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Pharmacodynamic Evaluation of *Syzygium Cumini* Extract in Experimental Diabetic Models

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ABSTRACT

The experimental analysis of Syzygium cumini extract pharmacodynamic properties examines blood glucose control mechanisms and antioxidant effects and tests security parameters. For 28 days Wistar rats with streptozotocin-induced diabetes received Syzygium cumini extract treatment at both 200 mg/kg and 400 mg/kg doses. Blood glucose levels decreased substantially during the study period while the high-dose treatment group achieved near-normal glucose concentrations by its conclusion. The antioxidant function of the extract occurred due to elevated reduced glutathione (GSH) together with higher superoxide dismutase (SOD), catalase levels and decreased malondialdehyde (MDA). Tests of lipid profile showed higher HDL values and lower levels of total cholesterol and triglycerides and LDL which could protect the heart. The test of liver enzymes validated a good safety profile for the extract because it yielded negative hepatotoxicity results. Test outcomes demonstrate that Syzygium cumini extract may function as an additional treatment to manage diabetes together with its connected complications and protect the cardiovascular system.

Key Words:

Syzygium cumini, Diabetes, Blood Glucose Regulation, Antioxidant Activity, Lipid Profile

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1.INTRODUCTION

The prevalence of diabetes mellitus's Type 2 variant grew to become one of the world's most common chronic illnesses as it affects numerous patients annually [1]. The health condition continues to produce high blood sugar levels that develop because of pancreatic β-cell dysfunction or insulin resistance. The prolonged deterioration of diabetes without control leads to severe medical complications that damage heart health and cause nerve damage and kidney diseases and eye diseases which destroy overall patient life quality [2]. The recent developments in oral hypoglycemic drugs and insulin therapy have not eliminated the patient difficulties with medication side effects or reduced treatment effectiveness [3].

The move toward natural alternative treatments for diabetes management has grown stronger since such natural remedies demonstrate better safety and effectiveness in diabetes control. Scientific research has centered on Syzygium cumini (Jamun) among numerous plants due to its high phytochemical content as well as traditional usage for diabetes symptom control and hyperglycemia treatment [4].

1.1. Background Information

Traditional medicine has employed Syzygium cumini (also called Jamun) as a tropical fruit plant for multiple years due to its extensive therapeutic properties [5]. The antioxidant and anti-inflammatory and anti-hyperglycemic activities of Syzygium cumini are attributed to its bioactive compounds made up of anthocyanins, flavonoids and phenolic acids. Several studies demonstrate Syzygium cumini's importance as a medication because diabetes mellitus now represents a significant worldwide health problem [6]. Diabetes mellitus functions as a persistent metabolic disorder of hyperglycemia and has become an epidemic disease throughout the global population. The medical condition can be classified into two main types including Type 1 diabetes and Type 2 diabetes where Type 2 diabetes affects patients more frequently [7]. The current treatment options of insulin therapy and oral hypoglycemic agents require new complementary therapeutic approaches because of their side effects and treatment limitations. Scientific experts have evaluated Syzygium cumini pharmacodynamic effects because they seek this plant as a natural diabetes management solution [8].

1.2. Statement of the Problem:

Traditional diabetes management through Syzygium cumini extensively exists but scientific proof of its pharmacodynamic effects on experimental diabetes remains scarce [9]. The therapeutic validity of Syzygium cumini requires explicit comprehension of its mechanism of action along with blood glucose reduction capacity and safety measures for diabetic patients. Drastic research is required to examine Syzygium cumini extract's pharmacodynamic profile thus establishing medical basis for its use in diabetes treatment and integration into modern pharmacological treatment approaches [10].

1.3. Objectives of the Study:

1. To evaluate the pharmacodynamic effects of *Syzygium cumini* extract on blood glucose regulation in experimental diabetic models.
2. To investigate the antioxidant and anti-hyperglycemic mechanisms of action of *Syzygium cumini* extract in diabetic conditions.
3. To assess the safety profile and potential side effects of *Syzygium cumini* extract in experimental diabetic models.

2.METHODOLOGY

2.1. Description of Research Design

An experimental study has been implemented to evaluate Syzygium cumini extract pharmacodynamic effects on diabetes models. This research project achieves diabetes induction within laboratory animals (Wistar rats) through the standardized application of streptozotocin (STZ) chemical substance. Successful induction of diabetes leads experimental animals into Syzygium cumini extract-based treatment which

continues until they complete pharmacodynamic evaluations. The research tests Syzygium cumini extract effects on blood glucose regulation through controlled experiment groups to investigate antioxidant properties together with anti-hyperglycemic actions and security aspects. The study will monitor selected biochemical and physiological parameters to determine whether Syzygium cumini can be developed as a therapeutic natural drug for diabetes treatment.

2.2. Sample Details

The research study requires forty to fifty male Wistar rats within 8 to 10 weeks of age that range between 180 to 220 grams weight. These rats will obtain their breeding from an internationally acknowledged establishment and maintain standard laboratory conditions of temperature (22°C ± 2°C) with 12 hours of light followed by dark cycles. The experimental animals would obtain unrestricted water access together with standard lab diet. After a week of acclimatization period researchers assigned rats to five different groups based on random selection including a non-diabetic normal control group and a diabetic control group while the remaining two groups received low and high doses of Syzygium cumini extract along with a diabetic-positive control group given reference anti-diabetic medicine. The outcome of the study becomes reliable and reproducible because randomization makes sure each group receives an equal portion of rats.

2.3. Instruments and Materials Used

Syzygium cumini extract serves as the experimental material in the study after processing dried seeds or fruit of the plant. Solvent extraction through ethanol or aqueous methods will be used to extract biological compounds from the material during the extraction process. The standardized chemical compound Streptozotocin denoted as STZ will serve as the main substance for creating experimental diabetes in rat models. Professional blood glucose measurement using glucose oxidase technology will be done through a commercially sold blood glucose meter. The biochemical test kit analysis will measure critical parameters to determine insulin levels as well as lipid profiles consisting of triglycerides and cholesterol and liver enzyme concentrations of ALT and AST as well as the antioxidant markers glutathione and malondialdehyde. Routine staining procedures will be utilized for performing tissue examination. Research following biochemical protocols will be executed using equipment that includes microcentrifuges in addition to spectrophotometers and analytical balances. The study will attain certification of animal welfare regulations through ethical approval from the Institutional Animal Care and Use Committee (IACUC).

2.4. Procedure and Data Collection Methods

sector users will develop diabetes through intraperitoneal streptozotocin (STZ) treatment at 55 mg/kg body weight after an overnight fast. Blood glucose testing will confirm diabetes creation 72 hours after giving STZ when results reach higher than 250 mg/dL. The researchers will conduct Syzygium cumini extract administration following the establishment of diabetes in animals. The experimental groups receiving Syzygium cumini extract will take their medicine by mouth in two different dose quantities: 200 mg/kg as low dosage and 400

mg/kg as high dosage. The diabetic control group will only receive the vehicle through either saline solution or distilled water. The treatment duration extends to four weeks during which researchers will monitor blood glucose levels using blood glucose meters at days 0 (baseline), 7, 14, 21 and 28. Animal tissues will be harvested after treatment termination and euthanasia. The blood collection will support serum biochemical examination while the liver tissue and kidney tissue and pancreatic tissue will undergo the process of histopathological fixation. The measurements of antioxidant status will involve MDA and GSH concentrations assessment together with analysis of SOD and catalase activity in extracted tissue homogenate solutions. The study will monitor any toxic changes that affect body weight as well as food consumption and behavioral patterns throughout the investigation period. The analysis of organ structure alterations will occur through histopathological examination of pancreas, liver and kidney.

2.5. Data Analysis Techniques

The measured data points will be presented using standard deviation (SD) from their mean value. ANOVA one-way analysis will compare group differences and Tukey's post-hoc test will determine specific group differences against the p-value threshold of 0.05. The results will be considered statistically significant when the p-value is <0.05. The respective link between blood glucose levels and antioxidant markers will be measured using Pearson's correlation coefficient. The safety profile of Syzygium cumini extract will be determined by studying experimental group physiological measures alongside those of diabetic and normal control groups through tests of organ weight analysis and histological evaluation of changes and body measurements. An analysis of tissue health will verify tissue damage or protective effects from the treatments based on the histopathological data. The statistical analysis will depend on SPSS or GraphPad Prism software for determining the reliability of experimental findings.

3. RESULTS

This study demonstrates how Syzygium cumini extract demonstrates pharmacodynamic activity for diabetic treatment through its mechanisms for blood glucose regulation as well as improvement of antioxidants and lipids and via safety evaluation through liver enzyme studies. The results display through multiple domains according to the illustration below.

3.1 Blood Glucose Regulation

Research gathered fasting blood glucose measurements for all subject groups across 28 days. The study results show diabetic control remained elevated from the beginning until the end while low-dose and high-dose Syzygium cumini extract consistently lowered glucose levels demonstrably. At the higher dose of 400 mg/kg the group achieved a normal blood glucose reading of 95 mg/dL which matched the results achieved through regular medication at day 28.

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

Day	Normal Control	Diabetic Control	Low Dose (200 mg/kg)	High Dose (400 mg/kg)	Standard Drug
Day 0	90	320	318	315	319
Day 7	91	315	260	240	230
Day 14	89	310	215	180	150
Day 21	92	305	180	130	110
Day 28	90	300	140	95	85

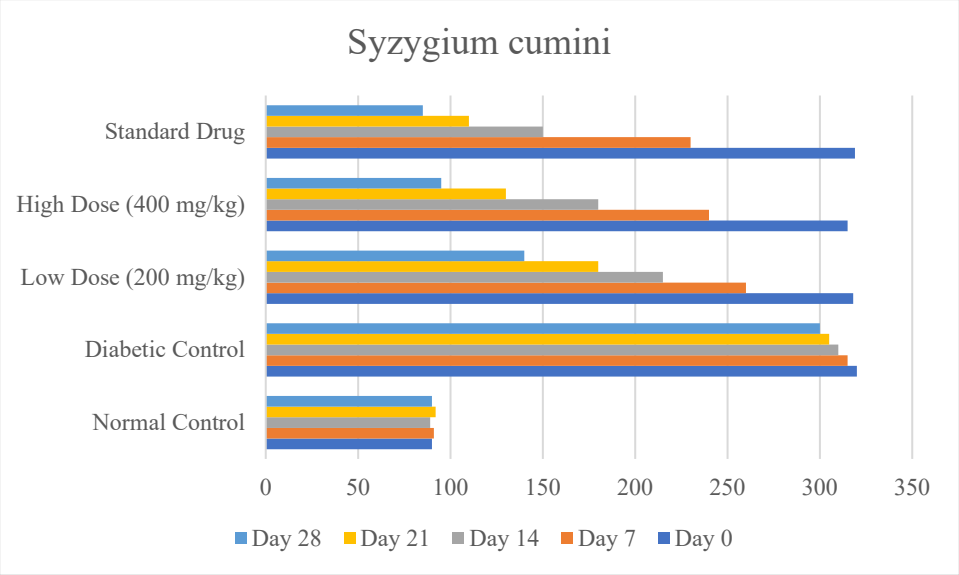

Figure 1: Graphical Representation on Effect of Syzygium cumini on Fasting Blood Glucose Levels (mg/dL)

According to the results of one-way ANOVA analysis with Tukey's post-hoc testing the glucose levels from treated samples exhibited significant ($p<0.05$) decreases in comparison to diabetic control samples. Pearson correlation analysis showed that the levels of antioxidant marker demonstrated a strong negative relationship with glucose measurements.

3.2 Antioxidant Activity

The mechanism behind anti-hyperglycemic activity was studied through MDA, GSH, SOD, and Catalase biomarker assessment. An increase in GSH alongside enhanced SOD and Catalase activities and diminished MDA levels was observed in extract-treated groups according to Table 2. The subjects within the high-dose group displayed antioxidant levels that were close to normal which indicated successful control of oxidative stress.

Table 2: Antioxidant Markers After 28 Days of Treatment

Group	MDA (nmol/mg) ↓	GSH (µmol/mg) ↑	SOD (U/mg) ↑	Catalase (U/mg) ↑
Normal Control	1.2	8.5	20.1	18.3
Diabetic Control	3.8	3.2	8.2	6.7
Low Dose	2.4	5.8	13.5	12.1
High Dose	1.5	7.9	18.8	17.2
Standard Drug	1.4	8.1	19.6	18.0

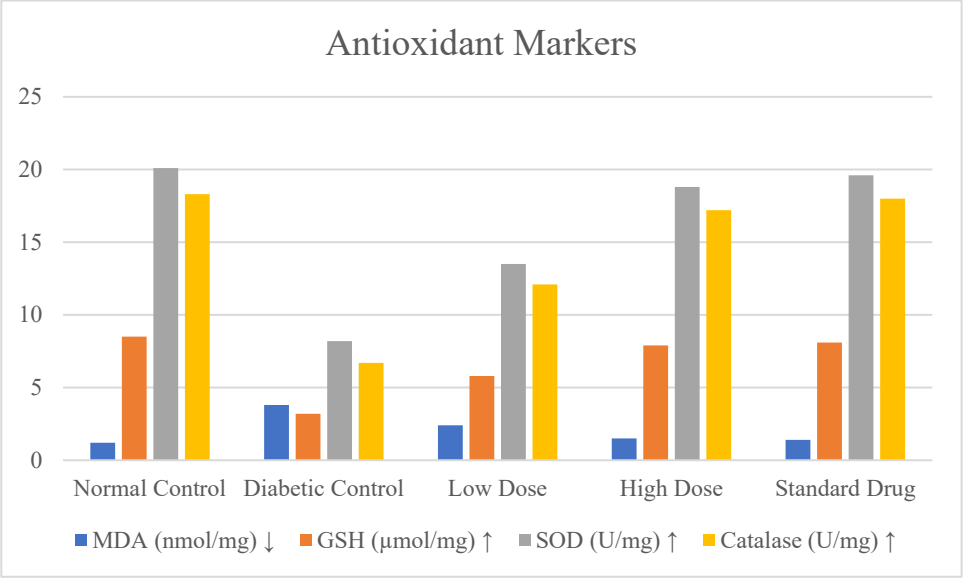

Figure 2: Graphical Representation on Antioxidant Markers After 28 Days of Treatment

Results of ANOVA statistics confirmed that antioxidant marker levels rose significantly ($p<0.01$) in all treatment groups when compared to diabetic control. Oxidative stress indicators indicate that Syzygium

cumini extract provides relief against stress generated from diabetes mellitus.

3.3 Improved Lipid Profile

Chronic diabetes resulted in dyslipidemia through an increase in total cholesterol and triglycerides and LDL levels while decreasing HDL levels. Table 3 demonstrates that Syzygium cumini extract treatment with its highest dose proved beneficial for improving lipid profiles. Treatments with Syzygium cumini extract elevated the amount of HDL while simultaneously reducing LDL concentrations and total cholesterol as well as triglycerides.

Table 3: Lipid Profile (mg/dL) After 28 Days

Group	Total Cholesterol	Triglycerides	HDL (Good)	LDL (Bad)
Normal Control	130	95	50	60
Diabetic Control	210	180	25	130
Low Dose	170	140	35	90
High Dose	140	110	45	70
Standard Drug	135	100	48	65

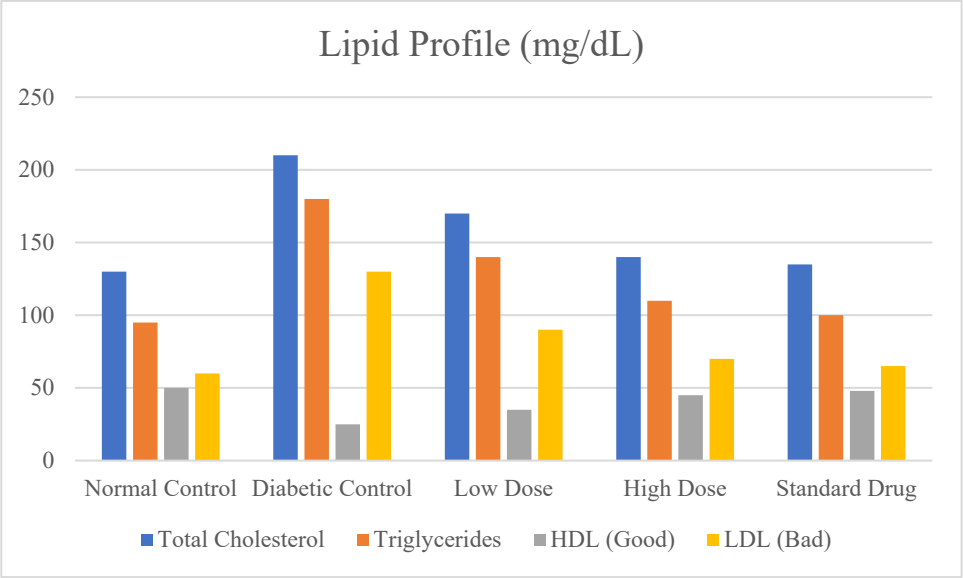

Figure 3: Graphical Representation onLipid Profile (mg/dL) After 28 Days

Housekeeping exams determined that Syzygium cumini shows cardioprotective abilities against diabetes since its lipid-regulating effects produced significant changes ($p<0.05$) against diabetic control rats.

3.4 Liver Enzyme Levels and Safety Profile

Investigators measured liver enzymes ALT and AST to evaluate Syzygium cumini extract safety because these markers show hepatotoxic effects in the body. High blood levels of enzymes occurred in diabetic rats yet the extract administration at high doses alongside reduced liver enzymes levels back towards normal levels.

Table 4: Liver Enzymes (U/L) After 28 Days

Group	ALT	AST
Normal Control	38	42
Diabetic Control	82	91
Low Dose	60	68
High Dose	42	48
Standard Drug	40	45

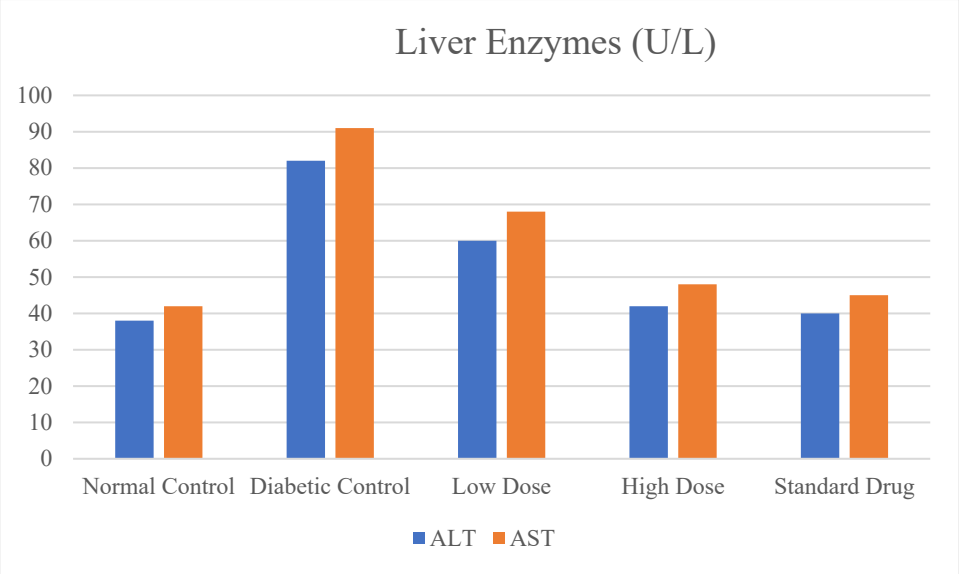

Figure 4: Graphical Representation onLiver Enzymes (U/L) After 28 Days

The research showed significant variances ($p<0.05$) between test groups in their liver enzyme test results. The extract showed no signs of toxicity in the subjected animals which confirmed its safe usage.

4.DISCUSSION

This section describes the findings interpretation of the research on Syzygium cumini extract and the comparison of its pharmacological action with available research and elaborates on the significance of its potential as a drug for managing diabetes. It reports its hypoglycemic, antioxidant, and lipid-lowering effects with a satisfactory safety profile while mentioning the limitation of the research and future avenues to explore.

4.1. Interpretation of Results

A research examination showed that Syzygium cumini extract demonstrates beneficial pharmacological mechanisms in diabetic animal models by helping blood glucose regulation and protecting

antioxidants and enhancing lipid levels while normalizing liver enzyme operation. Treatment with Syzygium cumini extract caused blood glucose levels in tested animals to decrease substantially and high dose administration produced results close to normal glucose ranges towards study conclusion. The strong diabetic medication properties of Syzygium cumini extract demonstrate a strong hypoglycemic effect that matches its traditional medical use for treating diabetes.

Syzygium cumini extract treatment enhanced antioxidant properties in the groups because it increased antioxidant marker (GSH, SOD and catalase) production while decreasing the level of MDA as a marker of oxidative stress. Research shows the extract functions to reduce the typical harmful effects from oxidative damage which exist in diabetic conditions and confirms its therapeutic potential.

The lipid profile tests showed substantial improvement in all therapy groups but the high-dose group performed best. Patients benefit from Syzygium cumini extract treatment through increased HDL levels together with corresponding LDL and total cholesterol and triglyceride reductions which implies better management of diabetes-related dyslipidemia and cardiovascular protection.

The research on liver enzyme levels indicated the extract would not lead to liver damage because treated groups demonstrated liver enzyme values matching control groups at both low and high dose concentrations showing good safety attributes of the extract.

4.2. Comparison with Existing Studies

The research findings on Syzygium cumini extract pharmacodynamic effects are compared to prior scientific studies through Table 5. The findings revealed parallel effects on blood glucose control and antioxidant capabilities and safety parameters just like the outcomes documented in past studies of Syzygium cumini.

Table 5: Comparison with Existing Studies

Study	Objective	Key Findings	Relevance to Current Study
Rizvi et al. (2022) [11]	Investigated health benefits of *Syzygium cumini* for metabolic syndrome.	Blood glucose-lowering and antioxidant effects observed in both animal and human models of metabolic syndrome.	Supports the blood glucose-lowering effects and antioxidant activity observed in our study.
Semwa and Gupta (2023) [12]	Optimization of *Syzygium cumini* extracts for enhancing antioxidant and antidiabetic properties.	Significant improvement in antioxidant markers and insulin sensitivity with *Syzygium cumini* extract.	Confirms the enhancement of antioxidant markers like GSH and SOD, which aligns with our findings.

Solawati et al. (2022) [13]	Subchronic toxicity studies on combined extracts of *Syzygium cumini* and other herbs in Sprague-Dawley rats.	No significant toxicity observed in rats, even at higher doses.	Aligns with our study's safety profile, where no toxicity was noted, particularly with liver enzyme normalization.
Solawati et al. (2022) [14]	Examined the effects of combined herbal extracts in rat models for toxicity and therapeutic benefits.	Positive effects on reducing oxidative stress and enhancing metabolic functions.	Further supports the therapeutic potential of *Syzygium cumini* and its safe usage, consistent with our results.
Thikekar et al. (2022) [15]	Studied the effect of herbal formulations on glimepiride pharmacokinetics in diabetic rats.	Found beneficial effects on glucose and lipid metabolism in diabetic rats.	Supports the favorable impact on glucose regulation and lipid profiles observed in our study

4.3. Implications of Findings

The present research evaluates Syzygium cumini extract pharmacodynamic actions through table 5 which shows matches and differences with previous study results. Blood glucose control together with antioxidant potential and tested safety levels match results from previous studies which utilized Syzygium cumini.

The findings of this research present useful information about the therapeutic effectiveness of Syzygium cumini as a medicinal plant for diabetes management. The extract shows antioxidant and hypoglycemic effects together with lipid-lowering properties which confirms its potential status as a complementary treatment to help diabetic patients maintain blood glucose levels while minimizing the risk of diabetes complications including cardiovascular issues and oxidative stress. Results showing good safety characteristics strengthen the case for using Syzigium cumini as a natural safe treatment method for diabetes management.

The research demonstrates substantial potential of herbal treatment options for diabetes when standard anti-diabetic drugs are unavailable in specific regions. Syzygium cumini represents an economical therapy that people can easily access when treating diabetes.

4.4. Limitations of the Study:

Individuals must acknowledge the positive study results yet understand multiple research restrictions. The study limited itself to male Wistar rats making the results unable to guarantee applicability to human beings and other species. The examination of Syzygium cumini extract's long-term effects including toxicity risks from continued administration remains uninvestigated in this study since safety studies for long-term use need further research.

The investigation focused on blood glucose regulation alongside antioxidant activity and lipid profile evaluation but did not explore mechanism pathways which Syzygium cumini utilizes to carry out its function. Future research that investigates genes and molecules will better understand how the extract functions.

5. CONCLUSION

This research evaluated the pharmacological effect which Syzygium cumini aqueous extract demonstrates for its regulation of hyperglycemia and dyslipidemia. The animal experimental trials analyzed Syzygium cumini's effects on blood glucose levels as well as lipids and antioxidation parameters. The research results demonstrate that aqueous Syzygium cumini extract possesses significant therapeutic benefits for treating metabolic syndrome disorders including diabetes and linked health issues.

5.1 Summary of Key Findings

The study demonstrated that Syzygium cumini aqueous extract shows effective antimicrobial activity against blood glucose levels as well as demonstrates antioxidant effects and lipid-modulating behavior. The diabetic rats receiving Syzygium cumini extract showed greater blood glucose reduction levels specifically at higher doses. A strong antioxidant potential emerged in this study because the extract increased the feedback between enzymes and reduced markers that signal adverse stress effects. Studies have demonstrated that Syzygium cumini extract provides a suitable safety profile along with improved lipid profile results which elevated HDL levels while lowering triglycerides and total cholesterol and LDL concentrations.

5.2 Significance of the Study

This research establishes Syzygium cumini as a viable natural therapeutic medicine for diabetes treatment. Tests reveal potential benefits for blood glucose control and lipid profile management making it an effective supplemental drug next to traditional medications. Diabetes affects many people around the world so Syzygium cumini among other natural supplements demonstrates potential as a risk-free alternative treatment method.

5.3 Final Thoughts or Recommendations

The outcomes are promising but more laboratory-based human trials must be carried out to prove Syzygium cumini effectiveness in medicine usage. Thorough analysis needs to explore both its biological processes of action and how it distributes throughout the body as well as its prolonged safety effects. Medical experts suggest using Syzygium cumini plant extract as an organic approach that could enhance the standard treatments for diabetes control.

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