

SYZYGIUM CUMINI (L.) SKEELS: A COMPREHENSIVE REVIEW OF PHYTOCHEMISTRY, PHARMACOLOGY, AND THERAPEUTIC POTENTIAL

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Article Received: 08 April 2026

Article Review: 29 April 2026

Article Accepted: 19 May 2026

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DOI: <https://doi.org/10.5281/zenodo.20455548>

How to cite this Article: Navya H. C., Dr. A. M. Krupanidhi, Dr. Prakash Dabadi (2026). *SYZYGIUM CUMINI* (L.) SKEELS: A COMPREHENSIVE REVIEW OF PHYTOCHEMISTRY, PHARMACOLOGY, AND THERAPEUTIC POTENTIAL. World Journal of Pharmacy and Medical Science, 2(6): 49-57.



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ABSTRACT

Syzygium cumini (L.) (SC) Skeels, commonly known as Jamun, is a widely used medicinal plant in traditional systems such as Ayurveda, Siddha, and Unani. The various parts of the plant, including seeds, leaves, bark, fruits, and flowers, are rich in bioactive constituents such as flavonoids, phenolic acids, tannins, terpenoids, anthocyanins, and alkaloids. The SC exhibits important pharmacological activities such as antidiabetic, cardioprotective, antihypertensive, antioxidant, anti-inflammatory, antimicrobial, anticancer, neuroprotective, anti-diarrheal, anti-allergic, anthelmintic, antileishmanial, radioprotective, and sun-protective qualities have been shown in experimental studies. By modifying oxidative stress, inflammation, lipid metabolism, and glucose homeostasis, the plant exhibits special promise in the treatment of cardiometabolic disorders. Its traditional claims are strongly supported by preclinical findings, but the majority of the evidence comes from in vitro and animal studies. To confirm its therapeutic efficacy and safety in humans, more carefully planned clinical trials, extract standardization, and active principle identification are necessary. Based on these pre-clinical evidences, *S. cumini* is an important natural resource with a great deal of promise for advancement in contemporary phytomedicine and nutraceutical applications.

KEYWORDS: *Syzygium cumini*, Jamun, Phytochemistry, Antidiabetic activity, Antioxidant, DPPH.

INTRODUCTION

Medicinal plants have long played a vital role in human health and continue to contribute significantly to modern medicine, with nearly 30% of contemporary pharmaceuticals derived from plant sources. According to the World Health Organization (WHO), about 80% of the global population relies on plant-based medicines for primary healthcare needs. The WHO has also emphasized the importance of scientific validation of medicinal plants, particularly in regions lacking access to safe synthetic drugs. India is one of the most biodiverse countries, possessing around 47,000 plant species across 15 agro-climatic zones, of which nearly 15,000 are considered to have medicinal value.^[1] Traditional systems such as Ayurveda, Siddha, and Unani depend extensively on herbal and mineral-based formulations.

These plants serve as valuable bio-resources for traditional and modern medicines, nutraceuticals, dietary supplements, and pharmaceutical intermediates.^[2] Their therapeutic effects are largely attributed to bioactive phytochemicals such as flavonoids, phenolics, alkaloids, and terpenoids, which exhibit antioxidant, anti-inflammatory, antibacterial, and cardioprotective activities.^[3]

Syzygium cumini L. (jamun) is a prominent species found throughout the Indian subcontinent (British Herbal Pharmacopoeia, 1976). In different systems of Ayurvedic, Siddha, Unani, and homeopathic medicines, different parts of *S. cumini* have been used. *S. cumini* was considered one of the best herbal medicines for diabetes mellitus before the discovery of insulin.^[4]

According to Ayurvedic texts, the bark of *S. cumini* is astringent, digestive, and heals wounds and is used in treating biliousness, dysentery, bronchitis, asthma, ulcers, and sore throat. In Unani medicine, it is classified as a liver tonic and has dentition and blood-enriching properties, while in Siddha medicine, it is classified as a semen-promoting, haematinic, and hypothermic drug. The fruits and seeds of *S. cumini* have been used extensively in South Asian traditional medicines, especially for the treatment of diabetes, and the seeds have been found to possess diuretic and astringent properties.^[5]

Many reports about *S. cumini* have been confirmed by empirical studies. The evidence suggests that the plant has hypoglycemic, anti-inflammatory, antipyretic, hypolipidaemic, antioxidant, antibacterial, antinociceptive, and cardioprotective properties.^[6]

Its prominent antioxidant property is ascribed to the presence of volatile compounds such as α -pinene, camphene, myrcene, β -pinene, and limonene, and flavonoids such as myricetin, catechin, and rutin, based on phytochemical analysis. These biological compounds increase physiological resistance and therapeutic properties by neutralizing free radicals and modulating cellular signaling pathways.^[7]

It is not possible to represent the complexity of human metabolic and cardiovascular disorders through any single model, despite extensive research using experimental models. Therefore, there is a need for further research on *Syzygium cumini* to comprehend its pharmacological properties.

Description: SYZYGIUM CUMINI (L)

Table 1: Taxonomical Classification.^[8]

Kingdom	Plantae
Division	Magnoliophyta
Class	Magnoliopsida
Order	Myrtales
Family	Myrtaceae
Genus	Syzygium
Species	cumini

SYNONYMS^[9]

- *Eugenia jambolana* Lam.
- *Syzygium jambolanum* (Lam.) DC.
- *Myrtus cumini* L.
- *Eugenia cumini* (L.) Druce
- *Calyptanthus jambolana* (Lam.) Willd.
- *Jambolifera pedunculata* Gaertn.
- *Syzygium jambos* sensu auct. non (L.) Alston

Table 2: Vernacular Names^[10]

Kannada	Nerale hannu
Hindi	Jamuna
English	Jambul
Sanskrit	Mahajambu, Ksudrajambu

Tamil	Naval
Bengali	Jaam, Kalajam
Gujarathi	Gambu, Jamun
Marati	Jambul
Malayalam	Nijaval

GEOGRAPHICAL DISTRIBUTIONS

It is a massive evergreen tree that grows to a height of 30 meters, with a girth of 3 to 6 meters and a bole of up to 15 meters. It grows in the entire Indian subcontinent up to 1800 meters. The trees are now distributed in Madagascar, the Asian subcontinent, Eastern Africa, South America, and Florida and Hawaii in the United States. *Syzygium cumini* is distributed in South Asia, India, Indonesia, Sri Lanka, Malaysia, Australia, Bangladesh, Nepal, and other countries. *Syzygium cumini* is found in larger numbers in the Himalayas, Kerala, Karnataka, Andhra Pradesh, North India, and East India.

Because of the palatable and edible fruits, the tree was introduced to southern Africa from tropical Asia and India.^[11-12]

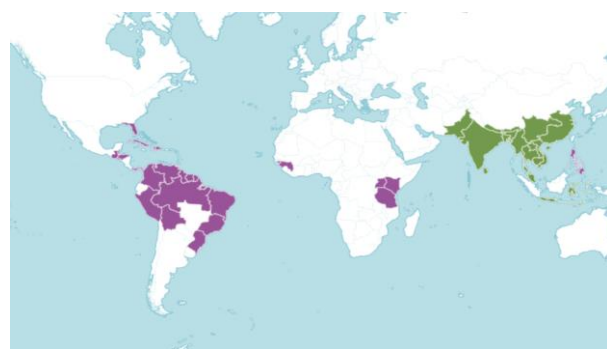


Figure 1: Global distribution of *Syzygium cumini*. Green: Native range. Purple: Introduced and naturalized regions. Source: POWO/Kew Science.

MORPHOLOGY

Leaves: The leaves are 5-15 cm long and 2-8 cm wide, opposite, broadly obovate, elliptic, or elliptic-oblong with cuneate or rounded base, short, rounded, or obtuse tip, not toothed, thick, coriaceous, glabrous, dark green on top and yellowish, dull on bottom, with light yellow, thin stalk 1.5-2 cm long, prominent, light yellow midrib, with fine, close, parallel, dotted veins.

Flowers: in clusters on old twigs at the back of leaves, 5-6 cm long and wide, with many paired stout forks at nearly right angles, end flower open first flowers, white, many, small, about 7 mm long, slightly fragrant, nearly stalkless, with cuplike, conical, light green base (hypoanthium) 3 mm long and broad; calyx with four white, rounded, concave petals, more than 2 mm long, united into a cap; stamens, white or pinkish, threadlike, numerous, small and stout; style white, 6-7 mm long.

Fruits: They look like large berries and usually emerge between May and June. Fruits occur in clusters of four to twenty. However, not all fruits in a flower cluster mature

at the same time. Fruits are ovoid-oblong to elliptical berries that are very abundant, crowded, and almost sessile along the twigs at the back of leaves; they are often curved, green when young, turning pink and then purple-black; they are 1-2.5 cm (up to 5 cm maximum) long, with a large seed in the middle; the flesh is grayish-yellow, white, or pale violet. The mature fruit has an astringent, slightly sour, and sweet taste. Vitamins A and C are rich in it.

Seed: Each berry has a central core seed that is 1-2 cm long, very astringent, and slightly bitter. Sometimes, two to five cornered, irregularly shaped seeds are lumpy together in a mass that looks like a single seed. The cotyledons are light green in color. Seeds cannot be kept for a long period of time because they are refractory.^[13]



Fig. 2: *Syzygium cumini*- Leaves, Flowers, Fruits, Seeds, and Bark.

Table 3: Phytochemicals and Bioactive Constituents of *Syzygium cumini*.^[14]

Plant Part	Chemical Constituents
Fruit (Pulp)	Organic acids: Malic acid (0.59%), oxalic acid; Phenolics: Gallic acid, tannins; Anthocyanins: Cyanidin diglycosides (deep purple color); Sugars: Glucose, fructose, mannose, galactose (total sugars 8.09%, non-reducing sugars 9.26%); Other acids: Sulfuric acid (1.21%); Minerals (per 100 g): Ca, Mg, P (including phytin P), Fe (ionizable Fe), Na, K, Cu, S, Cl; Vitamins (per 100 g): Vitamin A, thiamine, riboflavin, nicotinic acid, vitamin C, choline, folic acid
Seeds	Glucoside: Jamboline; Phenolics: Ellagic acid, gallic acid (1–2%), caffeic acid, ferulic acid, corilagin; Other phenols: Guaicol, resorcinol dimethyl ether; Tannins (~19%); Flavonoids: Rutin, quercetin; Sterols: β -sitosterol; Monoterpenoids: β -pinene, γ -terpinene, terpinolene, borneol, β -phellandrene, α -terpineol, eugenol; Fatty acids (seed oil): Lauric, myristic, palmitic, stearic, oleic, linoleic, malvalic, vernolic acids; Others: Essential oil (trace), chlorophyll, fats, resins, albumin, proteins, calcium, new steroidal and phenolic compounds
Stem Bark	Betulinic acid, β -sitosterol, friedelin, epi-friedelanol, eugenin (ester of epi-friedelanol), β -sitosterol-D-glucoside, kaempferol-3-O-glucoside, quercetin, myricetin, astragalol, gallic acid
Leaves	Sterols: Sitosterol; Triterpenoids: Betulinic acid, maslinic acid; Flavonoids: Quercetin, myricetin, myricitrin, acylated flavonol glycosides; Polyphenols & ellagitannins; Sugars: Glucose, fructose; Organic acids: Oxalic, citric, glycolic acids; Amino acids: Glycine, alanine, tyrosine, leucine; Essential oil (steam distilled): Limonene, dipentene; Others: Long-chain hydrocarbons and alcohols
Flowers	Oleanolic acid, maslinic acid, isoquercitrin, quercetin, kaempferol, myricetin

TRADITIONAL USES

Syzygium cumini, also known as Jamun, is a common ingredient in many traditional and folk medicinal practices, including Ayurvedic, Siddha, and Unani medicine, as well as other local folk medicinal practices like Anti-diabetic, UTI, Constipation etc. Almost every

part of this plant has been found to be useful in some form of folk medicine: seeds, fruits, leaves, bark, flowers, and roots.^[15-16]

PHARMACOLOGICAL PROPERTIES CLAIMED

1. Cardiometabolic disorders

Research indicates that *Syzygium cumini* can be used therapeutically to treat cardiometabolic syndromes, including diabetes, obesity, lipid abnormalities, and cardiovascular disease. Strong antihyperglycemic, antihyperlipidemic, antioxidant, and anti-inflammatory qualities have been discovered in *S. cumini* extracts.

These characteristics aid in controlling lipid levels, vascular function, and insulin sensitivity. The antithrombotic and antioxidant qualities are also linked to the cardioprotective and cardiometabolic complications.^[17]

2. Anti-diabetic activity

Syzygium cumini, also called jamun, has traditionally been used for the management of diabetes. Recent studies have confirmed the antidiabetic and antioxidant effects of the seed extract of *Syzygium cumini*, particularly. The seed extract at the dose range of 100-200 mg/kg was found to produce a dose-dependent decrease in blood glucose concentrations in streptozotocin-induced diabetic rats. Although the blood glucose-lowering effects of the seed extract of *Syzygium cumini* are less compared to the standard drug metformin, the combination of the seed extract of *Syzygium cumini* and metformin was found to produce greater blood glucose-lowering effects compared to the individual effects of the seed extract of *Syzygium cumini* and metformin. The seed extract using methanol and ethyl acetate solvents and the compound mycaminose showed strong blood glucose-lowering effects comparable to those of the standard drug glibenclamide.

Thus, the seed extract of *Syzygium cumini* traditionally used for the management of diabetes has been proved to possess antidiabetic effects. Further extensive studies are needed for the evaluation of the safety profile, the active compound, and the antidiabetic effects of the seed extract of *Syzygium cumini*.^[18-20]

3. Cardioprotective

According to recent studies, *Syzygium cumini* is a useful cardioprotective agent when myocardial injury is induced experimentally. Significant improvements in hemodynamic parameters and cardiac function, as well as a decrease in infarct size, have been observed when *S. cumini* extract is administered. A protective effect against myocardial injury was indicated by a decrease in serum cardiac biomarkers. Significant anti-inflammatory and antioxidant characteristics were linked to the cardioprotective effect, which reduced oxidative stress in cardiac tissue. The main contributors to these qualities have been identified as phytoconstituents, particularly flavonoids, polyphenols, and anthocyanins. It can be concluded from the current research that *S. cumini* may find use in the treatment and prevention of cardiovascular disorders.^[21]

4. Antihypertensive Activity

The antihypertensive potential of the hydroalcoholic extract of *Syzygium cumini* leaves was investigated in spontaneously hypertensive rats (SHR). The extract showed a dose-response decrease in blood pressure in normotensive rats and decreased blood pressure and heart rate in SHR after eight weeks of treatment. The results from the study on the effects of the extract on vascular tissue showed reduced contractile response to norepinephrine and calcium, resulting in decreased arterial tone. The hypotensive effects of the extract were partly mediated through the cholinergic system and the inhibition of calcium influx from the outside environment. The results validate the traditional use of the plant for the treatment of hypertension.^[22]

5. Anticancer

Syzygium cumini has been found to possess considerable chemopreventive and anticancer properties due to its high phenolic and flavonoid content. The seed extract has been found to possess strong antioxidant properties and protects DNA from oxidative damage in vitro.

Specifically, it has been found to decrease DNA strand breaks caused by hydroxyl radicals, suggesting a protective effect against mutational initiation. In carcinogen-treated animal models, the extract has been found to significantly reduce chromosomal aberrations and micronuclei. It also reduces lipid peroxidation and increases the activity of endogenous antioxidant enzymes such as glutathione (GSH), glutathione S-transferase (GST), superoxide dismutase (SOD), and catalase. In a 7,12-dimethylbenz[a]anthracene (DMBA)-induced skin cancer model, the extract has been found to reduce tumor incidence, tumor mass, and tumor yield.

Histopathological studies have also shown that the extract preserves near-normal skin tissue architecture in treated animals. The fruit skin extract has been found to inhibit the proliferation of cervical cancer cell lines HeLa and SiHa in a dose-dependent manner. The extract has been found to induce apoptosis rather than necrosis in a variety of cellular assays. Thus, *S. cumini* has been found to possess DNA protection, antioxidant, and tumor inhibition properties, although clinical validation is still required.^[23-25]

6. Anti-inflammatory activity

The anti-inflammatory properties of ethyl acetate and methanolic extracts of *Syzygium cumini* seeds were assessed using the carrageenan-induced paw edema model in Wistar rats. Both extracts, given orally at 200 and 400 mg/kg, caused significant inhibition of paw edema. The methanolic extract at 400 mg/kg caused maximum inhibition of paw edema, which was similar to that of diclofenac sodium.^[26]

7. Antioxidant activity

Extensive research has revealed that *Syzygium cumini* leaf extracts possess strong antioxidant properties. The

leaf extracts possess strong free radical scavenging activity, especially in DPPH assays, and possess strong ferric reducing antioxidant power (FRAP), thus justifying their ability to counteract reactive oxygen species. Among the fractions tested, the ethyl acetate fraction was found to possess the highest antioxidant activity, thus indicating that moderately polar compounds play an important role in the antioxidant activity. The analyses revealed high concentrations of phenolic and flavonoid compounds in the leaves, with a strong positive correlation between total phenolic content and antioxidant activity. Chromatographic analysis also revealed the presence of important bioactive compounds such as catechin and ferulic acid, thus justifying the fact that the antioxidant activity of *S. cumini* leaves is mainly due to their high phenolic content.^[27]

8. CNS activity

The current study evaluated the central nervous system (CNS) activity of *Syzygium cumini* seed extract using proven behavioral models in experimental animals. The seed extract showed significant sedative and depressant activity, as evidenced by a reduction in locomotor activity in actophotometer tests. Anxiolytic activity was also evident, as the treated animals exhibited increased open arm exploration in the elevated plus maze. Muscle relaxant activity was suggested by a reduction in grip strength and performance in the rotarod test. The above-mentioned CNS activity could be linked to the flavonoids and other phytoconstituents in the plant and may have potential in the treatment of anxiety-related disorders.^[28]

9. Anti-amnestic activity

The anti-amnestic activity of the test extract was evaluated using experimental models of amnesia induced in animals. Amnesia was induced using conventional amnesic drugs, resulting in a significant impairment of learning and memory. The administration of the extract resulted in a significant improvement in learning and memory functions. The extract was found to be equally effective as conventional nootropic drugs. Biochemical analysis indicated a restoration of cholinergic transmission by the inhibition of acetylcholinesterase activity. Furthermore, the antioxidant defense system in the brain was also enhanced. These results clearly suggest that the extract has potent anti-amnestic and neuroprotective actions.^[29]

10. Analgesic activity

The SC extracts decrease the number of writhing episodes in a dose-dependent manner, showing strong analgesic activity. The antinociceptive activity is probably due to the inhibition of prostaglandin synthesis or other mediators of inflammatory pain. Bioactive compounds such as flavonoids and phenolic compounds in the leaves are thought to be responsible for this analgesic activity.^[30]

11. Anti-arthritis activity

The current study evaluates the anti-arthritis effect of the methanolic extract of *Syzygium cumini* seeds using proven experimental models of arthritis in rats. Arthritis was induced to model chronic inflammatory joint diseases. The treatment with the extract caused a significant and dose-dependent reduction in paw edema, joint inflammation, and arthritic symptoms. In addition, the extract reduced body weight loss and decreased biochemical markers of inflammation. The anti-arthritis activity was similar to that of standard anti-inflammatory drugs. The activity is ascribed to the presence of flavonoids, tannins, and other phenolic compounds, hence justifying the traditional use of *S. cumini* in the treatment of arthritis.^[31]

12. Anti-diarrhoeal activity

The ethanolic extract of *Syzygium cumini* bark showed significant anti-diarrhoeal activity in the experimental model. In the castor oil-induced diarrhoea model, the extract caused a dose-dependent decrease in the number of diarrhoeal stools, suggesting a protective effect against intestinal hypersecretion. In the charcoal meal gastrointestinal transit model, the extract caused a decrease in intestinal motility, suggesting a decrease in gut propulsion. Although the activity was moderate compared to the standard anti-diarrhoeal drug loperamide, the results confirm the therapeutic potential.

The results are probably due to the presence of tannins, flavonoids, and other phytochemicals in the extract, which may inhibit intestinal secretion and motility, thus confirming the traditional use of *S. cumini* bark in diarrhoeal disorders.^[32]

13. Antimicrobial activity

The study evaluated the antimicrobial properties of a hydroalcoholic leaf extract of *Syzygium cumini* against a range of pathogenic microorganisms. The extract showed strong antimicrobial properties against *Candida krusei*, as indicated by a large inhibition zone and a low minimum inhibitory concentration (MIC). The extract also showed effectiveness against multi-drug resistant isolates of *Staphylococcus aureus*, *Pseudomonas aeruginosa*, and *Klebsiella pneumoniae*. The MIC was in the range of 70-200 µg/mL, suggesting a dose-dependent antimicrobial effect. The results can be attributed mainly to the presence of phenolic compounds and tannins in the leaves of *S. cumini*.^[33]

14. Anti-allergic activity

Syzygium cumini exerts significant anti-allergic effects by acting on both the early and late phases of allergic inflammation. An aqueous extract of the leaves, which is rich in polyphenols and mainly consists of flavonoids and tannins, has been found to inhibit mast cell degranulation and histamine- and serotonin-induced effects. In experimental models, the extract reduced acute allergic edema and selectively inhibited eosinophil accumulation in allergic pleurisy. This was found to be

associated with a decrease in the production of major eosinophil-regulating cytokines, interleukin-5 (IL-5), and CCL11 (eotaxin). These observations confirm the traditional use of *S. cumini* in allergic disorders and its potential as a natural source of anti-allergic drugs.^[34]

15. Anthelmintic activity

The aqueous leaf extract and fruit juice of *Syzygium cumini* showed promising in vitro anthelmintic activity against various helminthic species. The leaf extract showed activity against *Pheretima posthuma*, while the fruit juice showed activity against *Ascaridia galli* and *Ascaris suum*. At a concentration of 102.18 and 136.24 mg/mL, respectively, the results were comparable to that of the standard antiparasitic drug pyrantel pamoate. In both studies, an activity profile characteristic of dose-dependent activity was noted, where higher concentrations showed increased paralysis and death of the worms at a faster rate. The fruit juice at higher concentrations showed activity comparable to that of standard anthelmintic drugs, while the leaf extract also showed significant activity. The phytochemical constituents tannins, flavonoids, alkaloids, saponins, and anthocyanins are believed to be responsible for the reported anthelmintic activity.^[35-36]

16. Antileishmanial activity

The study evaluated the antileishmanial potency of *Syzygium cumini* extract against *Leishmania* spp. using in vitro models. The extract showed a significant inhibitory effect on the growth of the parasites in a dose-dependent manner. Cytotoxicity studies revealed a selective toxic effect on the parasite with minimal host cell toxicity. The observed antileishmanial activity was confirmed to be mediated by bioactive phytochemicals, such as polyphenols and flavonoids, which have been shown to interfere with the metabolism and viability of the parasite. The findings suggest that *S. cumini* has a considerable potential as an antileishmanial agent.^[37]

17. Radioprotective

The collective body of literature suggests that the *Syzygium cumini* leaf and seed extracts possess significant radioprotective activity against gamma radiation-induced damage in experimental animals. The use of these extracts as a pretreatment regimen increases survival rates, prolongs the time to onset of radiation sickness, and decreases mortality compared to non-pretreated irradiated controls. The protective activity is dose-dependent, with optimal doses providing maximal protection, beyond which higher doses do not provide additional benefits. Both leaf and seed extracts play a role in the protection of key radiation-sensitive tissues, such as the gastrointestinal tract and bone marrow, thus aiding in hematological recovery and maintenance of tissue integrity post-exposure. These radioprotective activities can be attributed primarily to the high concentration of antioxidant phytoconstituents, such as flavonoids, phenolics, and ellagic acid, in the plant,

which have free radical scavenging properties and protect against oxidative and DNA damage.^[38-40]

18. Sun protection

The research work evaluates the sun protection factor (SPF) activity of a serum formulation containing an ethanolic extract of *Syzygium cumini* leaves.

Phytochemical analysis reveals the presence of flavonoids, polyphenols, tannins, saponins, and terpenoids, which are responsible for UV protection and antioxidant properties. The prepared serums have optimal physicochemical stability with suitable pH, viscosity, and spreadability. SPF evaluation shows a dose-dependent increase in protection factor, ranging from 9.35 to 26.05, meeting the country's sunscreen standards. Higher concentrations of the extract provide better protection, ranging from moderate to ultra protection against UV radiation. Overall, the results indicate that the *Syzygium cumini* leaf extract has immense potential as a natural sunscreen agent and cosmetic ingredient.^[41]

19. Enhanced female reproductive activity

The present work investigated the possible action of the alcoholic extract from the stem bark of *Syzygium cumini* on the female reproductive system in Wistar rats and to provide scientific evidence for the plant's claimed traditional use as a fertility enhancer. At 500 mg/kg, treatment produced normal estrous cycles, with no overt toxicity; a slight increase in body and ovarian weights occurred. Histological observation indicated that there were no changes in ovarian structure. There was a significant increase in the corpus luteum number, which is indicative of increased ovulation in the treated group; besides that, there was a higher number of primary follicles, indicative of enhanced development of follicles. Put together, these findings suggest that the tested extract has potential for enhancing fertility because of its enhancing effects on ovarian function and ovulation in female rats.^[42]

20. Diuretics

Diuretics are used in the treatment of a number of human ailments, such as heart failure, hypertension, liver disease, certain types of renal problems, and cases of overdose or poisoning. Modern practice is gradually shifting towards the use of herbal diuretics. In this study, the extracts of SC bark, namely petroleum ether, chloroform, methanolic, and aqueous extracts, were tested for diuretic activity in Wistar albino rats at a dose of 500 mg/kg body weight. The methanolic and aqueous extracts showed diuretic activity, as evidenced by the augmentation of total urine output and changes in electrolyte excretion, specifically sodium and potassium ions.^[43]

21. Hepatoprotective Activity

In vitro studies were conducted to assess the hepatoprotective activity of *Syzygium cumini* peel and pulp

extract against carbon tetrachloride (CCl₄)-induced toxicity in rat isolated hepatocytes. The antioxidant activity of the anthocyanin-rich peel extract of *Syzygium cumini* (SCA) was significant and non-toxic at the tested concentrations.

CCl₄-induced toxicity resulted in decreased cell viability, lactate dehydrogenase leakage, and glutathione depletion, and increased lipid peroxidation in rat isolated hepatocytes.

Pre-incubation of the isolated rat hepatocytes with SCA significantly increased cell viability, reduced lactate dehydrogenase leakage by 54%, restored glutathione levels, and reduced lipid peroxidation. SCA significantly potentiated glutathione peroxidase activity, while showing minimal effects on catalase and SOD activity. The pulp extract showed poor activity in comparison with the peel extract. The results of the present study demonstrate that the hepatoprotective activity of the peel extract of *S. cumini* is mediated by the glutathione antioxidant system and may be useful in the prevention of oxidative liver injuries.^[44]

CONCLUSION

Syzygium cumini (L.) Skeels is an important medicinal plant that has been used extensively in traditional medicine practices and has been increasingly supported by empirical evidence. Various parts of the plant, namely the seeds, bark, leaves, and fruits, have been found to possess a wide range of pharmacological properties, such as antidiabetic, cardioprotective, antihypertensive, antioxidant, anti-inflammatory, antimicrobial, anticancer, and neuroprotective properties.

These properties are mainly due to the presence of a diverse range of phytochemicals, such as flavonoids, phenolic acids, tannins, terpenoids, and anthocyanins.

Experimental studies have clearly demonstrated the potential of the plant in the treatment of cardiometabolic syndromes, oxidative stress, inflammation, and infectious diseases. In addition, recent studies have also revealed the potential of the plant in the prevention of radiation damage, sun damage, allergies, arthritis, and enhancement of fertility. Although the preclinical studies have been promising, most of the studies have been conducted on in vitro and animal models, thereby necessitating the need for well-designed clinical trials to validate the safety, efficacy, and optimal dosage of the plant in human subjects.

Moreover, standardization of plant extracts and isolation of active principles are also required for therapeutic development. In conclusion, *Syzygium cumini* is a valuable natural resource that has immense potential for use in modern phytomedicine and nutraceuticals, thereby providing a bridge between traditional medicine and modern biomedical research.

FUNDING SOURCE

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

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