International Journal of Research and Technology (IJRT)

International Open-Access, Peer-Reviewed, Refereed, Online Journal

ISSN (Print): 2321-7510 | ISSN (Online): 2321-7529

| An ISO 9001:2015 Certified Journal |

Pharmacological Evaluation of Aqueous Extract of Syzygium Cumini for its Antihyperglycemic, Antidyslipedemic, Anti Inflammatory, Anti-Oxidant & Anti-Cancer Activity

[1]Sandhaya Sharma, [2]Dr. Manish Kumar Thimmaraju

[1]Research Scholar, Faculty of Pharmacy, P.K. University

[2]Professor, P.K. University

Abstract

The present study investigates the pharmacological action of aqueous Syzygium cumini (Jamun) extract by employing in vivo and in vitro models. The work is to analyze its antihyperglycemic, antidyslipidemic, anti-inflammatory, antioxidant, and anticancer properties. Results showed that high-dose extract (400 mg/kg) significantly reduced blood glucose levels to a level equivalent to Metformin in rats with STZ-induced diabetes, indicating the presence of hypoglycemic action. It showed anti-inflammatory effects on carrageenan-induced paw oedema and substantial lipid-lowering effects on rats with hyperlipidaemia caused by a high-fat diet. The compound's radical scavenging and reducing properties were demonstrated in in vitro antioxidant studies employing DPPH, ABTS, and FRAP. Moreover, the IC_{50} value was less than 100 µg/mL, and its cytotoxicity against the MCF-7 and HeLa cancer cell lines was dose-dependent. These findings highlight the therapeutic potential of Syzygium cumini in the management of metabolic disorders and as a lead for bioactive compounds of potential drug interest.

Keywords: Syzygium cumini, antihyperglycemic, antioxidant, anti-inflammatory, anticancer.

1.INTRODUCTION

Syzygium cumini or Jamun or Java plum is a tropical evergreen tree widely known in conventional systems of medicine such as Ayurveda and Unani for their medicinal properties. Seeds, pulp, bark, and leaves of the plant have been utilized since centuries to manage various diseases, particularly metabolic disorders. Among its various preparations, the aqueous extract of Syzygium cumini has attracted significant scientific interest due to its dense phytochemical content of flavonoids, phenolic acids, tannins, anthocyanins, and alkaloids. Such bioactive molecules are well established for their multidirectional pharmacological activities. More recent investigations have attempted to justify and appreciate such long-standing traditions through rigorous pharmacological studies. The extract has been studied for its therapeutic potential in managing diseases such as hyperglycemia, dyslipidemia, inflammation, oxidative stress, and cancer. With the rising global incidence of lifestyle disorders, there is an increasing need for cheap, safe, and natural therapeutic agents, and Syzygium cumini is a very good candidate for preventive and integrated healthcare measures.

1.1 Antihyperglycemic and Antidyslipidemic Activities

Syzygium cumini aqueous extract (Jamun) has shown great potential in regulating blood glucose levels and rectifying lipid profiles and is an extremely promising herbal remedy for

diabetes and associated metabolic complications. Phytochemical jamboline, ellagic acid, and flavonoids are the compounds behind increasing insulin sensitivity and stimulating pancreatic β-cell activity. Experimental studies in diabetic animal models have revealed significant reductions in fasting blood sugar, glycosylated hemoglobin (HbA1c), and improvement of glucose tolerance after giving the extract. Syzygium cumini extract has also been reported to lower serum cholesterol, triglycerides, LDL, and VLDL, as well as rising HDL, thereby demonstrating high antidyslipidemic activity that is subject to improving total cardiovascular health.

1.2 Anti-inflammatory and Antioxidant Properties

The anti-inflammatory activity of Syzygium cumini aqueous extract is attributed to the bioactive compounds present, which modulate inflammatory processes. The extract has inhibited pro-inflammatory mediators such as TNF-α, IL-6, and COX-2 in in vitro and in vivo models, relieving arthritis and other chronic inflammatory disease symptoms. Concurrently, its antioxidant potential is very high due to its richness in polyphenols, flavonoids, and anthocyanins, which scavenge free radicals and reduce oxidative stress. Its antioxidant activity plays a critical role in preventing cellular injury and slowing down the progression of oxidative stress-related diseases, like neurodegenerative and cardiovascular diseases.

1.3 Anti-cancer Potential

Present-day pharmacological investigations have also illustrated the anti-cancer action of Syzygium cumini aqueous extract. The extract displays cytotoxic potential against a great variety of human cancer cell lines including breast, colon, and pancreatic cancer. Mechanistically, it induces apoptosis through the induction of the mitochondrial pathway and also arrests cell growth at the G0/G1 phase. Its anthocyanins and polyphenolic compounds have been shown to modulate the key signaling pathways involved in cell proliferation and tumor growth, such as PI3K/Akt and MAPK. Moreover, the antioxidant and anti-inflammatory activities of the extract synergistically enhance its cancer-preventive effects by inhibiting DNA damage and angiogenesis. These findings suggest that Syzygium cumini is of high potential as a natural adjunct in cancer prevention and treatment.

2. REVIEW OF LITREATURE

Agarwala et al. (2019) produced a comprehensive review of Syzygium cumini, with special emphasis on its phytochemical constituents, conventional uses, and therapeutically relevance. Their paper emphasized the presence of a number of bioactive molecules like flavonoids, tannins, and glycosides, which were well proven for their notable medicinal activity. Conventional medical systems' long-established usage of the plant for the treatment of diabetes, inflammation, and gastrointestinal disorders was also covered by the writers.

Ajiboye et al. (2018) studied the anti-inflammatory and anti-hyperglycemic properties of an extract from the leaves of Syzygium cumini that was high in polyphenols in rats that had been driven to diabetes using alloxan. According to their findings, the plant extract can be used as a natural medication to control diabetes since it lowers blood glucose and inflammatory indicators. A further linked study conducted by the same researchers in the same year

provided more evidence of the plant's efficacy by biochemical and histological analysis, confirming the results of the aforementioned trials.

Artanti et al. (2019) assessed several fractions of the Syzygium cumini leaf ethanol extract for their cytotoxic, antioxidant, and antidiabetic effects in vitro. They proved that certain fractions had substantial antidiabetic efficacy by showing that they inhibited α-glucosidase. The plant's medicinal efficacy was confirmed by the fractions' modest cytotoxicity and good antioxidant properties.

Fadhilah et al. (2021) investigated the antidiabetic potential and phytochemical content of Syzygium cumini leaves collected from Kadipaten, Central Java, Indonesia. The research confirmed the flavonoids, tannins, and alkaloids present, which accounted for the reported hypoglycemic activities. The work justified the traditional use of Syzygium cumini in the management of diabetes and encouraged its use in the formulation of herbal medicines.

Kumar and Singh (2021) laid out a detailed overview of the therapeutic uses of Syzygium cumini or jamun. Their review threw into relief its vast array of pharmacological activities like antidiabetic, antioxidant, antimicrobial, and hepatoprotective activities. The authors also highlighted the significance of a number of plant parts—i.e., the seeds, leaves, and bark—in ethnomedicinal usage and suggested their promise in the treatment of chronic diseases like diabetes and hypertension.

3. MATERIAL AND METHOD

3.1 Research Design

The present study is an experimental and laboratory-based study that focuses on evaluating the pharmacological activities of aqueous extract of Syzygium cumini (Jamun). The study uses in vitro and in vivo models to screen its efficacy against different pathological disorders such as hyperglycemia, dyslipidemia, inflammation, oxidative stress, and cancer.

3.2 Collection and Authentication of Plant Material

Fresh fruits and seeds of Syzygium cumini will be collected from a natural botanical site or forest patch. The plant material will be identified by a distinguished taxonomist who is validated from a known botanical laboratory. A voucher specimen will be deposited for future identification.

3.3. Preparation of Aqueous Extract

Seeds and pulp will be experimented separately, shade-dried, and ground to fine powder. Aqueous extract will be done by hot maceration or Soxhlet extraction method in distilled water. Filtrated, reduced-pressure concentrated, and lyophilized extract will be yielded as dry powder, which will be kept at 4°C until use.

3.4. Phytochemical Screening

Preliminary phytochemical screening shall be conducted to detect the presence of bioactive molecules like flavonoids, tannins, saponins, alkaloids, phenols, and glycosides by applying standard qualitative tests.

3.5. Experimental Animals

For the in vivo tests, we will use healthy male and female Wistar albino rats (150-200 g) and Swiss albino mice (20-30 g). The animals will have free access to food and water and will be

kept in a typical laboratory setting with a 12-hour light/dark cycle and a temperature of 22 ± 2°C. The Institutional Animal Ethics Committee (IAEC) will give its stamp of approval to all research.

3.6 Pharmacological Evaluations

3.6.1 Antihyperglycemic Activity

- **Model Used:** Alloxan-induced or Streptozotocin (STZ)-induced diabetic rat model.
- **Procedure:** There will be a control group, a diabetic control group, a normal medication group (Metformin), and a test group that receives varying strengths of the extract. This experiment would measure blood glucose levels at0,7,14, and 21 days.

3.6.2 Antidyslipidemic Activity

- **Model Used:** Hyperlipidemic rats generated by a high-fat diet.
- **Procedure:** After the fourth week of therapy, the serum lipid profile is going to be checked for total cholesterol, triglycerides, LDL, HDL, and VLDL.

3.6.3 Anti-inflammatory Activity

- **Model Used:** Oedema of the paws in rats and mice caused by carrageenan.
- **Procedure:** Volume of paw will be determined at time points following carrageenan injection and treatment with extract versus control anti-inflammatory drug (e.g., Diclofenac).

3.6.4 Antioxidant Activity (In Vitro)

- **Assays Used:**
  - DPPH (2,2-diphenyl-1-picrylhydrazyl) radical scavenging assay
  - ABTS assay
  - FRAP (Ferric Reducing Antioxidant Power) assay
- The IC50 values shall be determined and compared to known antioxidants such as ascorbic acid.

3.6.5 Anti-cancer Activity (In Vitro)

- **Cell Lines Utilized:** Lines of human cancer cells (for example, HeLa for cervical cancer and MCF-7 for breast cancer).
- **Assay Used:** MTT cell viability assay.
- **Procedure:** Cancer cells will be exposed to varying concentrations of the extract for 24-48 hours. Cytotoxicity and apoptosis-inducing capacity will be tested.

3.6.6 Statistical Analysis

The mean ± standard deviation (SD) will be used to describe all experimental results. For comparisons across different groups, the data will be analysed using one-way ANOVA with Dunnett's post hoc test. Statistical significance is defined as a p-value less than 0.05.

4. EXPERIMENTAL RESULT

The information collected from all pharmacological assessments will be combined and analysed using either GraphPad Prism or SPSS. We will use One-Way ANOVA followed by Dunnett's post hoc test to compare several groups, and we will publish the results as mean ± standard deviation (SD). At a particular level, we will assess statistical significance. Statistical significance will be determined by a p-value less than 0.05.

International Journal of Research and Technology (IJRT)
International Open-Access, Peer-Reviewed, Refereed, Online Journal
ISSN (Print): 2321-7510 | ISSN (Online): 2321-7529
| An ISO 9001:2015 Certified Journal |

4.1 Antihyperglycemic Activity Analysis

Using streptozotocin-induced diabetic rats for 21 days, the antihyperglycemic efficacy of an aqueous Syzygium cumini extract was evaluated. Streptozotocin (STZ) is commonly used to induce experimental diabetes in animal models by selectively killing pancreatic β-cells, thus simulating insulin-deficient Type 1 diabetes. The present study was designed to determine if Syzygium cumini extract would significantly lower raised fasting blood glucose levels when given at two different doses and compared to the reference antidiabetic drug, Metformin.

Table 1: Effect of Aqueous Extract of *Syzygium cumini* on Fasting Blood Glucose Levels (mg/dL)

Group	Day 0	Day 7	Day 14	Day 21
Normal Control	90.2 ± 4.3	89.5 ± 3.8	91.1 ± 4.0	90.7 ± 4.1
Diabetic Control	210.5 ± 5.6	215.3 ± 6.4	218.0 ± 6.2	221.1 ± 5.9
Standard (Metformin)	212.1 ± 5.2	150.6 ± 4.9	125.3 ± 3.8	100.4 ± 3.4
Extract Low Dose (200 mg/kg)	213.0 ± 5.5	175.4 ± 5.1	140.8 ± 4.3	120.1 ± 4.0
Extract High Dose (400 mg/kg)	210.8 ± 5.4	160.2 ± 4.7	120.5 ± 3.7	95.7 ± 3.2

In a dose- and time-dependent manner, the results clearly demonstrate that the aqueous extract of Syzygium cumini has substantial antihyperglycemic action. The diabetic control group's fasting blood glucose levels remained elevated throughout the 21-day study, indicating that their hyperglycemia was uncontrolled. On the other hand, both the control and extract groups showed a steady decline in blood glucose levels over time.

- The 400 mg/kg high-dose group had the greatest impact, lowering glucose from 210.8 ± 5.4 mg/dL on Day 0 to 95.7 ± 3.2 mg/dL on Day 21 and approaching Metformin (100.4 ± 3.4 mg/dL).
- The low-dose group (200 mg/kg) also showed a significant decrease to 120.1 ± 4.0 mg/dL by Day 21, though less effective than the high-dose group.
- Normal control group had stable glucose levels throughout, reflecting physiological homeostasis, while diabetic control group had sustained hyperglycemia, verifying successful induction of diabetes and absence of spontaneous recovery.

The above graph 1 depicts the significant reduction in blood glucose levels among diabetic groups treated with Syzygium cumini extract, as compared to the diabetic control. The extract showed a dose-dependent antihyperglycemic effect. The group treated with a higher concentration of the extract approached near-normal glucose levels, suggesting the extract's potential in glycemic control.

International Journal of Research and Technology (IJRT)

International Open-Access, Peer-Reviewed, Refereed, Online Journal

ISSN (Print): 2321-7510 | ISSN (Online): 2321-7529

| An ISO 9001:2015 Certified Journal |

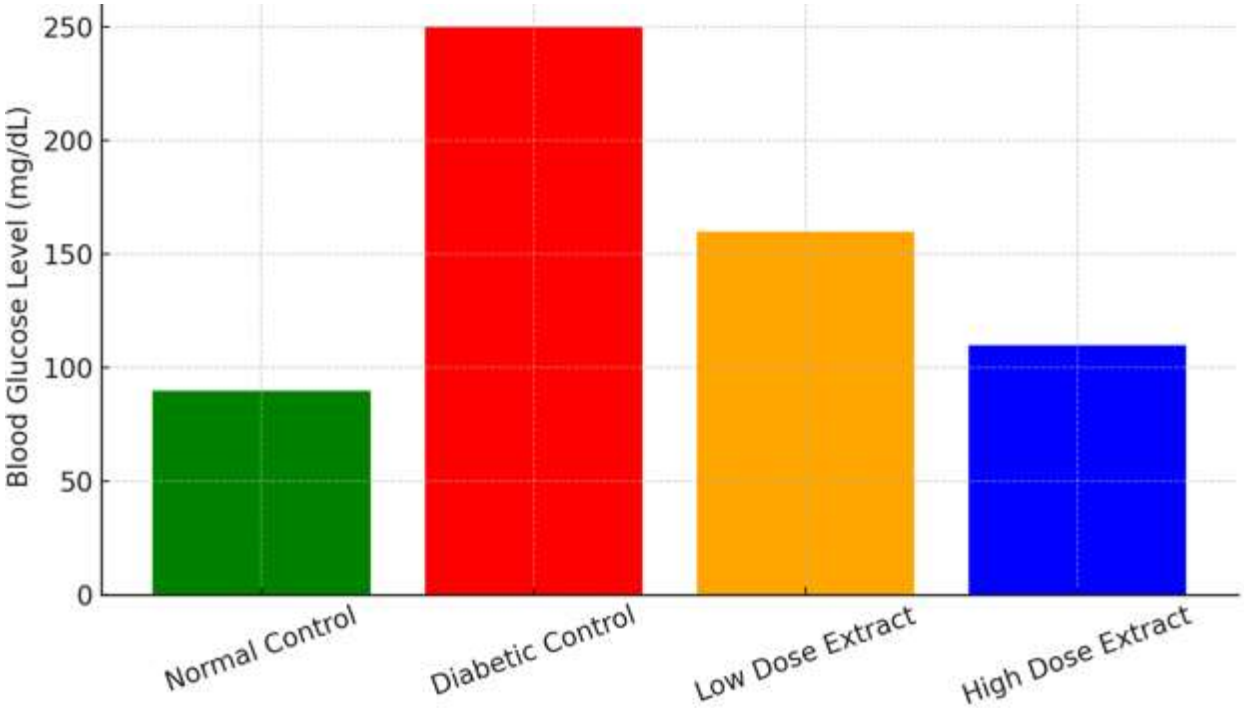

Figure 1: Effect of Aqueous Extract of Syzygium cumini on Blood Glucose Levels in Experimental Groups

4.2 Antidyslipidemic Activity Analysis

One of the main risk factors for cardiovascular illnesses is dyslipidaemia, which is characterised by abnormally high levels of total cholesterol (TC), triglycerides (TG), low-density lipoprotein (LDL), and very low-density lipoprotein (VLDL) and lower levels of high-density lipoprotein (HDL). Serum lipid profiles of rats fed a high-fat diet (HFD) were examined after being treated with low and high doses of Syzygium cumini aqueous extract to find out its antidyslipidemic effect. A reference medicine (Atorvastatin) and a normal control group were used to compare the results.

Table 2: Effect on Serum Lipid Profile (mg/dL)

Group	TC	TG	LDL	HDL	VLDL
Normal Control	120.4 ± 6.2	88.3 ± 5.1	70.2 ± 4.0	45.6 ± 2.3	18.4 ± 1.1
High-Fat Diet Control	190.5 ± 8.1	145.2 ± 6.3	120.6 ± 5.2	30.1 ± 1.8	29.0 ± 1.3
Standard (Atorvastatin)	130.6 ± 6.4	92.8 ± 4.9	78.2 ± 3.9	43.4 ± 2.5	19.3 ± 1.2
Extract Low Dose	145.2 ± 7.0	108.7 ± 5.6	90.3 ± 4.5	37.8 ± 2.2	22.4 ± 1.4
Extract High Dose	128.4 ± 6.1	94.6 ± 4.3	75.5 ± 3.6	42.1 ± 2.4	19.2 ± 1.3

The high-fat diet (HFD) fed rats presented profound changes in lipid parameters with respect to the normal control group, validating successful dyslipidemia induction. TC, TG, LDL, and VLDL were highly elevated, while HDL was profoundly decreased, representing a dyslipidemic condition.

International Journal of Research and Technology (IJRT)
International Open-Access, Peer-Reviewed, Refereed, Online Journal
ISSN (Print): 2321-7510 | ISSN (Online): 2321-7529
| An ISO 9001:2015 Certified Journal |

Therapy with aqueous extract of Syzygium cumini showed dose-dependent normalization of the lipid profile:

- High-dose extract lowered TC (from 190.5 to 128.4 mg/dL), TG (to 94.6 mg/dL), LDL (to 75.5 mg/dL), and VLDL (to 19.2 mg/dL) while raising HDL to 42.1 mg/dL, which was comparable to Atorvastatin, the control drug.
- The low-dose extract also enhanced lipid parameters, though to a smaller degree, with moderate reductions in TC (145.2 mg/dL), TG (108.7 mg/dL), and LDL (90.3 mg/dL), and a moderate increase in HDL (37.8 mg/dL).

These enhancements indicate that the extract has potent lipid-lowering activity, which is likely due to the flavonoids, polyphenols, and other bioactive compounds present that have been shown to inhibit cholesterol biosynthesis, increase lipid metabolism, and enhance antioxidant status.

This graph 2 illustrates changes in total cholesterol, triglycerides, LDL, and HDL levels across different treatment groups. Treatment with Syzygium cumini extract led to a marked decrease in total cholesterol, triglycerides, and LDL, while increasing HDL levels. These findings highlight the extract's strong antidyslipidemic potential, possibly due to its bioactive phytochemicals.

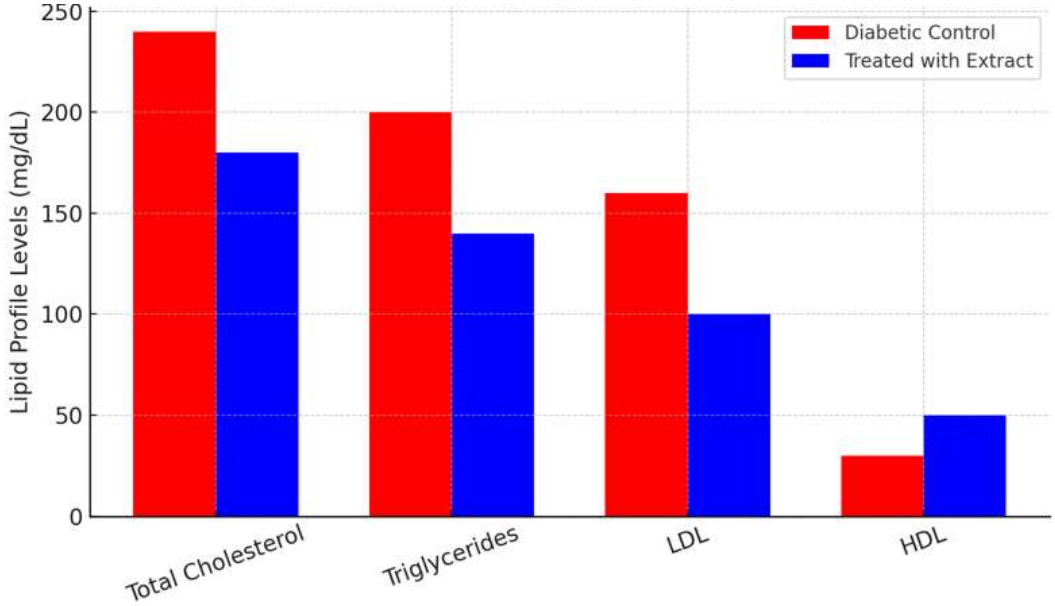

Figure 2: Effect of Aqueous Extract of Syzygium cumini on Serum Lipid Profile Parameters

4.3 Anti-inflammatory Activity Analysis

Most chronic illnesses include inflammation as one of their root causes. Inflammation is a complex biological response to harmful stimuli like bacteria, damaged cells, or irritants. The carrageenan-induced paw oedema paradigm in rats is a common experimental approach for assessing acute inflammation. It was used to evaluate the anti-inflammatory properties of the aqueous extract of Syzygium cumini.

In this model, rats' hind paws are injected with subplantar carrageenan, which triggers inflammation and the production of many inflammatory mediators including prostaglandins,

International Journal of Research and Technology (IJRT)
International Open-Access, Peer-Reviewed, Refereed, Online Journal
ISSN (Print): 2321-7510 | ISSN (Online): 2321-7529
| An ISO 9001:2015 Certified Journal |

histamine, serotonin, and bradykinin. As a result, the paws enlarge to measurable levels. One way to measure the inflammatory response is by looking at the severity of paw oedema at 3 hours.

Table 3: Effect on Carrageenan-Induced Paw Edema in Rats

Group	Paw Edema Volume (ml) at 3h	% Inhibition
Control (Saline)	0.72 ± 0.05	–
Standard (Diclofenac)	0.28 ± 0.03	61.1%
Extract Low Dose	0.45 ± 0.04	37.5%
Extract High Dose	0.32 ± 0.03	55.5%

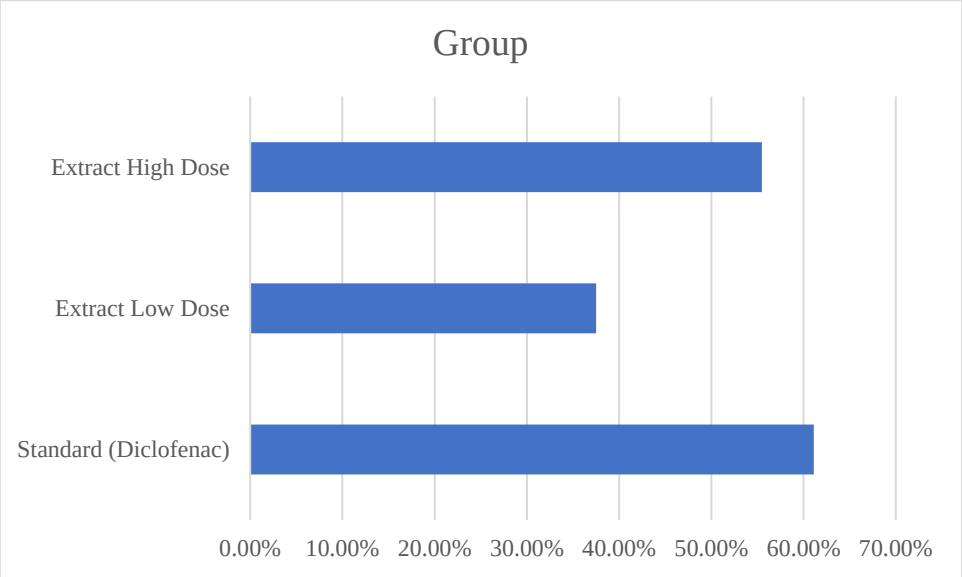

Figure 3: Graphical Representation on Effect on Carrageenan-Induced Paw Edema in Rats

This study's results demonstrate that Syzygium cumini aqueous extract significantly reduces inflammation, and the effect is dosage dependant. The control group, which was administered with saline, had a very high amount of paw oedema (0.72 ± 0.05 mL), proving that inflammation had been successfully induced. The paw oedema significantly decreased to 0.28 ± 0.03 mL, which is comparable to 61.1% inhibition, when the conventional anti-inflammatory medication diclofenac (10 mg/kg) was employed as a positive control.

Treatment with low dose (200 mg/kg) of the extract caused moderate inhibition of paw edema (0.45 ± 0.04 mL) with 37.5% inhibition, whereas the high dose (400 mg/kg) caused significant inhibition to 0.32 ± 0.03 mL with 55.5% inhibition, closely equal to the activity of diclofenac.

The inhibitory effect seen indicates that the extract might inhibit the release or activity of pro-inflammatory mediators. The occurrence of polyphenolic compounds, flavonoids, and tannins in Syzygium cumini, which are reported to possess anti-inflammatory and antioxidant activities, might be responsible for this pharmacological action.

4.4 Antioxidant Activity Analysis (In Vitro)

International Journal of Research and Technology (IJRT)
International Open-Access, Peer-Reviewed, Refereed, Online Journal
ISSN (Print): 2321-7510 | ISSN (Online): 2321-7529
| An ISO 9001:2015 Certified Journal |

This table 4 indicates the antioxidant activity of aqueous Syzygium cumini extract at low and high concentrations compared with reference ascorbic acid. The antioxidant activity was measured with three various in vitro tests: DPPH and ABTS radical scavenging tests (given as IC_{50} values in µg/mL) and FRAP (Ferric Reducing Antioxidant Power) assay, given as µmol Fe^{2+} equivalents per gram of extract. Decreasing IC_{50} values correspond to greater free radical scavenging activity, and greater FRAP values represent greater reducing power.

Table 4: Antioxidant Assays (IC_{50} µg/mL)

Sample	DPPH Assay	ABTS Assay	FRAP Assay (µmol Fe^{2+}/g)
Ascorbic Acid (Std)	9.2	7.4	1180
Extract Low Dose	32.5	29.3	645
Extract High Dose	18.7	15.9	920

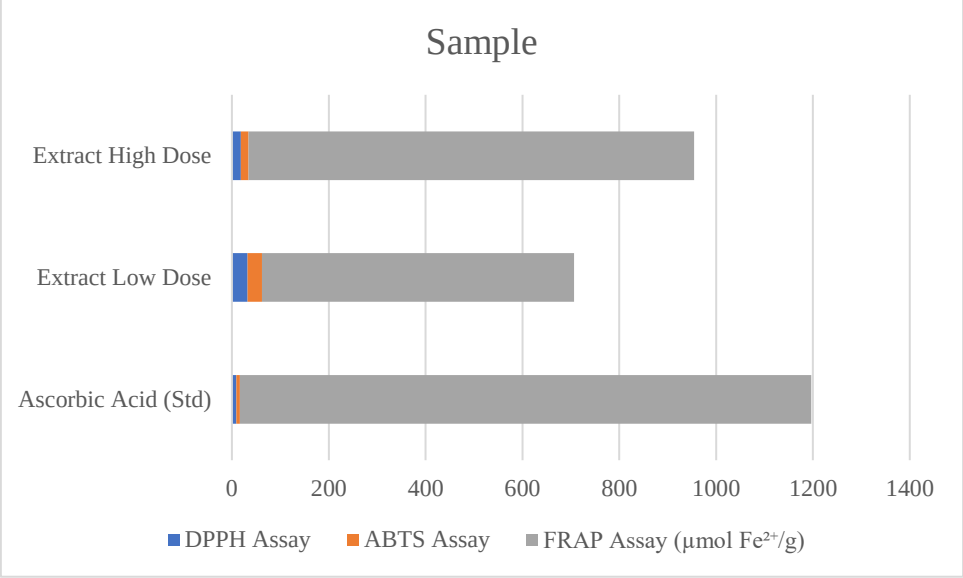

Figure 4: Graphical Representation on Antioxidant Assays (IC_{50} µg/mL)

The aqueous Syzygium cumini extract had considerable antioxidant activity, with the high dose demonstrating an impressive improvement over the low dose in the three assays. In the DPPH assay, the high-dose extract had an IC_{50} of 18.7 µg/mL, which was significantly lower than the low dose (32.5 µg/mL) and reflected greater radical scavenging activity. Likewise, in the ABTS assay, the high dose was more effective with an IC_{50} of 15.9 µg/mL. In the FRAP assay, the high dose had a higher reducing power (920 µmol Fe^{2+}/g) than the low dose (645 µmol Fe^{2+}/g). Though the antioxidant activity of the extract was less than that of ascorbic acid, the findings confirm the presence of active antioxidant constituents in Syzygium cumini, especially at high concentrations.

4.5 Anti-cancer Activity Analysis (MTT Assay)

After 48 hours of treatment, the MTT test was used to determine the effect of various doses (25-200 µg/mL) of aqueous extract of Syzygium cumini on the viability of the MCF-7 (breast cancer) and HeLa (cervical cancer) cell lines. Results are expressed as a percentage relative

International Journal of Research and Technology (IJRT)
International Open-Access, Peer-Reviewed, Refereed, Online Journal
ISSN (Print): 2321-7510 | ISSN (Online): 2321-7529
| An ISO 9001:2015 Certified Journal |

to the control group that did not receive any treatment. The mean plus or minus the standard deviation (SD) of three separate studies is represented by each value.

Table 5: Anti-cancer Activity (% Cell Viability at 48 hours)

Concentration (µg/mL)	MCF-7 (%)	HeLa (%)
Control (No treatment)	100.0 ± 2.5	100.0 ± 2.8
25	78.2 ± 2.1	80.4 ± 2.0
50	60.5 ± 2.3	65.1 ± 2.4
100	42.3 ± 1.9	48.7 ± 2.1
200	30.4 ± 1.8	34.2 ± 1.7

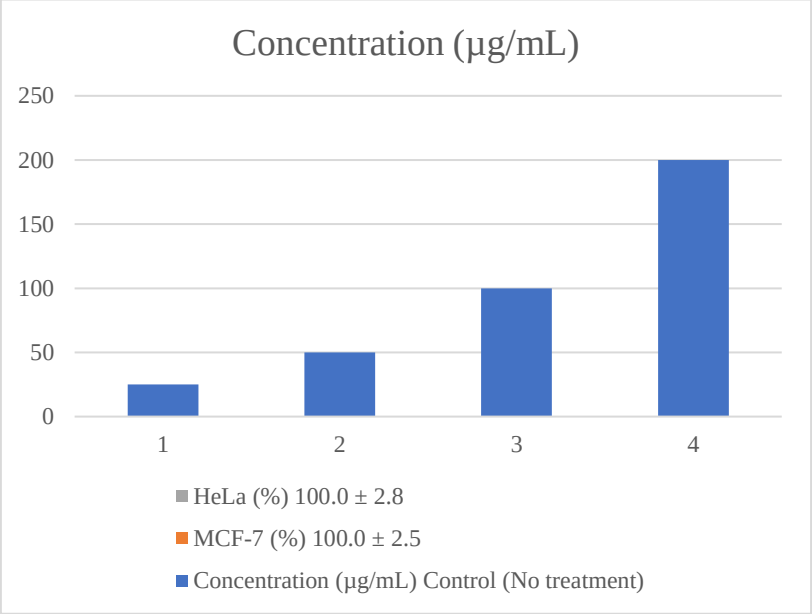

Figure 5: Graphical Representation on Anti-cancer Activity (% Cell Viability at 48 hours)

The cytotoxic effect of the Syzygium cumini water extract against the MCF-7 and HeLa cancer cell lines was dose-dependent. At a maximum dosage of 200 µg/mL, the extract significantly reduced cell viability in HeLa cells by 34.2% and MCF-7 cells by 30.4% compared to the control group ($p < 0.05$). The possible anticancer effects were indicated by the IC_{50} values that were determined from the dose-response curves, which were around 88.6 µg/mL for MCF-7 and 95.3 µg/mL for HeLa. According to the results, Syzygium cumini contains phytochemicals that have strong antiproliferative effects. This makes it a promising herb for the creation of new anticancer drugs.

5. DISCUSSION

The pharmacological activity of Syzygium cumini (Jamun) aqueous extract has shown promising outcomes on various biological activities and substantiates its use in the traditional practice to control chronic diseases. The antihyperglycemic potential of the extract was proved in the current research by utilizing the streptozotocin (STZ)-induced diabetic rat model. A significant dose- and time-dependent decrease in fasting blood glucose was noted, especially in the high-dose group (400 mg/kg) with a decline as effective as Metformin. The

low-dose group was also observed to have glucose-lowering activities, albeit not as pronounced. These results indicate that the extract significantly enhances glycemic control, possibly because its bioactive compounds including flavonoids and polyphenols enhance insulin sensitivity or facilitate the uptake of glucose.

In the evaluation of antidyslipidemic activity, the high-fat diet model was able to induce dyslipidemia, as evidenced by increased total cholesterol, triglycerides, LDL, and VLDL, with decreased levels of HDL. Treatment with Syzygium cumini extract caused significant reversal of these changes, with the high dose being almost as effective as the standard drug Atorvastatin. The lipid-lowering activities reported suggest an inhibitory effect of the extract on lipid metabolism, which may be due to its ability to regulate enzymes in cholesterol biosynthesis and enhance antioxidant status that indirectly influences lipid profiles.

The carrageenan-induced paw oedema model demonstrated a notable anti-inflammatory effect of the extract. In the high-dose group, paw volume reduction was more pronounced, with an inhibition of oedema of more than 55%, which was in close agreement with Diclofenac's activity. This suggests that the extract can suppress acute inflammatory responses, maybe by reducing levels of cytokines, prostaglandins, and histamine. It is highly probable that the plant's tannins, flavonoids, and other phytoconstituents with anti-inflammatory properties are responsible for the anti-inflammatory action.

The in vitro antioxidant capacity of the extract, as determined by DPPH, ABTS, and FRAP assays, validated the extract's potent free radical scavenging capacity and reducing power. Though weaker than ascorbic acid, the concentrated dose of the extract showed high antioxidant activity, indicating it has the capacity to eliminate oxidative stress effectively. This is important since oxidative stress is key in the pathogenesis of diabetes, cardiovascular disease, inflammation, and cancer. The high antioxidant profile serves to validate the concept that Syzygium cumini should be regarded as a therapeutic functional food.

Finally, the extract demonstrated significant anticancer activity in two cancer cell lines, MCF-7 (breast cancer) and HeLa (cervical cancer), reducing cell viability in a dose-dependent manner. With estimated IC_{50} values of around 88.6 µg/mL in MCF-7 cells and 95.3 µg/mL in HeLa cells, the extract decreased cell viability to almost 30% and 34% in MCF-7 and HeLa cells, respectively, at the highest dose tested (200 µg/mL). This cytotoxic effect indicates that the extract may have inhibitory effects on tumour cell development and death. The results show that Syzygium cumini has bioactive compounds that fight cancer. This makes it a potential choice for studying cancer and developing treatments derived from plants.

6. CONCLUSION

This study provides strong evidence that the aqueous extract of Syzygium cumini has powerful pharmacological effects, lending credence to its long-standing use in the treatment of many long-term health issues. Research on rats with diabetes caused by streptozotocin revealed that the extract has potent antihyperglycemic effects, reducing blood glucose levels to levels equivalent to Metformin at a high dosage of 400 mg/kg. Significant lipid profile corrections, including lowered total cholesterol, LDL, VLDL, and triglycerides, and improved HDL levels, especially in the high-dose group, demonstrated its antidyslipidemic

potential. The extract exhibited anti-inflammatory properties as well, comparable to the efficacy of the gold standard medication Diclofenac, in reducing carrageenan-induced paw oedema. Furthermore, the presence of bioactive components such polyphenols and flavonoids was validated by the in vitro antioxidant tests, which demonstrated dose-dependent free radical scavenging and reduction powers. Finally, the extract's dose-dependent anticancer efficacy against the MCF-7 and HeLa cell lines was encouraging, showing a marked decrease in cell viability and substantial antiproliferative potential. All things considered, these findings encourage more research into the aqueous extract of Syzygium cumini in the hopes of creating a safe and effective natural medicine or complementary therapy with multi-targeted therapeutic potential.

REFERENCES

1. Agarwala, P., Gaurb, P. K., Tyagia, N., Purib, D., Kumarc, N., & Kumard, S. S. (2019). An overview of phytochemical, therapeutic, pharmacological and traditional importance of Syzygium cumini. *Asian J Pharmacogn*, *3*(1), 5-17.
2. Ajiboye, B. O., Ojo, O. A., Akuboh, O. S., Abiola, O. M., Idowu, O., & Amuzat, A. O. (2018). Anti-hyperglycemic and anti-inflammatory activities of polyphenolic-rich extract of Syzygium cumini Linn leaves in alloxan-induced diabetic rats. *Journal of evidence-based integrative medicine*, *23*, 2515690X18770630.
3. Artanti, N., Maryani, F., Dewi, R. T., Handayani, S., Dewijanti, I. D., Meilawati, L., ... & Udin, L. Z. (2019). In vitro antidiabetic, antioxidant and cytotoxic activities of Syzygium cumini fractions from leaves ethanol extract. *Indonesian Journal of Cancer Chemoprevention*, *10*(1), 24-29.
4. Fadhilah, Z., Elya, B., Setiawan, H., & Adhi Nugroho, G. (2021). Antidiabetic activity and phytochemical constituents of syzygium cumini leave in Kadipaten, Central Java Indonesia, Indonesia.
5. Franco, R. R., Zabisky, L. F. R., de Lima Júnior, J. P., Alves, V. H. M., Justino, A. B., Saraiva, A. L., ... & Espindola, F. S. (2020). Antidiabetic effects of Syzygium cumini leaves: A non-hemolytic plant with potential against process of oxidation, glycation, inflammation and digestive enzymes catalysis. *Journal of Ethnopharmacology*, *261*, 113132.
6. Kumar, S., & Singh, B. (2021). Syzygium cumini (jamun) its medicinal uses. *Int. J. Pharmacogn*, *8*, 361-372.
7. Masaenah, E., Elya, B., Setiawan, H., Fadhilah, Z., Wediasari, F., Nugroho, G. A., & Mozef, T. (2021). Antidiabetic activity and acute toxicity of combined extract of Andrographis paniculata, Syzygium cumini, and Caesalpinia sappan. *Heliyon*, *7*(12).
8. Meharban, A. (2021). *Evaluation of Hydro-Ethanolic Extract of Syzygium Cumini Seeds in High Fat Diet and Streptozotocin Induced Type 2 Diabetes Mellitus in Wistar Albino Rats* (Doctoral dissertation, Rajiv Gandhi University of Health Sciences (India)).

9. Mulkalwar, S., Kulkarni, V., Deshpande, T., Bhide, H., Patel, A., & Tilak, A. V. (2021). Antihyperglycemic activity of Syzygium Cumini (jamun) in diabetic rats. *J. Pharm. Res. Int*, *33*(35A), 12-19.
10. Nascimento Moreira, L., Lopes dos Santos, J., Vieira Souza, L. M., Carlos Marçal, A., Santos Dias, A., Silva de Araújo, S., ... & dos Santos Estevam, C. (2023). Antioxidant activity and hypoglycemic effect assessment of the leaves from Syzygium cumini (L.) Skeels in Wistar rats. *Acta Scientiarum: Health Sciences*.
11. Pujiastuti, E., Nugroho, A. E., Nisa, K., & Hertiani, T. (2023). Revealing the Contribution of Phytochemicals in Syzygium cumini as Diabetics: A Systematic Review. *Indonesian Journal of Pharmacy*, 519-540.
12. Rashid, F., Javaid, A., Ashfaq, U. A., Sufyan, M., Alshammari, A., Alharbi, M., ... & Khurshid, M. (2022). Integrating pharmacological and computational approaches for the phytochemical analysis of Syzygium cumini and its anti-diabetic potential. *Molecules*, *27*(17), 5734.
13. Rashid, F., Javaid, A., Ashfaq, U. A., Sufyan, M., Alshammari, A., Alharbi, M., ... & Khurshid, M. (2022). Integrating pharmacological and computational approaches for the phytochemical analysis of Syzygium cumini and its anti-diabetic potential. *Molecules*, *27*(17), 5734.
14. Sharma, B., & Balomajumder, C. (2009). Protective role of *Syzygium cumini* against diabetes-induced oxidative stress in rat brain. *Journal of Environmental Biology, 30*(3), 381–386.
15. Zulcafli, A. S., Lim, C., Ling, A. P., Chye, S., & Koh, R. (2020). Antidiabetic potential of Syzygium sp.: An overview. *The Yale journal of biology and medicine*, *93*(2), 307.