2) G-HHDP-glucose-2, (2) G-HHDP-glucose-3, (3) G-HHDP-glucose, trisgalloyl-HHDP-glucose-1, trisgalloyl-HHDP-glucose-2 Phenolic acids: quinic acid, gallic acid, chlorogenic acid, caffeic acid Coumarins: umbelliferon, scopoletin Terpenoid: rosmanol	Gastro-protective Anti-ulcerative Anti-scorbutic Diuretic Carminative Stomachic Anti-sterility	[20,44,48,49]
Flowers	Flavonoids: isoquercetin, quercetin, kaempferol, myricetin, Terpenoid: oleanolic acid, Phenolic acid: ellagic acids	Anti-diabetic Anti-inflammatory Anti mutagenic Antiseptic Hepatoprotective Hypotensive	[44]
Essential oils	Terpenoids: α-terpeneol, myrtenol, eucarvone, muurolol, α-myrtenal, 1, 8-cineole, geranyl acetone, α-cadinol, pinocarvone		[49]

In a similar vein, myricetin inhibits the growth of human leukemia cells, causes apoptosis, and exhibits anticancer properties. When there is hyperglycemia, saponin decreases glucagon action whereas flavonoids increase blood insulin secretion.[50] It was shown that flavonoid leaf extract effectively inhibits the enzymes that hydrolyze carbohydrates (α-amylase and α-glucosidase), which in turn inhibits aldose reductase, the main enzyme in the polyol pathway, and prevents the development of acute gastroenteritis (AGEs).[51]

4.2. Anthocyanins

Anthocyanins are active ingredients found in fruits and vegetables. S. cumini has been reported to have high anthocyanin content (126.54–185.35 mg per 100 g). Major anthocyanins include delphidin 3,5-diglucoside (256 mg), cyanidin 3,5-diglucoside (29 mg), malvidin 3,5-diglucoside (166 mg), petunidin 3,5-diglucoside (245 mg), and peonidin 3,5-diglucoside (75 mg) per 100 g on a dry weight basis.[52] The presence of 3, 5-diglucoside aglycones characterizes the anthocyanin composition.[53] The purple color of S. cumini is primarily due to the anthocyanin pigment.[54] The sour and astringent taste of the fruit is caused by gallic acid and tannins[55] Anthocyanins have been found to have anti-cancer properties; research has indicated that petunidin prevents apoptosis and breast cancer in humans, while malvidin causes apoptosis in cell lines, human cell proliferation, and efficiently prevents cAMP hydrolysis. In a similar vein, ellagic acid lessens DNA damage to shield yeast cells from the harmful effects of gamma radiation. The fruit has relatively low color intensity because to the glycosylation structure as diglucoside, however the color and other anthocyanin qualities were determined to be persistent. Using molecules of caffeic acid, ferulic acid, sinapic acid, and rosemary polyphenolic extracts during copigmentation might intensify color.[56] Monomeric anthocyanins were found to be elevated throughout various drying techniques, such as spray drying, tray drying, and freezing drying. Some researchers identified the anthocyanin pigments from S. cumini fruit peels as diglucosides of delphinidin, petunidin, and malvidin. They discovered that at 5.0 ppm concentration, these pigments inhibited rat brain lipid peroxidation by 94.4% (one ppm being equivalent to 3.5 μ ascorbic acid, as determined by the reducing power assay).[57] All of the biological models showed nearly comparable activity, with the exception of human erythrocyte ghost cells, where it only shown 48% inhibition at 5.0 ppm. S. cumini is a possible source of natural colorant and antioxidants due to the pigments' greater durability and comparatively stronger antioxidant activity.

4.3. Hyperlipidemia and cardio-protective activity

An abnormally high blood lipid level is known as hyperlipidemia (s). Any change in the lipid profile causes heart disease, which can then progress to atherosclerosis, myocardial infarction, stroke, and CVD. The ability of several S. cumini components to decrease cholesterol has been studied. Research indicates that the flavonoid-enriched seed extract has anti-lipidemic characteristics, lowering LDL and raising HDL in rats.[58] Reduction of serum lipid levels is another benefit of S. cumini extract. In mice treated with alloxan (oxidation product of uric acid 2, 4, 5, 6-pyrimidinetetrone), aqueous seed extract has been shown to lower triglyceride and LDL levels and raise HDL levels.[59] One-third of all deaths worldwide are caused by cardiac conditions, which include peripheral vascular disease, ischemia, stroke, and coronary heart disease.There have been reports of cardio-protective benefits from.[60] S. cumini. Research has demonstrated that the methanolic extract from its seed has cardio-protective properties when it comes to rats that have had myocardial infarction caused by isoproterenol. Thirty days of oral feeding produced a concentration-dependent defense against myocardial infarction.[61] Discovered that the methanolic extract of S. cumini seeds has anti-hyperglycemic and anti-hyperlipidemic properties. It can also help diabetic rats heal from liver and heart damage.

4.4. Antimicrobial

S. cumini has several sections that are useful for human health as antimicrobial and antibacterial agents. There have been reports that seeds and leaves are effective against Bacillus cereus, B. megaterium, Proteus vulgaris, Salmonella paratyphi, and ethanolic extract of the bark, pulp, leaves, and seeds have demonstrated possible antibacterial action against Gram negative bacteria (Bacilla cereus and Staphylococcus aureus) and Gram-positive bacteria (Vibrio cholera, Shigella flexneri). In contrast to B. cereus, the diethyl extract of S. cumini exhibited a high percentage of inhibition

and had a greater % inhibitory potential compared to extracts of water, acetone, and ethyl acetone.[62] Comparative analysis revealed that the leaf and bark extracts have more potency than the pulp and seed extracts.[63] It was discovered that the fruit extract of the plant was effective against Pseudomonas aeruginosa, and that the aqueous extract of the stem and leaf was effective against Staphylococcus aureus, Staphylococcus saprophyticus, Escherichia coli, and other microbes. Maximum suppression against Candida albicans and Penicillium chlorogenum was observed. It was discovered that S. cumini root extract was more effective against both Gram positive and Gram negative bacteria. Its roots' ethanolic extract exhibited the strongest suppression against E. coli, Staphylococcus aureus, and Staphylococcus epidermidis.[64] The leaves, fruit, bark, and steam all have aqueous, chloroform, petroleum ether, benzene, methanolic, ethanolic, and n-hexane extracts that have demonstrated antifungal activity. These extracts are effective against Candida albicans and Candida krusei and also impede the growth of Microsporum gypsem and Trichoderma mentagrophytes, two dermatophytic fungi[65,66] The leaves of S. cumini have been shown to have maximal antibacterial activity and to be active against E. Coli, P. aeruginosa, Kocuria rhizophila, Sh. flexneri, St. aureus, and V. cholera[67] in methanolic, aqueous hydroalcholic, and ethanol extracts, respectively. Like the leaves, the seeds' methanolic, petroleum ether, and ethyl acetate extracts have also been shown to have antibacterial properties, with minimum bacterial concentrations (MBC) against V. cholera ranging from 0.125 to 4 mg ml−1 and against P. aeruginosa and Solanum nigrum from 8 to 12 mg ml−1. Strong action against B. subtilis, Enterococcus faecalis, E. coli, Pseudomonas, Sh. flexneri, St. aureus, Salmonella typhi, P. aeruginosa, Enterobacter aerogenes, and Gram positive bacteria has been demonstrated by water extract of seed at concentrations ranging from 1.75 to 8 mg ml−1. Together with the seed extract, the bark's acetone and ethanolic extracts have antibacterial properties against Sh. boydii and Sh. Dysenteriae, and the essential oils extracted from the leaf extract have anti-schistosomiasis and anti-leishmaniasis properties.[68]

4.5. Anticancer and radio-protective

Cancer is a disease that results from aberrant cell division and is extremely dangerous because of its high death rate.[72] The cytotoxic properties of various S. cumini components have been studied in vitro. Using an MTT test, the crude extract of its skin was examined for HeLa (HPV-18 positive) and SiHac (HPV-16 positive) cells. It was discovered that the extract more effectively induced its cytotoxic effects in HeLa cells. Similarly, HeLa cells exposed to 50% methanol extract displayed apoptosis. It was discovered that the freeze-dried pulp extract inhibited the growth and multiplication of MCF-10A, MCF-7, and MDA-MB-231 breast cancer cells. On MCF-10A cells, however, this extract did not have the same effect as it did on MCF-7 and MDA-MB-231 breast cancer cells. Additionally, S. cumini fruit extract has shown reported to cause DNA fragmentation, which has lethal effects on HCT-116 colon cancer cells. One of the most common cancer therapies is radiotherapy, yet it has serious underlying adverse effects that can harm healthy cells. Research has demonstrated that S. cumini has radioprotective properties and shields normal cells from harmful radiation.[74] Human peripheral blood cells were treated with varying concentrations of 1: 1 DCM–MET (di-chloro-methane and methanol) leaf extract prior to being exposed to 3 Gy gamma radiation in order to assess the radioprotective effect of S. cumini. This treatment reduced the amount of DNA damage. In human blood cells, extracts containing dichloromethane and methanol were both effective in preventing DNA damage caused by radiation. Mice given a hydroalcholic extract of seeds for five days prior to being exposed to a radiation dose that would have killed them were protected from the radiation; the highest level of protection was seen at 80 mg kg^{-1}. The fruit's strong antioxidant profile is linked to its anti-mutagenicity function, which prevents cancerous cells from proliferating and developing. ScAuNPs, or S. cumini gold nanoparticles, were useful as anticancer agents because they had strong antioxidant capabilities.

4.6. Gastroprotective and antidiarrheal activity

One of the most prevalent gastrointestinal conditions, ulcers significantly impact a large number of people.

By changing how cells behave, S. cumini demonstrates gastroprotective qualities. Preclinical research revealed that fruits have gastroprotective benefits in both normal and diabetic mice caused by streptozotocin rattling Rats given isolated tannins from S. cumini were shown to be protected against ethanol/HCl-induced stomach ulcers.[63] Tannin therapy considerably reduced the damage to the gastrointestinal mucosa, providing protection. According to earlier research, an ethanolic bark extract administered orally at a dose of 400 mg kg−1 p.o. (p.o. denoting twice daily or by mouth) decreased diarrhea by preventing gastrointestinal motility and causing enteropooling, which is the buildup of fluid in the colon and small intestine. In a stress-reduction research, the seed extract of S. cumini also changed the test animal's overall behavior, including decreased movement, decreased aggression, and increased sleep duration in a dose-dependent manner. Researchers discovered a strong analgesic effect against the writhing motion and drop in body temperature caused by acetic acid. Similarly, 30 mg per kg body weight of S. cumini extract protected mice from radiation-induced bone marrow mortality. The most common ailment in children is diarrhea, which is mostly caused by dietary mistakes and the weaning process. Diarrhea might be considered a small, untimely illness, but in its chronic form, it can impair food absorption and result in malnutrition. When rats were given an ethanolic bark extract, it effectively prevented both castor oil- and prostaglandin-induced diarrhea as well as enteropooling.[66]

4.7. Antianemic, anti-cariogenic and anti-clastogenic

The extract from S. cumini seeds increases hemoglobin levels overall and inhibits the production of free radicals in bodily tissues. One of the most common illnesses in people is dental caries, which can seriously impair masticatory function. Research has indicated that extracts of S. cumini, whether hydromethanolic, methanolic, or aqueous, exhibit efficacy against cariogenic bacteria, including Streptococcus mutans, a facultative anaerobic Gram positive bacteria present in the oral cavity of humans. Chromosome fragmentation can be caused by clastogens, which are mutagenic agents that cause chromosome disruption or breakage. S. cumini exhibits anti-clastogenic action, preventing chromosomal disruption and mutagenesis. Aqueous extract was discovered to reduce the chromosomal abnormalities in mice, and alcoholic seed extract was reported to lessen the strand breaks in pBR322 DNA caused by hydroxyl radicals in vitro.[68]

4.8. Anti-inflammatory

In traditional medicine, S. cumini bark is used to treat both acute and chronic inflammations [80]. In studies where rats were given carrageen (acute), kaolin carrageenin (sub-acute), formaldehyde (sub-acute), and pellet granuloma, anti-inflammatory action was noted. Anti-arthritis properties were demonstrated by S. cumini (arthritis is a chronic variety of inflammatory illnesses of the joints). It was discovered that the seed's aqueous extract worked well against human neutrophils. Similarly, it has been observed that the fruit's flavonoid extract reduces the inflammatory response that human lymphocytes and monocytes have to the hepatitis B vaccination.[61]

*4.9. The dietary composition of Syzygium **cumini***

Cumini is a valuable source of several nutrients, such as antioxidants, anthocyanins, minerals,

Vitamins and carbs. A fruit's color and taste are influenced by the polyphenol, tannin, and gallic acid content.

4.10. The fruit's nutritional makeup

Per 100 g base, the fruit provides 60 kcal of energy, 14 g of carbohydrates, 0.70–0.13 g of protein, 0.15–0.30 g of fat, and 0.30–0.90 g of fiber.[84] Potassium (55–79 mg), sodium (14–26.20 mg), magnesium (15–35 mg), calcium (8.3–19 mg), phosphorous (15–17 mg), sulfur (13 mg), chlorine (7–8 mg), copper (0.23 mg), folic acid (3.00 μg), iron (0.19–1.62 mg), zinc (0.28 mg), ascorbic acid (5.70–18.00 mg), β-carotene (48 mg), choline (7 mg), cyanocobalamine (3 mg), thiamine (0.03–0.08 mg), riboflavin (0.009–0.01 mg), and niacin (0.20–0.29 mg) are all present in the fruit (per 100 g basis). The fruit also has high anthocyanin content (731 mg per 100 g).[67]

4.11. The seed's nutritional makeup

The seed has 41.4 g of carbs, 6.3–8.5 g of protein, 0.83–1.18 g of fat, 2.04 g of ash, 2.3–16.9 g of fiber, 0.41 mg of calcium, 0.17 mg of phosphorus, 361.40 mg of polyphenols, and 168.24 mg of

tannins per 100 g.[89] Fatty oils found in the fruit include stearic (6.5%), malvalic (1.2%), oleic (32.2%), sterculic (1.8%), lauric (1.2%), linoleic (16.1%), vernolic acid (3%), myristic (31.7%), and palmitic (4.7%). Additionally, the seed has trace amounts of phytosterol (β-sitosterol) and oils with 1-chlorooctadecane (33.2%), tetracontane (9.24%), 4-(2-2-dimethyl-6-6-methylene-cyclohexyl) butanol (5.29%), octadecane (5.15%), octacisane (3.97%), heptacosane (1.72%), and eicosane (1.71%). These are among the other compounds found in the seed.[67]

4.12. Leaf's nutritional makeup

The leaf's pleasing scent is attributed to its 9.1 g of protein, 4.3 g of fat, 17.0 g of crude fiber, 0.19 mg of phosphorus, 1.3 mg of calcium, and essential oils per 100 g.

5. Conclusion

Syzygium cumini L. provides several important necessary elements as well as unique bioactive ingredients. The fruit's purple hue is due to anthocyanin, while the sour flavor and astringency are caused by tannins and gallic acid. Numerous in vitro studies have demonstrated that the presence of different phytochemicals results in different disease-preventing properties, such as anticancer, anti-neoplastic, anti-anemic, etc. In the traditional technique, different pathological illnesses are treated using either the entire fruit or specific sections of the fruit. Because the fruit is exceedingly perishable, there is interest in processing it to create several valuable goods. The current review focuses on its phytochemistry, nutraceutical qualities, and the use of all fruit components in food processing and products. In addition to being employed in food and medicine, it is also utilized in the creation of nanoparticles, natural colors, and adsorbents that remove pollutants from the environment. This implies that in order to maximize its use in food and maintain the nutrients in this priceless fruit, a great deal of research and industrial application are required.

6. Abbreviations

DHQ, dihydroquercetin; MDHQ, methyl-dihydroquercetin; DHM, dihydromyricetin; MDHM, methyldihydrolmyricetin; DMDHM, dimethyl-dihydromyricetin. G, number (n) of Galloyl; HHDP, number (n) of hexahydroxydiphenoyl.

7. Source of Funding

None.

8. Conflict of Interest

None.

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