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COMPREHENSIVE PHYTOCHEMICAL PROFILING OF *SYZYGIUM CUMINI* L

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ABSTRACT

Syzygium cumini L., commonly known as Jamun, is a medicinal plant widely recognized for its diverse pharmacological properties and rich phytochemical composition. The present study focuses on the comprehensive phytochemical profiling of *Syzygium cumini* with the aim of identifying and characterizing its bioactive constituents. Various parts of the plant, including seeds, leaves, and pulp, are known to contain important phytochemicals such as alkaloids, flavonoids, tannins, glycosides, phenolic compounds, and anthocyanins, which contribute to its therapeutic potential. In this study, preliminary phytochemical screening was carried out using standard qualitative methods to detect the presence of major classes of phytoconstituents. Advanced analytical techniques such as chromatography and spectroscopic methods were employed for detailed profiling and identification of active compounds. The results revealed a rich presence of phenolic and flavonoid compounds, which are known for their antioxidant and antidiabetic activities. The comprehensive phytochemical analysis of *Syzygium cumini* highlights its potential as a valuable source of natural bioactive compounds for pharmaceutical and nutraceutical applications. The study supports the traditional use of this plant and provides a scientific basis for further pharmacological investigations and drug development.

KEYWORDS: Syzygium cumini; Phytochemical profiling; Flavonoids; Phenolic compounds; Antioxidant activity; Medicinal plant; Chromatography; Bioactive compounds.

Syzygium cumini, often referred to as Java plum, Jamun, or Indian blackberry, constitutes a tropical evergreen arboreal species classified within the Myrtaceae family. Its geographical distribution spans across India, Sri Lanka, and Southeast Asia. The fruit, seeds, bark, and foliage of S. cumini have been comprehensively utilized in traditional medicinal practices for the amelioration of a variety of health conditions, including diabetes, infections, and inflammatory disorders. Syzygium cumini, widely acknowledged as Jamun, is distinguished for its antidiabetic and antioxidant attributes, rendering it an invaluable element in herbal formulations targeted at the management of diabetes mellitus (Semwal & Gupta, 2023) (Narkhede et al., 2024). The formulation of such tablets frequently necessitates the optimization of extraction and formulation methodologies to augment the therapeutic efficacy of the bioactive constituents. For instance, the application of freeze-dried Syzygium cumini pomace powder has been demonstrated to enhance the phytonutrient and antioxidant profiles of nutraceutical tablets, which also manifest commendable bioavailability and stability over time (Kaur & Aggarwal, 2022). Furthermore, the integration of Syzygium cumini in conjunction with other medicinal botanicals such as Gymnema sylvestre and Zingiber officinale has been investigated to develop polyherbal formulations that provide synergistic antidiabetic effects (Dhondiram et al., 2024) (Rather et al., 2023). The formulation process conventionally encompasses the utilization of diverse excipients and polymers to achieve the desired tablet characteristics, including sustained release, rapid disintegration, and effective drug delivery. For example, the incorporation of HPMC and ethyl cellulose in matrix tablets has been shown to prolong the release of active constituents over a duration of 12 hours, which is advantageous for maintaining consistent therapeutic concentrations (Aruna, 2011). Moreover, the characterization of these formulations typically entails the assessment of their physicochemical properties, including hardness, friability, and disintegration time, alongside their in vitro antidiabetic activity evaluated through assays such as α-amylase and α-glucosidase inhibition (Rather et al., 2023) (Aruna, 2011). In aggregate, the formulation and characterization of Syzygium cumini-based herbal tablets represent intricate processes that necessitate meticulous consideration of extraction techniques, formulation strategies, and evaluative criteria to ensure both efficacy and safety in the management of diabetes and its associated conditions (Narkhede et al., 2024) (Aruna, 2011). Herbal medicines have constituted a fundamental aspect of healthcare for centuries, experiencing a resurgence in

global interest due to heightened concerns regarding the dependence on and safety of conventional pharmaceuticals. Numerous natural remedies are perceived to yield superior outcomes with diminished side effects. Diabetes mellitus (DM), a prominent metabolic disorder affecting the metabolism of carbohydrates, proteins, and lipids, impacts nearly 10% of the global populace. While synthetic pharmacological agents effectively manage DM, they frequently present serious adverse effects, thereby propelling the ongoing search for indigenous natural antidiabetic substances. Herbal medicines are increasingly esteemed for the treatment of diabetes owing to their reduced side effects and lower economic burden in comparison to synthetic hypoglycemic agents. The seeds of Syzygium cumini (L.), abundant in polyphenols and flavonoids, are extensively recognized in traditional medicine for the management of diabetes. Notwithstanding, natural therapeutic agents often encounter limitations stemming from suboptimal physicochemical properties, resulting in diminished bioavailability and therapeutic efficacy. To address these constraints, the advancement of Novel Herbal Drug Delivery Systems (NHDDS) with superior absorption characteristics is imperative. These innovative formulations present benefits such as augmented solubility, enhanced stability, increased membrane permeability, improved bioavailability, prolonged release, and diminished toxicity, thereby administering pharmaceuticals at a specified rate to the designated site. Micro/nano-sized NHDDS exhibit considerable potential for amplifying efficacy and resolving challenges related to phytopharmaceuticals. Historically, herbal medicines garnered limited scholarly attention for NDDS development owing to processing complexities, yet contemporary scientific progress has paved the way for novel herbal formulations. Polymeric microspheres represent a promising domain of inquiry for targeted drug delivery. Ethyl cellulose (EC) is a frequently utilized, semi-synthetic, lipophilic, non-toxic, biocompatible, non-degradable, and economically viable polymer for controlled release applications. The solvent evaporation technique is regarded as the most straightforward approach for the fabrication of microspheres. This investigation sought to formulate and characterize innovative herbal formulations of Syzygium cumini seed extract utilizing ethyl cellulose polymeric microspheres through the emulsion solvent evaporation method. No previous endeavors to create a novel formulation for Syzygium cumini seed extract have been documented. (Biswas & Sen, 2018)

PLANT PROFILE

Fig 1: JAVA PLUM *(SYZYGIUM CUMINI).*

***Syzygium cumini* (L.) Skeels**

Taxonomical Classification

Rank	**Scientific Name**
Kingdom	Plantae
Division	Angiosperms
Class	Dicotyledonae
Order	Myrtales
Family	Myrtaceae
Genus	*Syzygium*
Species	*cumini*

Here's a **paraphrased and well-structured version** of your text on the **Medicinal and Pharmacological Properties of *Syzygium cumini*** — written in a clear, academic tone suitable for reports or publications.

Medicinal Properties of *Syzygium cumini*

1. Antidiabetic Activity

The seeds of *S. cumini* are widely recognized for their potent hypoglycemic action. Bioactive constituents such as **jamboline**, **ellagic acid**, and **jambosine** slow down starch-to-sugar conversion and improve insulin responsiveness. Both **clinical and animal studies** have

demonstrated significant reductions in **fasting blood glucose**, **HbA1c**, and improved **lipid metabolism** following administration of seed extracts.

2. Antioxidant Activity

Rich in **anthocyanins**, **flavonoids**, and **phenolic compounds**, the fruit of *S. cumini* exhibits strong antioxidant capacity. These compounds neutralize free radicals and protect cellular structures from **oxidative stress**, thereby preventing damage to lipids, proteins, and DNA.

3. Antimicrobial Activity

Methanolic and ethanolic extracts from the **leaves, bark, and seeds** of *S. cumini* show pronounced antimicrobial action against both **Gram-positive** and **Gram-negative bacteria**, including *Staphylococcus aureus*, *Escherichia coli*, and *Pseudomonas aeruginosa*. Additionally, the plant possesses **antifungal properties** effective against *Candida albicans* and *Aspergillus niger*, supporting its therapeutic use in managing **oral, dermatological, and ocular infections**.

4. Anti-inflammatory and Analgesic Activity

The **flavonoids**, **tannins**, and **terpenoids** found in the bark and leaves inhibit **cyclooxygenase (COX)** and **lipoxygenase (LOX)** enzyme pathways, leading to reduced inflammation and pain. These properties make the plant beneficial in conditions such as **arthritis**, **sore throat**, and **inflammatory eye disorders**.

5. Hepatoprotective Effect

Syzygium cumini seed extract offers significant **liver protection** against toxins such as **carbon tetrachloride (CCl_4)** and **paracetamol**, mainly by boosting **glutathione** levels and minimizing **lipid peroxidation**.

6. Cardioprotective and Hypolipidemic Activity

The **fruit pulp** and **seed extracts** help lower **total cholesterol**, **triglycerides**, **LDL**, and **VLDL** levels, while elevating **HDL** concentrations. These effects contribute to the prevention of **atherosclerosis** and **cardiovascular diseases**.

7. Anticancer Activity

Polyphenolic constituents such as **ellagic acid**, **gallic acid**, and **quercetin** exhibit cytotoxic effects on **breast, colon,** and **liver cancer** cell lines by inducing **apoptosis**, suggesting their potential in **cancer chemoprevention**.

8. Gastroprotective and Carminative Effects

The **fruit pulp** alleviates **hyperacidity** and **flatulence**, while the **seed powder** acts as a **carminative**, supporting overall **digestive health**.

9. Antihypertensive Effect

Aqueous seed extracts of *S. cumini* function as **natural vasodilators**, helping to **regulate blood pressure** and **stabilize cardiac rhythm**.

Pharmacological Activities of *Syzygium cumini*

1. Antidiabetic Effect

Both **ethanolic** and **aqueous seed extracts** significantly reduce blood glucose in normal and diabetic models. This effect is attributed to **regeneration of pancreatic β-cells** and **enhanced peripheral glucose utilization**.

2. Antioxidant and Hepatoprotective Effect

Methanolic extracts from the fruit enhance **antioxidant enzyme activities**—notably **catalase** and **superoxide dismutase (SOD)**—thereby protecting hepatic tissues from **oxidative injury**.

3. Antimicrobial Effect

Various *S. cumini* extracts exhibit **broad-spectrum antibacterial activity**. Ethanol seed extract effectively inhibits *E. coli*, *S. aureus*, *K. pneumoniae*, and *B. subtilis*, while the plant's **essential oil** displays notable **antifungal potential**.

4. Antiplasmodial and Antiviral Activities

Extracts from the **leaves and seeds** demonstrate moderate **antiplasmodial action** against *Plasmodium falciparum* and also inhibit replication of certain viruses, including **herpes simplex virus**.

5. Effects on the Reproductive System

At higher doses, *S. cumini* seed extract temporarily decreases **sperm motility and count** in male rats in a **dose-dependent** manner. However, these effects are **reversible** upon discontinuation of treatment.

MATERIALS AND METHODS

Fresh Seed were dried at 35º C for 48 hours and powdered using electric mixer grinder and stored in a desiccator. Care was taken to avoid fungal contamination while drying.

FIG. 2: JAVA PLUM *(SYZYGIUM CUMINI) LEAF, SEED.*

Sample Collection

Plant material of Fresh *SYZYGIUM CUMINI (Jawaplum)* was collected from Ground in front of ISBM University Nawapara Kosmi Chhura Gariyaband Chhattisgarh, India during the month of Jun-July 2025.

Preparation Of Plant Samples

Plant materials collected were washed under running tap water and were allowed to drain before air drying under shade for two weeks. The roots were separated from the leaves and the stem, because that is what is traditionally done. The leaves together with the stem and the small branches were then grinded mechanically with mortar and pestle

Extraction Process

Soxhlet Extraction

Soxhlet extraction is only required where the desired compound has a limited solubility in a solvent, and the impurity is insoluble in that solvent. If the desired compound has a high

solubility in a solvent, then a simple filtration can be used to separate the compound from the insoluble substance. The advantage of this system is that instead of many portions of warm solvent being passed through the sample, just one batch of solvent is recycled.

Three extraction procedures were carried out. The first extraction process consisted of using different proportions of the two main extraction solvents namely water and ethanol. The ratios of water to ethanol used for the proportions are presented in

PROCEDURE

About 100 gm of powdered material of *SYZYGIUM CUMINI (Jawaplum)* was extracted with ethanol as a solvent by hot extraction method using Soxhlet apparatus. The extraction was continued until the solvent in the thimble became clear then few drops of solvent were collected in the test tube during the completion of the cycle and chemical test of the solvent was performed.

After each extraction, the extract was evaporated to dryness some part of the extract was preserved for preliminary Phytochemical screening for the detection of various plant constituents and rest extract was used for formulation of gel batches.

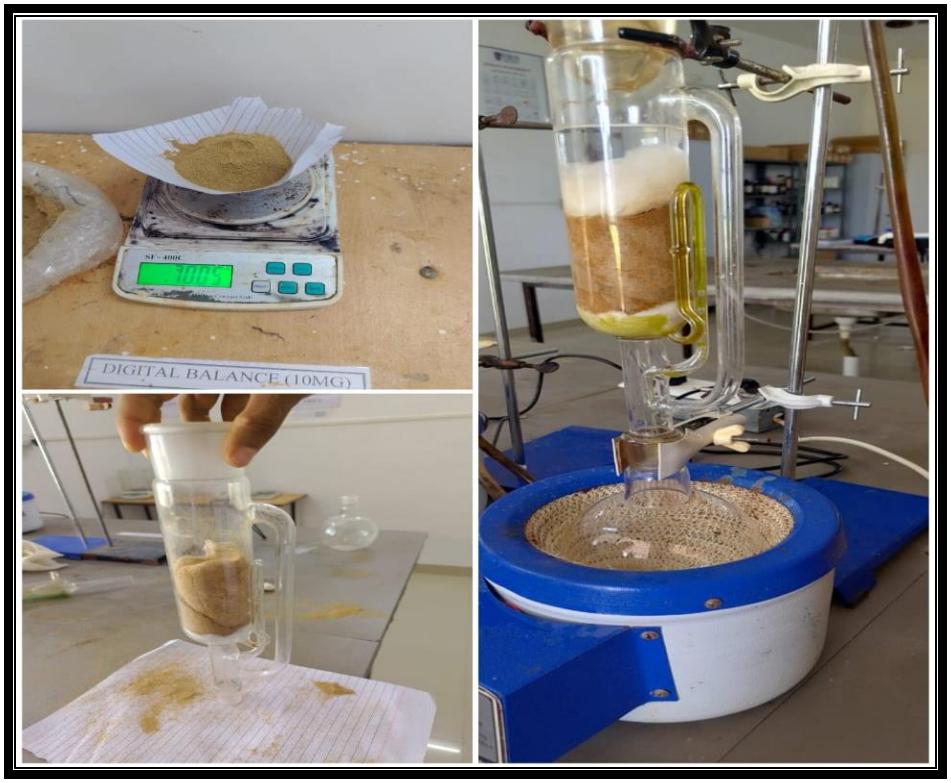

Fig. 2: Ethanol extraction

Fig. 3: - Water extraction.

PHYTOCHEMICAL SCREENING

Phytochemical screening was carried out to investigate the various classes of natural compounds present in the extract. Phytochemical tests were performed for primary and secondary chemical constituents.

Fig. 4: Evaporation Process.

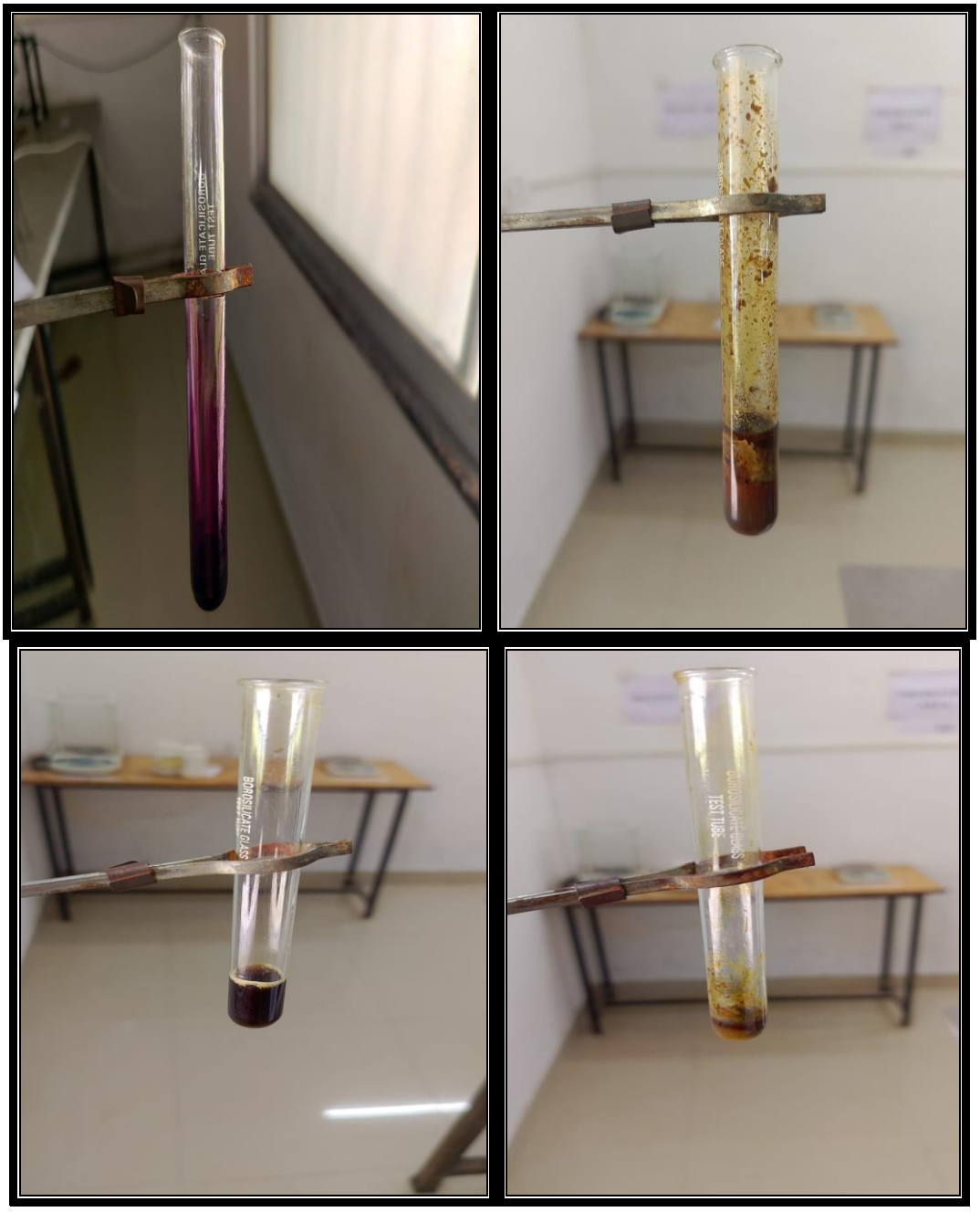

Fig 5: PHYTOCHEMICAL SCREENING.

Primary chemical constituents: - Amino acid, protein, carbohydrate.

Secondary chemical constituents: - Alkaloids, glycosides, tannins, flavanoids, terpinoids etc.

Table no - 1 Alkaloids.

Sr. No.	Test Performed	Observation	Inference
1.	**b) Mayer's Test: -** Treat test solution with Mayer's reagent (potassium mercuric iodide	Cream colored ppt.	Alkaloids present.
	c) Wagner's Test: - Treat test solution with Wagner's reagent (iodide in potassium iodide).	Reddish brown ppt	Alkaloids present.
	d) Hager's Test: - Treat test solution with Hager's reagent.	Yellow ppt.	Alkaloids present.
2.	**Glycosides :** **Test A: -** Extract 200 mg of drug with 5 ml of dil. H_2SO_4 by warming on water bath, filter it, & neutralize the acid extract with 5% solution of NaOH. Add 0.1 ml Fehling's solution A & B until it becomes alkaline & heat on water bath for 2 minutes.	Red ppt occurs.	General test for glycoside passes.
	Test B: - Repeat test A procedure by using 5 ml of water instead of dil. H_2SO_4. Note the quantity of red ppt formed.	Compared ppt of test A	Ppt in test A is greater than in test B then glycoside may be present.
A.	**Anthraquinone Glycoside: Boil** the test material with 1 ml of H_2SO_4 for 5 minute. Filter while hot, cool the filtrate, shake with equal volume of $CHCl_3$. Separate the lower layer of dichloromethane or $CHCl_3$;shake it with half of its volume of dil. NH_3.	Ammonical layer shows pink colour.	Anthraquinone glycoside present.
	Modified Borntrager's Test : Boil the test material with 1 ml of H2SO4. Treat with 2 ml of 5% aqueous $FeCl_3$ solution for 5 minute. Shake well with equal volume of $CHCl_3$ & continue the test as above.	Ammonical layer shows pink to red colour.	Anthraquinone glycoside present.
B.	**Cardiac Glycoside: Kedde's Test: -** Extract drug with chloroform evaporate it to dryness. Add 1 drop of 90% alcohol & 2 drops of 2% NaOH solution.	Purple colour is produced.	Cardiac glycoside present.
	b) Killer Killani's Test: Extract drug with $CHCl_3$ evaporate it to dryness. Add 0.4 ml of glacial acetic acid containing $FeCl_3$ add	Reddish brown colour appears at junction.	Cardiac glycoside present.

	carefully 0.5 ml of conc. H_2SO_4 by the side of tube.		
	Legal's Test: - Treat test solution with pyridine made alkaline with sodium nitroprusside.	Pink to red coloue appears.	Cardiac glycoside present.
C.	**Coumarine glycoside:** place small amount of sample in test tube & covered it with filter paper moistened with dil. NaOH solution. Place the covered test tube on water bath for several minutes. Remove the paper & expose it to ultraviolet light.	It shows yellow green fluroscence.	Coumarine glycoside present.
3.	**Flavonoids** **a) Shinoda Test: -** Treat test solution with fragments of Mg ribbon, add conc. Hcl acid.	Pink colour produced.	Flavonoids present.
	b) Alkaline Reagent Test: - Treat test solution with NaOH solution.	Yellow colouration.	Flavonoids present.
4.	**Steroids & Triterpenoids :Libermann Burchard Test** Treat extract with few drops of acetic anhydride, boil, cool and add conc. H_2SO_4 from the side of test tube.	Red, blue & finally green colour roduced.	Steroids& Triterpenoids present.
	Salkowski Test: - Treat extract with few drops of conc. H_2SO_4 acid.	Chloroform layer appears red, acid layer appears greenish yellow fluorescence.	Steroids& Triterpenoids present.
5.	**Tannins and phenolics** **a) Ferric chloride Test: -** Treat test solution with few drops of Ferric chloride solution.	Deep blue colour, green colour.	Hydrolysable Tannins Present.
	c) Lead acetate Test: - Treat test solution with few drops of 10% lead acetate solution.	White ppt.	Tannins & Phenolic compound present.
	d) To the test solution add few drops of acetic acid solution.	Red coloured produced.	Tannins & Phenolic compound present.
	e) To the test solutoion add few drops of Bromine water.	Decoloration of Bromine water.	Tannins & Phenolic compound present.
6.	**Saponins :** To the test solution, a drop of $NaHCO_3$ solution was added. The test tube was shaken vigorously and left for 3 minutes.	Formation of honeycomb like froth.	Saponin present.
	Carbohydrates Molisch'Test:-To the test tube add few drops of Molisch's reagent	Violet ring is formed at the junction of two liquids.	Carbohydrate present.

7.	2ml of conc. H2SO4 is added slowly from the side of the test tube.		
	Barfoed's Test: Test solution heatedwith Barfoed's reagent on water bath.	Red ppt is obtained.	Monosaccharide present.
	Benedict's test: - Test solution shaken with 10 ml of water, filtered and the filtrate was concentrated. To this 5 ml of Benedict's solution was added and boiled for 5 minutes.	Brick red coloured ppt.	Carbohydrate present.
	Anthrone Test: - Test solution shaken with 10 ml of water, filtered and the filtrate was concentrated. To this 2 ml of anthrone reagent solution was added.	Green or blue colour obtained.	Carbohydrate present.
8.	**Proteins :** **Heat Test: -** Heat the test solution in boiling water bath.	Coagulation occurs.	Protein present.
	Biuret Test: - Test solution treated with Biuret reagent (40% NaOH & dil. Copper solution).	Violet or pink colour obtained.	Protein present.
9.	**Amino acid :-** **Millon's Test:** - Treat Solution with Millon's reagent & heat on water bath.	Brick red ppt.	Amino acid present.
	Ninhydrin Test: - Boil test solution with Ninhydrin reagent.	Purple or bluish colour obtained.	Amino acid present.
10.	**Terpenoids Copper acetate test:** Extracts were dissolved in water and treated with 3-4drop of copper acetate solution	Formation of emerald green color indicaters presnt	Terpenoids present.

RESULT AND DISCUSSION

Rheometers for measuring powder flow have also been investigated recently. The method is demonstrated in order to understand how processing factors might affect particle systems.

The force-displacement measurement through the powder bed is part of the device's basic operating mechanism. Measuring the angle of repose, Carrs compressibility index, Hausner ratio, mass, and actual density to characterise the flow behaviour of powders and granules and comparing it to compendial methods. Various methods are available for measuring the powder flow.

Table – Phytochemical constituents of *JAVA PLUM (SYZYGIUM CUMINI)*.

Sr. No.	Chemical Test	F_1	F_2
1.	Carbohydrates	-	+
2.	Proteins	+	+
3.	Amino acids	+	-
4.	Alkaloids	+	+
5.	Glycosides	-	+
6.	Tannins	-	+
7.	Flavonoids	+	-
8.	Saponins	+	+
9.	Steroids	+	+
10.	Terpenoids	-	+

CONCLUSION

Recently, the world market has been moving towards **herbal medicines** for health care and beauty care. Indian traditional literature and pharmacological studies indicate that a number of plants possess significant medicinal uses. In this study, **Java Plum (Syzygium cumini)** has been reported for its diverse pharmacological properties. The phytoconstituents of this plant hold major medicinal importance, contributing to its widespread therapeutic applications. **Herbal formulations** continue to experience growing demand in the global market, and a significant effort has been made to establish the potential of **Syzygium cumini** in this regard. The ethanolic extract of the plant provides an excellent base for promoting health benefits such as antioxidant, antidiabetic, and antimicrobial effects. Studies have revealed that **Syzygium cumini** extract exhibits great potential as a natural antioxidant source. Qualitative phytochemical screening of the extract shows the presence of a high content of **flavonoids, tannins, phenolic compounds, and saponins**, with moderate levels of alkaloids and terpenoids. These phytochemicals contribute to the plant's antioxidant and free radical scavenging abilities. Previous research has reported that **Syzygium cumini** contains bioactive compounds such as **quercetin, rutin, kaempferol, ellagic acid, and gallic acid**, which are known for their antioxidant and antimicrobial properties. The presence of these compounds supports the plant's therapeutic efficacy and establishes **Java Plum** as a potent natural source for developing effective **herbal formulations**.

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