



CODEN [USA]: IAJ PBB

ISSN : 2349-7750

INDO AMERICAN JOURNAL OF  
**PHARMACEUTICAL SCIENCES**

SJIF Impact Factor: 7.187

<https://doi.org/10.5281/zenodo.18788587>

Available online at: <http://www.iajps.com>

Research Article

**BIOSYNTHESIS OF SILVER NANOPARTICLE USING  
PSIDIUM GUJAVA LEAF EXTRACT AND SCREENING OF  
ITS ANTIDIBETICS ACTIVITY**

**Tanveer khajapasha Janahemad<sup>1\*</sup>, Dr. Ajay Kshirsagar<sup>2</sup>**

<sup>1\*</sup> M. Pharm Scholar, D. K. Patil Institute of Pharmacy, Loha, Nanded, Maharashtra

<sup>2</sup>Principal, D. K. Patil Institute of Pharmacy, Loha, Nanded, Maharashtra

**Abstract:**

**Objective:** Diabetes mellitus is a chronic metabolic disorder characterized by persistent hyperglycemia and associated complications affecting multiple organs. *Psidium guajava* L. (family Myrtaceae) has been traditionally used in the management of diabetes in various parts of India. The present study aimed to evaluate the antidiabetic potential of aqueous leaf extract and biosynthesized silver nanoparticles of *Psidium guajava* in streptozotocin-induced diabetic rats.

**Methods:** Experimental diabetes was induced in overnight-fasted Wistar rats by a single intraperitoneal injection of streptozotocin (55 mg/kg) prepared in 0.1 M citrate buffer (pH 4.5). After 72 hours, rats with fasting blood glucose levels  $\geq 200$  mg/dL were selected for the study. Diabetic rats were treated orally for 21 days with *Psidium guajava* aqueous extract (200 and 300 mg/kg), *Psidium guajava* silver nanoparticles (200 and 300 mg/kg), and metformin (100 mg/kg) as the standard drug. Blood glucose levels, lipid profile parameters, and body weight changes were evaluated.

**Results:** Treatment with *Psidium guajava* extract and its silver nanoparticles significantly reduced blood glucose levels in diabetic rats in a dose-dependent manner. Both treatments also improved lipid profile by reducing serum triglycerides, total cholesterol, LDL, and VLDL while increasing HDL levels. Additionally, treatment prevented diabetes-induced body weight loss. The nanoparticle formulation exhibited greater antidiabetic efficacy compared to the aqueous extract and showed effects comparable to metformin.

**Conclusion:** The findings indicate that *Psidium guajava* possesses significant dose-dependent antihyperglycemic and hypolipidemic activity. Biosynthesized silver nanoparticles demonstrated enhanced therapeutic efficacy compared to crude extract. These results support the traditional use of *Psidium guajava* in diabetes management and suggest its potential as a promising natural antidiabetic agent.

**KEYWORDS:** *Psidium guajava*, silver nanoparticles, diabetes mellitus, streptozotocin, antihyperglycemic activity, lipid profile.

**Corresponding author:**

**Tanveer khajapasha Janahemad,**

M. Pharm Scholar,

D. K. Patil Institute of Pharmacy,

Loha, Nanded, Maharashtra

Email ID: [shabanakj1982@gmail.com](mailto:shabanakj1982@gmail.com)



Please cite this article in press Tanveer khajapasha Janahemad et al Biosynthesis Of Silver Nanoparticle Using *Psidium Gujava* Leaf Extract And Screening Of Its Antidibetics Activity, Indo Am. J. P. Sci, 2026; 13(02).

**INTRODUCTION:**

Nanotechnology has emerged as a transformative scientific field with broad applications in medicine, pharmacy, electronics, and environmental science. Nanoparticles are ultra-small materials typically ranging from 1 to 100 nm in size, exhibiting unique physicochemical properties such as high surface area, enhanced reactivity, improved stability, and tunable optical behavior. Based on their composition, nanoparticles are broadly classified into organic nanoparticles (such as carbon-based nanomaterials) and inorganic nanoparticles, which include metal nanoparticles (silver, gold, platinum, palladium), magnetic nanoparticles, and semiconductor nanoparticles like titanium dioxide and zinc oxide.<sup>1-4</sup>

Conventionally, nanoparticles are synthesized using physical and chemical approaches such as ion sputtering, reduction techniques, sol-gel processing, and solvothermal methods. Although these techniques allow controlled particle formation, they often require high energy input, expensive instrumentation, and hazardous chemicals that may remain adsorbed on nanoparticle surfaces.<sup>5-7</sup> such residues can limit biomedical applications due to potential toxicity and environmental concerns. These limitations have encouraged the development of alternative strategies based on environmentally sustainable principles.

Green synthesis has therefore gained considerable attention as a safer and more eco-friendly approach to nanoparticle production. This method employs natural biological resources such as plant extracts, microorganisms, sugars, vitamins, and biodegradable polymers as reducing and stabilizing agents.<sup>8-10</sup> Plant-mediated synthesis is particularly advantageous because plant phytochemicals such as flavonoids, phenolic compounds, alkaloids, and terpenoids can effectively reduce metal ions while simultaneously stabilizing the resulting nanoparticles. This eliminates the need for toxic reagents and harsh processing conditions, making the process cost-effective, scalable, and biocompatible.

**Silver nanoparticles and their biomedical relevance**

Among various metal nanoparticles, silver nanoparticles (AgNPs) have received exceptional attention due to their remarkable biological and physicochemical properties. Their nanoscale size, high surface reactivity, and strong antimicrobial potential make them highly suitable for biomedical applications. Silver nanoparticles demonstrate broad-spectrum activity against bacteria, viruses, and fungi even at low concentrations, while maintaining relatively low toxicity toward human cells when properly synthesized.

AgNPs exhibit several functional advantages including improved stability, enhanced catalytic efficiency, increased selectivity, and superior therapeutic potential. These properties have led to their widespread use in wound dressings, infection control, diabetic ulcer management, dental materials, medical device coatings, tissue engineering scaffolds, and drug delivery systems. Additionally, their optical and electrical characteristics enable applications in biosensors, imaging, catalysis, and diagnostic technologies. Their multifunctional nature makes them valuable candidates for therapeutic interventions targeting complex metabolic disorders.<sup>11-14</sup>

***Psidium guajava* as a green nanoparticle synthesizing agent**

*Psidium guajava* (guava) is a well-known medicinal plant widely used in traditional systems of medicine. Its leaves contain abundant phytoconstituents including flavonoids, tannins, phenolic acids, saponins, and triterpenoids, which possess antioxidant, antimicrobial, anti-inflammatory, and antidiabetic activities. These phytochemicals have strong reducing potential and can efficiently convert silver ions into stable nanoparticles.

In addition to facilitating nanoparticle formation, the intrinsic biological properties of guava leaf phytochemicals may enhance the therapeutic potential of synthesized nanoparticles. Therefore, plant-mediated silver nanoparticles derived from *Psidium guajava* represent a promising nanobiotechnological system with potential pharmacological benefits, particularly in metabolic disorders.<sup>15-17</sup>



Figure 1: Leaves of *Psidium guajava* L

### Diabetes mellitus: a global metabolic disorder

Diabetes mellitus is a chronic metabolic disease characterized by persistent hyperglycemia resulting from impaired insulin secretion, defective insulin action, or both. It disrupts carbohydrate, lipid, and protein metabolism and is associated with long-term complications affecting multiple organs. Chronic hyperglycemia contributes to the development of retinopathy, nephropathy, neuropathy, cardiovascular disease, and endothelial dysfunction, significantly increasing morbidity and mortality.

The prevalence of diabetes has risen dramatically worldwide due to urbanization, sedentary lifestyle, dietary changes, and population aging. Global estimates indicate a continuous increase in disease burden, with projections suggesting substantial future growth. India is among the countries most affected by diabetes, making the search for effective and affordable therapeutic strategies an urgent priority.<sup>18-19</sup>

### Classification and Pathophysiology

Diabetes mellitus is broadly classified into type 1 diabetes, type 2 diabetes, gestational diabetes, and other specific forms. Type 1 diabetes results from autoimmune destruction of pancreatic  $\beta$ -cells leading to absolute insulin deficiency. Type 2 diabetes, which accounts for the majority of cases, involves insulin resistance combined with relative insulin deficiency. Persistent metabolic dysregulation leads to oxidative stress, inflammation, and progressive tissue damage.

Insulin resistance plays a central role in type 2 diabetes, reducing glucose uptake in peripheral tissues and increasing hepatic glucose production. Over time, pancreatic  $\beta$ -cells fail to compensate for increased insulin demand, leading to chronic hyperglycemia. These pathological mechanisms

make diabetes a complex disorder requiring multifaceted therapeutic approaches.

Management of diabetes typically involves insulin therapy, oral hypoglycemic agents, lifestyle modification, and dietary control. Although existing medications can effectively reduce blood glucose levels, many are associated with adverse effects, high cost, and limited long-term efficacy. Furthermore, conventional therapies do not always prevent disease progression or complications. These limitations have encouraged the exploration of alternative strategies, including plant-derived therapeutics and nanotechnology-based interventions.

Experimental animal models are essential for evaluating potential antidiabetic agents. Streptozotocin (STZ), a nitrosourea compound derived from *Streptomyces* species, is widely used to induce diabetes in laboratory animals. It selectively targets pancreatic  $\beta$ -cells through GLUT2 glucose transporters, causing DNA damage, oxidative stress, and cellular necrosis. The resulting insulin deficiency produces persistent hyperglycemia resembling human diabetes, making STZ-induced models highly suitable for evaluating antidiabetic activity of novel therapeutic agents.<sup>20-22</sup> The convergence of nanotechnology and phytomedicine offers new possibilities for developing innovative antidiabetic therapies. Plant-mediated silver nanoparticles combine the therapeutic potential of bioactive phytochemicals with the enhanced bioavailability and functional properties of nanomaterials. *Psidium guajava* leaf extract, rich in biologically active compounds, provides an ideal natural reducing and stabilizing system for nanoparticle synthesis.

Considering the growing global burden of diabetes and the need for safer therapeutic alternatives,

biosynthesized silver nanoparticles may offer a promising approach for glycemic control and metabolic regulation. Therefore, the present study focuses on the green synthesis of silver nanoparticles using *Psidium guajava* leaf extract and the evaluation of their antidiabetic activity using an experimental diabetes model.

#### MATERIALS AND METHODS:

##### Plant material collection and authentication

Fresh leaves of *psidium guajava* were collected from the Bangalore district. The collected plant material was thoroughly washed with distilled water to remove adhering dust and impurities, followed by shade drying at room temperature until complete removal of moisture. The dried leaves were subjected to mechanical size reduction to obtain a coarse powder, which was stored in airtight containers at room temperature for further experimental use.



Figure 2: Fresh *Psidium guajava* leaves



Figure 3: Dried *Psidium guajava* leaves and leaves coarse powder

##### Preparation of aqueous plant extract

The aqueous extract of *psidium guajava* leaves was prepared by weighing 10 g of the coarse powdered material and transferring it into a 250 ml erlenmeyer flask containing 100 ml of sterile double-distilled water. The mixture was heated and boiled for 20 minutes to facilitate extraction of phytoconstituents. After cooling, the extract was decanted and filtered through whatman filter paper no. 1 to obtain a clear filtrate. The filtrate was used for phytochemical screening and biosynthesis of silver nanoparticles.<sup>23-24</sup>



Figure 4: Filtration of extract

**Preliminary phytochemical screening**

Qualitative phytochemical analysis of the aqueous extract was performed to detect the presence of major secondary metabolites using standard chemical tests. Alkaloids were identified using dragendorff's, wagner's, mayer's, and hager's tests based on precipitate formation. Glycosides were detected by keller–killiani, legal's, and borntrager's tests based on characteristic color changes. Carbohydrates were confirmed using molisch and fehling's tests. Steroids and sterols were evaluated using liebermann–burchard and salkowski tests. Flavonoids were detected by shinoda test. Tannins were identified using ferric chloride reaction. Proteins and amino acids were detected by biuret and xanthoprotein tests. Saponins were identified by foam formation test.<sup>25-27</sup>

**Experimental animals**

Albino wistar rats of either sex weighing 140–200 g were used for the study. Animals were maintained under standard laboratory conditions (temperature  $27 \pm 1^\circ\text{C}$  and relative humidity  $55 \pm 1\%$ ) with a 12-hour light–dark cycle. Standard pellet diet and water were provided ad libitum. All experimental procedures were conducted according to institutional guidelines for animal care and use.

**Green synthesis of silver nanoparticles**

Silver nanoparticles were synthesized using the aqueous leaf extract of *psidium guajava*. A 1 mm aqueous silver nitrate solution was prepared by dissolving 21.2 mg of  $\text{AgNO}_3$  in 125 ml of milli-q water. For nanoparticle synthesis, 12 ml of plant extract was mixed with 88 ml of 1 mm silver nitrate solution and incubated at room temperature. The formation of silver nanoparticles was indicated by a color change from pale yellow to brownish yellow. The reaction mixture was further incubated for four days to ensure complete reduction of silver ions. The mixture was then centrifuged at 4000 rpm for 20 minutes. The obtained pellet was collected and washed repeatedly with distilled water to remove residual impurities. The purified pellet was dried in a hot air oven until complete removal of moisture.

The dried nanoparticles were collected and stored for characterization and biological evaluation.<sup>28-30</sup>

**Characterization of silver nanoparticles<sup>31-35</sup>****Uv–visible spectroscopy**

Formation of silver nanoparticles was confirmed by uv–visible spectrophotometry (shimadzu 1700). Samples were diluted with deionized water and scanned between 200–800 nm using a quartz cuvette with distilled water as reference.

**Fourier transform infrared (FTIR) spectroscopy**

FTIR analysis (bruker FTIR) was performed to identify functional groups involved in nanoparticle synthesis and stabilization. Samples were analyzed using the atr method to detect plant biomolecules responsible for reduction and capping.

**Zeta potential analysis**

The stability of synthesized nanoparticles was evaluated by measuring zeta potential. Higher negative values indicated enhanced colloidal stability of silver nanoparticles.

**Scanning electron microscopy (SEM)**

Surface morphology and particle size were determined using scanning electron microscopy. A small amount of sample was placed on a carbon-coated grid, dried under a mercury lamp, and examined under SEM.

**In-vivo antidiabetic activity<sup>36-48</sup>****Induction of experimental diabetes**

Diabetes was induced in overnight-fasted wistar rats by intraperitoneal injection of freshly prepared streptozotocin (55 mg/kg body weight) dissolved in 0.1 m citrate buffer (ph 4.5). To prevent initial hypoglycemic shock, animals were provided with 20% glucose solution for 24 hours post-injection. After 72–74 hours, fasting blood glucose levels were measured, and rats with glucose levels  $\geq 200$  mg/dl were considered diabetic and included in the study.

**Experimental Design:**

Animals were divided into seven groups (n=6 per group) and treated for 21 days:

**Table 1: Experimental design and treatment protocol**

Group No.	Group Name	Treatment Administered	Dose	Route of Administration	Duration of Treatment	Number of Animals (n)
Group I	Normal Control	Normal saline	—	Oral	21 days	6
Group II	Diabetic Control	Streptozotocin (STZ) only	55 mg/kg (IP, single dose)	Intraperitoneal	—	6
Group III	Standard Treatment	Metformin	100 mg/kg	Oral	21 days	6
Group	Test Group	<i>Psidium guajava</i> leaf	200 mg/kg	Oral	21 days	6

IV	I	extract				
Group V	Test Group II	<i>Psidium guajava</i> leaf extract	300 mg/kg	Oral	21 days	6
Group VI	Test Group III	<i>Psidium guajava</i> silver nanoparticles	200 mg/kg	Oral	21 days	6
Group VII	Test Group IV	<i>Psidium guajava</i> silver nanoparticles	300 mg/kg	Oral	21 days	6

#### Preparation and administration of test suspensions

Plant extract, nanoparticles, and standard drug were suspended in distilled water using 0.1% sodium carboxymethyl cellulose (CMC). The preparations were administered orally using an intragastric catheter once daily for 21 days.

#### Experimental procedure and sample collection

Blood glucose levels and body weight were measured on days 1, 7, 14, and 21. Blood samples were collected from the tail vein for glucose estimation. At the end of the experimental period, animals were fasted overnight and anesthetized with ketamine hydrochloride. Blood samples were collected by cardiac puncture into edta tubes and centrifuged to obtain serum for biochemical analysis.

#### Evaluation parameters

**Blood glucose measurement:** blood glucose levels were measured using a digital glucometer from tail vein blood samples.

**Body weight:** body weight of animals was recorded weekly throughout the study period.

**Biochemical analysis:** serum samples were analyzed for lipid profile parameters including triglycerides, total cholesterol, hdl-c, ldl-c, and vldl-c.

#### Statistical analysis

All results were expressed as mean  $\pm$  standard error of mean (sem). Statistical comparisons between

groups were performed using one-way analysis of variance (anova) followed by dunnett's multiple comparison test. A value of  $p < 0.05$  was considered statistically significant.

#### RESULTS:

##### Qualitative Phytochemical Screening of *Psidium guajava* Leaf Extract

Preliminary phytochemical analysis of the aqueous leaf extract of *Psidium guajava* revealed the presence of several bioactive secondary metabolites. Alkaloids were detected by Dragendorff's and Hager's tests, while Wagner's and Mayer's tests were negative. Carbohydrates were confirmed by positive Molisch, Fehling's, and Benedict's reactions, indicating the presence of reducing sugars. Flavonoids and tannins were strongly present as evidenced by positive Shinoda and ferric chloride tests, respectively.

Steroids and sterols were confirmed by both Liebermann–Burchard and Salkowski reactions. Glycosides were not detected in the applied qualitative tests. Similarly, proteins, amino acids, and saponins were absent in the extract. Overall, the phytochemical profile demonstrated the presence of important bioactive compounds such as alkaloids, flavonoids, tannins, carbohydrates, and sterols, which may contribute to the reducing and stabilizing potential of the extract during nanoparticle synthesis and its pharmacological activity.

**Table 2: Qualitative Phytochemical Screening of *Psidium guajava* Leaf Extract**

S. No.	Phytochemical Class	Test Performed	Result
1	Alkaloids	Dragendorff's test	+
		Wagner's test	-
		Mayer's test	-
		Hager's test	+
2	Glycosides	Keller–Killiani test	-
		Legal's test	-
3	Carbohydrates	Molisch test	+
		Fehling's test	+
		Benedict's test	+
4	Flavonoids	Shinoda test	+
5	Tannins	Ferric chloride test	+
6	Proteins	Biuret test	-
		Xanthoprotein test	-
7	Saponins	Foam test	-
8	Steroids and Sterols	Liebermann–Burchard test	+
		Salkowski test	+

(+ = Present, - = Absent)

### Characterization of Biosynthesized Silver Nanoparticles

#### UV–Visible Spectroscopy

The formation of silver nanoparticles was confirmed by UV–visible spectrophotometric analysis. The absorption spectrum showed a characteristic surface plasmon resonance peak at 425 nm, indicating the successful reduction of silver ions to silver nanoparticles. The progressive increase in peak intensity with time reflected nanoparticle formation and growth. No further change in absorbance after 48 hours indicated completion of the reduction process and stabilization of nanoparticles.

#### Fourier Transform Infrared Spectroscopy (FTIR)

FTIR spectral analysis revealed prominent absorption peaks at 2977, 1582, and 1388  $\text{cm}^{-1}$ , indicating the presence of functional groups associated with plant biomolecules involved in nanoparticle formation. These peaks suggest the participation of phytoconstituents such as phenolic compounds and proteins in the reduction and stabilization of silver nanoparticles, confirming the role of plant metabolites as capping agents.

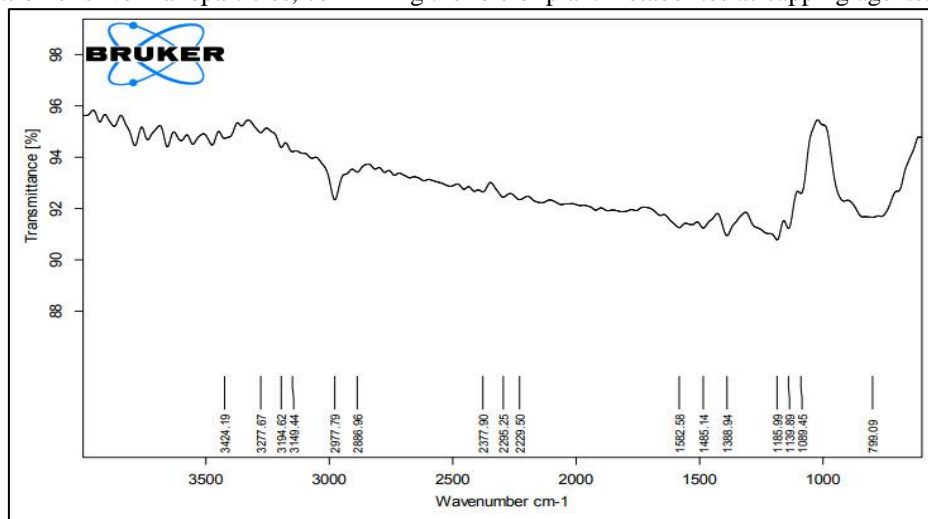


Figure 5: FT-IR Spectra of *Psidium guajava* nanoparticles

#### Zeta Potential Analysis

Zeta potential measurement of the synthesized nanoparticles showed a sharp peak at  $-30.7$  mV. This high negative surface charge indicates strong electrostatic repulsion between particles, confirming good colloidal stability and reduced aggregation of the synthesized silver nanoparticles.

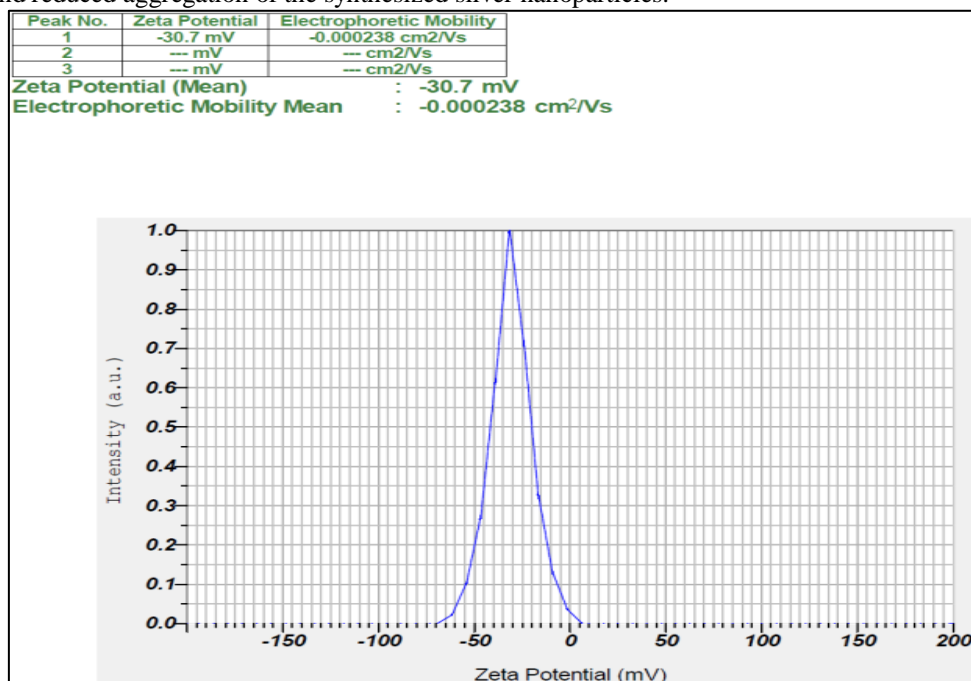
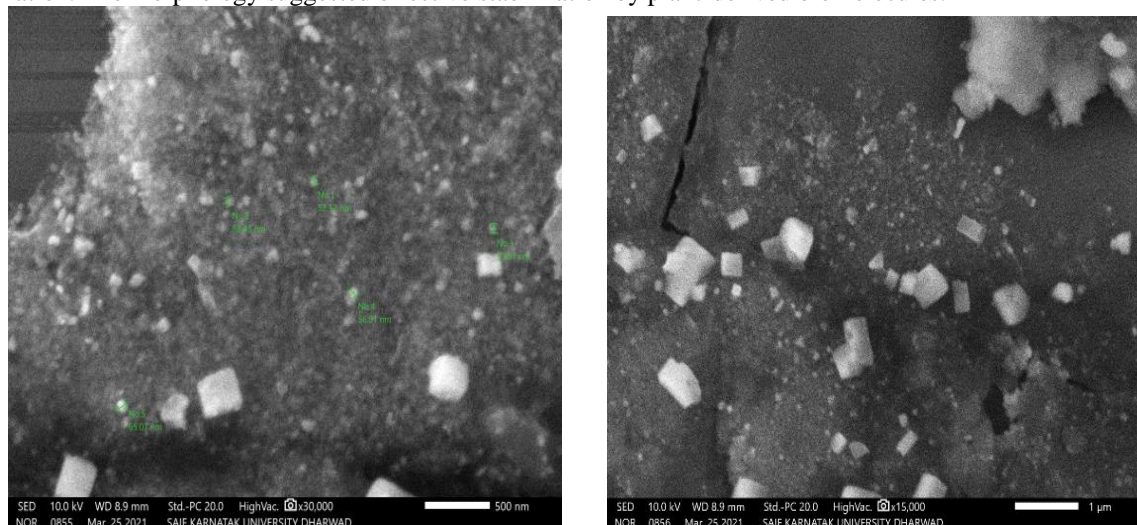


Figure 6: Zeta potential measurement *Psidium guajava* nanoparticles

**Scanning Electron Microscopy (SEM)**

SEM analysis revealed that the biosynthesized silver nanoparticles were predominantly spherical in shape with a relatively uniform size distribution. The average particle size was approximately 58.5 nm, confirming nanoscale formation. The morphology suggested effective stabilization by plant-derived biomolecules.



**Figure 7: SEM image of *Psidium guajava* nanoparticles**

**Evaluation of Antidiabetic Activity****Effect on Blood Glucose Levels**

Administration of streptozotocin produced a marked elevation in blood glucose levels in diabetic control rats compared with normal controls, confirming successful induction of diabetes. Treatment with metformin significantly reduced blood glucose levels over the 21-day study period.

Oral administration of *Psidium guajava* extract and its silver nanoparticles resulted in a significant reduction in blood glucose levels in a dose-dependent manner. The higher dose of plant extract (300 mg/kg) produced greater glycaemic reduction compared to the lower dose. Similarly, silver nanoparticles exhibited significant antihyperglycaemic activity, with the higher nanoparticle dose (300 mg/kg) producing effects comparable to the standard drug metformin. These findings demonstrate that nanoparticle treatment enhanced antidiabetic efficacy relative to crude extract.

**Table 3: Effect of *Psidium guajava* Extract and Silver Nanoparticles on Blood Glucose Levels in Streptozotocin-Induced Diabetic Rats**

Group	Blood Glucose (mg/dL) Mean $\pm$ SEM (n=6)			
	Day 1	Day 7	Day 14	Day 21
Normal control	97 $\pm$ 0.57***	96.5 $\pm$ 1.87***	95.3 $\pm$ 0.88***	94.5 $\pm$ 0.76***
Diabetic control	281.16 $\pm$ 1.13	289.5 $\pm$ 0.76	289.7 $\pm$ 0.88	293.3 $\pm$ 0.55
Metformin (100 mg/kg)	231.5 $\pm$ 1.25**	189.8 $\pm$ 0.94**	147.5 $\pm$ 0.76**	104.5 $\pm$ 0.76**
Extract (200 mg/kg)	251.83 $\pm$ 1.3*	229.5 $\pm$ 0.76*	186.5 $\pm$ 0.76*	135.8 $\pm$ 0.6*
Extract (300 mg/kg)	246.3 $\pm$ 1.35*	219.7 $\pm$ 2.48*	161.2 $\pm$ 1.07*	115.8 $\pm$ 1.24*
AgNPs (200 mg/kg)	248.5 $\pm$ 1.23*	221 $\pm$ 1.3*	169.8 $\pm$ 0.94*	126.8 $\pm$ 0.79*
AgNPs (300 mg/kg)	243 $\pm$ 1.6**	207.3 $\pm$ 1.52**	153 $\pm$ 0.81**	109.7 $\pm$ 0.88**

(\* $p$ <0.05, \*\* $p$ <0.01, \*\*\* $p$ <0.001 vs diabetic control)

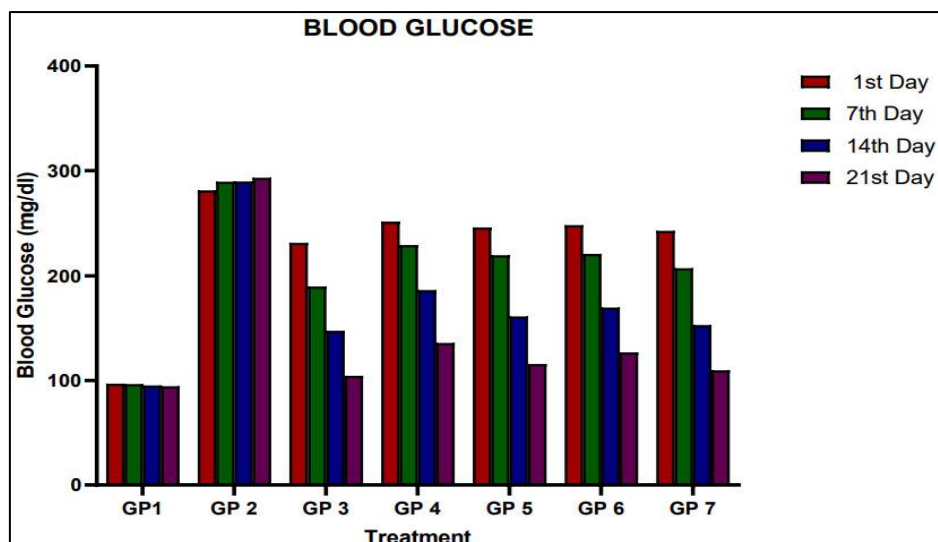


Figure 8: Effect of *Psidium guajava* on blood glucose level

**Effect on Body Weight**

Streptozotocin-induced diabetic rats showed a progressive decrease in body weight compared with normal control animals. Treatment with metformin significantly improved body weight over the experimental period. Both plant extract and nanoparticle-treated groups demonstrated recovery in body weight in a dose-dependent manner. The nanoparticle-treated groups exhibited greater improvement than extract-treated groups, suggesting better metabolic regulation and reduced catabolic state in treated animals.

Table 4: Effect of *psidium guajava* extract and silver nanoparticles on body weight in streptozotocin-induced diabetic rats

Group	Body Weight (g) Mean ± SEM (n=6)			
	Day 1	Day 7	Day 14	Day 21
Normal control	189.8 ± 2.89***	193.2 ± 3***	195.8 ± 2.7***	198.2 ± 2.05***
Diabetic control	198.2 ± 1.64	193.3 ± 1.66	189 ± 1.5	175.2 ± 2.0
Metformin (100 mg/kg)	196 ± 2.7**	199.5 ± 2.4**	203.2 ± 2.4**	206.7 ± 1.92**
Extract (200 mg/kg)	191.7 ± 3.45*	194.3 ± 3.33*	197 ± 3.4*	201.7 ± 2.8*
Extract (300 mg/kg)	194.2 ± 2.38*	199.2 ± 2.38*	203.8 ± 2.2*	206.8 ± 1.77*
AgNPs (200 mg/kg)	197 ± 2.74*	200.2 ± 2.3*	204 ± 2.1*	206.5 ± 1.6*
AgNPs (300 mg/kg)	196.7 ± 3.8**	201.5 ± 3.8**	205.3 ± 2.72**	209 ± 2.38**

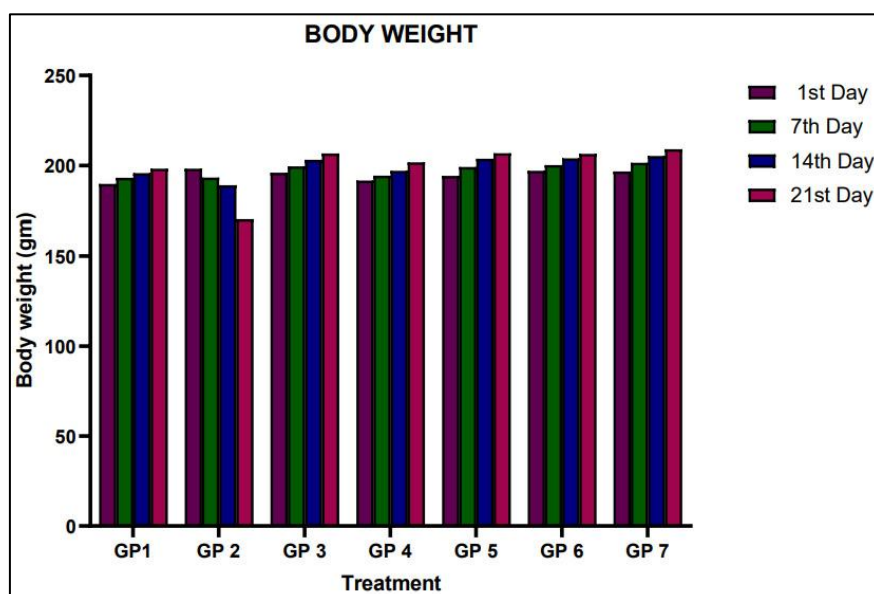


Figure 9: Effect of *Psidium guajava* on body weight

### Effect on Lipid Profile

Diabetic control rats exhibited significant dyslipidemia characterized by elevated triglycerides, total cholesterol, LDL, and VLDL levels along with reduced HDL levels. Treatment with metformin significantly restored lipid profile toward normal values.

Administration of *Psidium guajava* extract improved lipid parameters, with greater improvement observed at higher dose levels. Silver nanoparticle treatment produced more pronounced lipid-lowering effects compared to crude extract. The higher nanoparticle dose significantly reduced triglycerides, total cholesterol, LDL, and VLDL while increasing HDL levels, indicating strong hypolipidemic activity and improved metabolic control.

**Table 5: Effect of *Psidium guajava* Extract and Silver Nanoparticles on Lipid Profile in Streptozotocin-Induced Diabetic Rats**

Group	Triglycerides	Total Cholesterol	HDL	LDL	VLDL
Normal control	85.5 ± 0.76***	132.5 ± 0.76***	53.5 ± 1.17***	34.5 ± 0.76***	18.5 ± 0.76***
Diabetic control	143.3 ± 0.88	265.3 ± 0.91	31.33 ± 0.66	65 ± 1.06	41.83 ± 0.79
Metformin (100 mg/kg)	89.5 ± 0.99**	147.7 ± 0.61**	45.17 ± 0.94**	39.5 ± 0.76**	22.5 ± 0.76**
Extract (200 mg/kg)	133.8 ± 0.60*	252.5 ± 0.76*	39.83 ± 0.60*	46.17 ± 1.01*	35.33 ± 0.88*
Extract (300 mg/kg)	101 ± 0.85*	172.8 ± 0.70*	40.17 ± 0.60*	43 ± 0.57*	26.5 ± 0.76*
AgNPs (200 mg/kg)	134.7 ± 0.76*	255.3 ± 0.76*	35.5 ± 0.86*	55.33 ± 0.88*	34.5 ± 0.78*
AgNPs (300 mg/kg)	96.33 ± 0.6**	166.2 ± 1.04**	42.33 ± 0.61**	40.67 ± 0.77**	26 ± 0.57**

### Histopathological Observations

#### Liver Histology

Histological examination of liver sections from normal control rats showed intact hepatic architecture with normal hepatocytes and portal triads. In contrast, diabetic control rats showed fatty degeneration of hepatocytes, inflammatory infiltration, and structural disruption, indicating hepatic damage associated with diabetes.

Treatment with metformin restored near-normal hepatic architecture. Similarly, treatment with *Psidium guajava* extract showed improvement with reduced fatty changes and mild sinusoidal dilation. Silver nanoparticle-treated groups exhibited more pronounced restoration of normal liver structure, suggesting hepatoprotective activity.

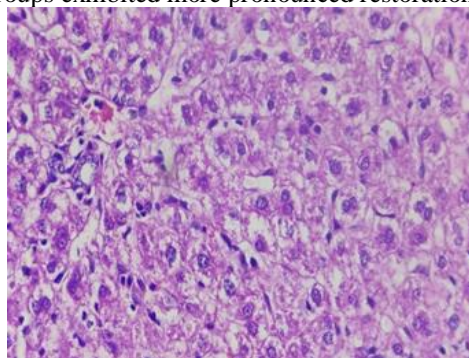


Figure 10: Group1

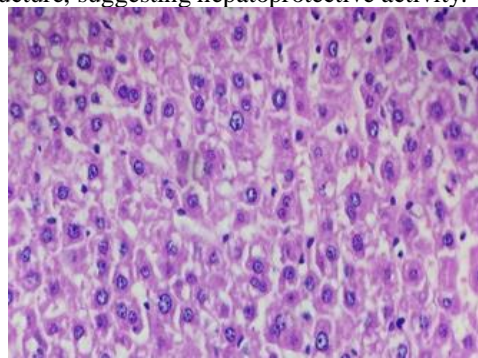


Figure 11: Group 2

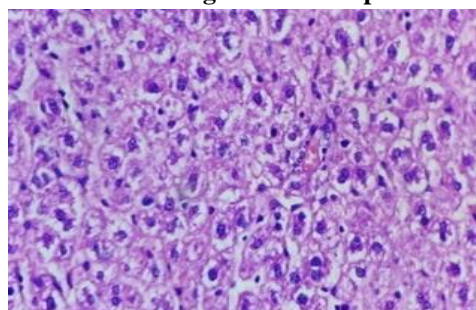


Figure 12: Group3

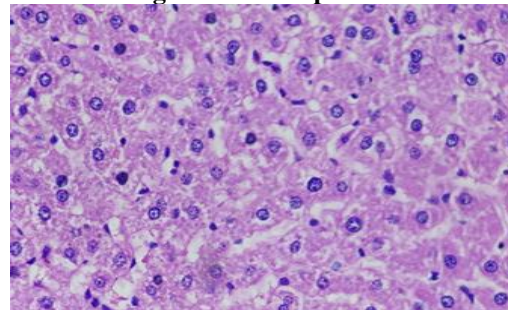


Figure 13: Group 4

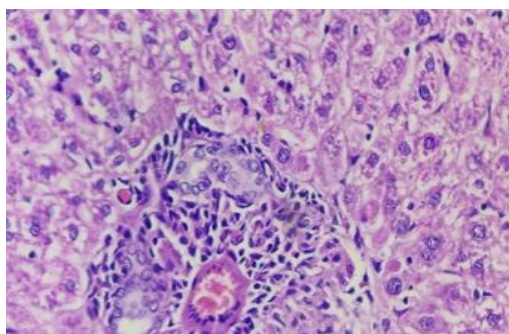


Figure 14: Group 5

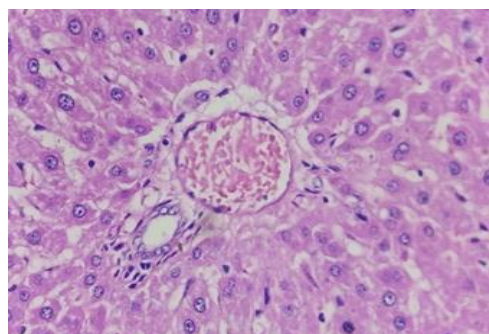


Figure 15: Group 6

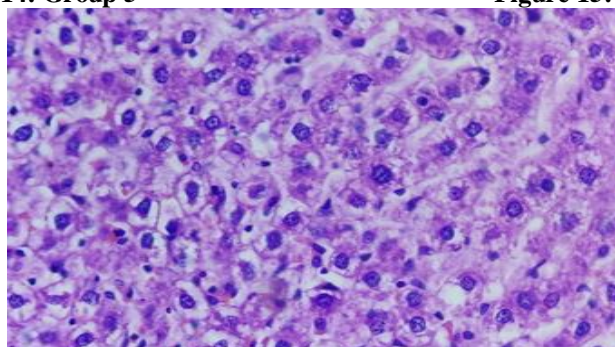


Figure 16: Group 7

### Pancreatic Histology

Pancreatic tissue from normal rats displayed well-defined islets of Langerhans with normal cellular arrangement. Diabetic rats showed severe destruction of islets and reduced  $\beta$ -cell population. Treatment with metformin resulted in partial regeneration of pancreatic islets. Administration of plant extract showed improvement in islet architecture with evidence of regeneration. Notably, silver nanoparticle-treated groups demonstrated greater restoration of pancreatic structure with increased number of regenerating islets, indicating enhanced protective and regenerative effects on pancreatic  $\beta$ -cells.

### DISCUSSIONS:

Diabetes mellitus is a chronic metabolic disorder characterized by persistent hyperglycemia resulting from impaired insulin secretion or reduced insulin action. Prolonged hyperglycemia leads to serious complications including cardiovascular disease, nephropathy, neuropathy, and retinopathy. Streptozotocin-induced diabetes is widely used as an experimental model because it selectively damages pancreatic  $\beta$ -cells through DNA alkylation, resulting in insulin deficiency, hyperglycemia, weight loss, and dyslipidemia. These metabolic disturbances closely resemble human diabetes.

The increasing global prevalence of diabetes and the limitations associated with conventional antidiabetic drugs have stimulated interest in plant-based therapies. Medicinal plants and their

bioactive constituents are increasingly explored due to their safety, affordability, and therapeutic potential. In this context, the present study evaluated the antidiabetic activity of *Psidium guajava* leaf extract and its biosynthesized silver nanoparticles in streptozotocin-induced diabetic rats.

Treatment with *Psidium guajava* extract and silver nanoparticles produced a significant reduction in blood glucose levels compared with diabetic control animals. The effect was dose-dependent and comparable to the standard drug metformin, particularly at higher nanoparticle doses, which nearly restored glucose levels to normal by the end of the treatment period. This antihyperglycemic activity may be attributed to stimulation of pancreatic  $\beta$ -cells, enhanced insulin secretion, or improved insulin sensitivity.

Diabetic animals typically exhibit body weight loss due to impaired glucose utilization and increased protein catabolism. Administration of *Psidium guajava* extract and nanoparticles significantly improved body weight, indicating better metabolic control and utilization of nutrients. Restoration of body weight suggests effective regulation of hyperglycemia and reduced tissue breakdown.

Diabetes is also associated with abnormal lipid metabolism, characterized by elevated triglycerides, total cholesterol, LDL, and VLDL, along with decreased HDL levels. These alterations increase the risk of cardiovascular complications.

In the present study, treatment with *Psidium guajava* extract and nanoparticles significantly improved the lipid profile by reducing serum lipids and increasing HDL levels. The hypolipidemic effect may result from improved insulin action and reduced mobilization of fatty acids from adipose tissue.

Histopathological observations further supported the biochemical findings. Streptozotocin caused structural damage to liver and pancreatic tissues, whereas treatment with *Psidium guajava*, particularly in nanoparticle form, showed marked restoration of tissue architecture and regeneration of pancreatic islets.

Overall, the findings demonstrate that *Psidium guajava* leaf extract and its biosynthesized silver nanoparticles possess significant antihyperglycemic and hypolipidemic activity. The nanoparticle formulation exhibited enhanced therapeutic efficacy compared with the crude extract, suggesting improved bioavailability and biological activity. These results indicate that *Psidium guajava* may serve as a promising natural therapeutic agent for the management of diabetes and its associated metabolic complications.

#### CONCLUSION:

The present study successfully demonstrated the green synthesis of silver nanoparticles using *Psidium guajava* leaf extract and evaluated their antidiabetic potential in a streptozotocin-induced diabetic rat model. The synthesized nanoparticles were confirmed and characterized using UV-visible spectroscopy, FTIR, zeta potential analysis, and SEM, indicating successful formation of stable nanosized particles.

Both the aqueous leaf extract and biosynthesized silver nanoparticles exhibited significant antihyperglycemic activity, improvement in body weight, and favorable modulation of lipid profile by reducing LDL and VLDL levels while increasing HDL levels. The therapeutic effects were comparable to the standard antidiabetic drug metformin, with the nanoparticle formulation showing enhanced efficacy following repeated administration.

These findings support the traditional use of *Psidium guajava* as an antidiabetic agent and indicate that its plant extract and derived silver nanoparticles possess promising potential in the management of diabetes and associated metabolic disturbances. However, further studies involving isolation of active constituents and detailed mechanistic investigations are necessary to fully elucidate the pathways underlying its antidiabetic action.

#### CONFLICT OF INTERESTS:

The authors declare that there are no conflicts of interest regarding the publication of this research work.

#### REFERENCES:

- Jain N, Bhargava A, Majumdar S, Tarafdar JC, Panwar J. Extracellular biosynthesis and characterization of silver nanoparticles using *Aspergillus flavus* NJP08: a mechanistic perspective. *Nanoscale*. 2011;3(2):635-41.
- Kalaiarasi K, Prasannaraj G, Sahi SV, Venkatachalam P. Phytofabrication of biomolecule-coated metallic silver nanoparticles using leaf extracts of in vitro-raised bamboo species and its anticancer activity against human PC3 cell lines. *Turk J Biol*. 2015;39(2):223-32.
- Shankar SS, Rai A, Ahmad A, Sastry M. Rapid synthesis of Au, Ag, and bimetallic Au core-Ag shell nanoparticles using Neem (*Azadirachta indica*) leaf broth. *J Colloid Interface Sci*. 2004;275(2):496-502.
- Rai M, Yadav A, Gade A. Silver nanoparticles as a new generation of antimicrobials. *Biotechnol Adv*. 2009;27(1):76-83.
- Parashar V, Parashar R, Sharma B, Pandey AC. Parthenium leaf extract mediated synthesis of silver nanoparticles: a novel approach towards weed utilization. *Dig J Nanomater Biostruct*. 2009;4(1):45-50.
- Abbasi E, Milani M, Fekri Aval S, Kouhi M, Akbarzadeh A, Tayefi-Nasrabadi H, et al. Silver nanoparticles: synthesis methods, bio-applications, and properties. *Crit Rev Microbiol*. 2016;42(2):173-80.
- Rasve V, Chakraborty AK, Jain SK, Vengurlekar S. Study of phytochemical profiling and in vitro studies on antioxidant properties of ethanolic extract of *Clematis triloba*. *Eur Chem Bull*. 2022;11(12):2658-2677. doi:10.53555/ecb/2022.11.12.2162022.
- Banerjee P, Satapathy M, Mukhopadhyay A, Das P. Leaf extract mediated green synthesis of silver nanoparticles from widely available Indian plants: synthesis, characterization and antimicrobial property. *Bioresour Bioprocess*. 2014;1:3.
- Santhoshkumar T, Rahuman AA, Rajakumar G, Marimuthu S, Bagavan A, Jayaseelan C, et al. Synthesis of silver nanoparticles using *Nelumbo nucifera* leaf extract and its larvicidal activity. *Parasitol Res*. 2011;108(3):693-702.
- Ahmed S, Saifullah, Ahmad M, Swami BL, Ikram S. Green synthesis of silver nanoparticles using *Azadirachta indica* aqueous leaf extract. *J Radiat Res Appl Sci*. 2016;9(1):1-7.

11. Dhand V, Soumya L, Bharadwaj S, Chakra S, Bhatt D, Sreedhar B. Green synthesis of silver nanoparticles using *Coffea arabica* seed extract and its antibacterial activity. Mater Sci Eng C. 2016;58:36-43.
12. Moodley JS, Krishna SB, Pillay K, Govender P. Green synthesis of silver nanoparticles from *Moringa oleifera* leaf extracts and its antimicrobial potential. Adv Nat Sci Nanotechnol. 2018;9(1):015011.
13. Alsammaraie FK, Wang W, Zhou P, Mustapha A, Lin M. Green synthesis of silver nanoparticles using turmeric extracts and investigation of antibacterial activities. Colloids Surf B Biointerfaces. 2018;171:398-405.
14. Abdel-Aziz MS, Shaheen MS, El-Nekeety AA, Abdel-Wahhab MA. Antioxidant and antibacterial activity of silver nanoparticles biosynthesized using *Chenopodium murale* leaf extract. J Saudi Chem Soc. 2014;18(4):356-63.
15. Khalil MM, Ismail EH, El-Baghdady KZ, Mohamed D. Green synthesis of silver nanoparticles using olive leaf extract and antibacterial activity. Arab J Chem. 2014;7(6):1131-9.
16. Mallikarjuna K, Narasimha G, Dillip GR, Praveen B, Shreedhar B, Lakshmi CS, et al. Green synthesis of silver nanoparticles using *Ocimum* leaf extract and characterization. Dig J Nanomater Biostruct. 2011;6(1):181-6.
17. Awwad AM, Salem NM, Abdeen AO. Green synthesis of silver nanoparticles using carob leaf extract and antibacterial activity. Int J Ind Chem. 2013;4(1):1-6.
18. Veerasamy R, Xin TZ, Gunasagan S, Xiang TF, Yang EF, Jeyakumar N, et al. Biosynthesis of silver nanoparticles using mangosteen leaf extract and antimicrobial activity. J Saudi Chem Soc. 2011;15(2):113-20.
19. Bindhu MR, Umadevi M. Synthesis of monodispersed silver nanoparticles using *Hibiscus cannabinus* leaf extract. Spectrochim Acta A Mol Biomol Spectrosc. 2013;101:184-90.
20. Prakash P, Gnanaprakasam P, Emmanuel R, Arokiyaraj S, Saravanan M. Green synthesis of silver nanoparticles from *Mimusops elengi* leaf extract. Colloids Surf B Biointerfaces. 2013;108:255-9.
21. Devaraj P, Kumari P, Aarti C, Renganathan A. Synthesis and characterization of silver nanoparticles using cannonball leaves and cytotoxic activity. J Nanotechnol. 2013;2013:1-6.
22. Fowler MJ. Microvascular and macrovascular complications of diabetes. Clin Diabetes. 2008;26(2):77-82.
23. Rasve V, Chakraborty AK, Jain SK, Vengurlekar S. Comparative evaluation of antidiabetic activity of ethanolic leaves extract of *Clematis triloba* and their SMEDDS formulation in streptozotocin induced diabetic rats. J Popul Ther Clin Pharmacol. 2022;29(4):959-971. doi:10.53555/jptcp.v29i04.2360.
24. Cho N, Shaw JE, Karuranga S, Huang Y, Fernandes JD, Ohlrogge AW, et al. IDF Diabetes Atlas global estimates of diabetes prevalence. Diabetes Res Clin Pract. 2018;138:271-81.
25. Saeedi P, Petersohn I, Salpea P, Malanda B, Karuranga S, Unwin N, et al. Global and regional diabetes prevalence estimates for 2019 and projections. Diabetes Res Clin Pract. 2019;157:107843.
26. Thomas CC, Philipson LH. Update on diabetes classification. Med Clin North Am. 2015;99(1):1-16.
27. Baynes HW. Classification, pathophysiology, diagnosis and management of diabetes mellitus. J Diabetes Metab. 2015;6(5):1-9.
28. Petersmann A, Nauck M, Müller-Wieland D, Kerner W, Müller UA, Landgraf R, et al. Definition, classification and diagnosis of diabetes mellitus. Exp Clin Endocrinol Diabetes. 2018;126(7):406-10.
29. Harding JL, Pavkov ME, Magliano DJ, Shaw JE, Gregg EW. Global trends in diabetes complications. Diabetologia. 2019;62(1):3-16.
30. Gregg EW, Sattar N, Ali MK. The changing face of diabetes complications. Lancet Diabetes Endocrinol. 2016;4(6):537-47.
31. Tao Z, Shi A, Zhao J. Epidemiological perspectives of diabetes. Cell Biochem Biophys. 2015;73(1):181-5.
32. Ogurtsova K, Guariguata L, Cho NH, et al. IDF Diabetes Atlas global estimates for 2015 and 2040. Diabetes Res Clin Pract. 2017;128:40-50.
33. Szkudelski T. The mechanism of alloxan and streptozotocin action in  $\beta$ -cells. Physiol Res. 2001;50(6):537-46.
34. Lenzen S. Mechanisms of alloxan- and streptozotocin-induced diabetes. Diabetologia. 2008;51(2):216-26.
35. Rasve VR, Paithankar VV, Shirsat MK, Dhobale AV. Evaluation of antiulcer activity of *Aconitum heterophyllum* on experimental animals. World J Pharm Pharm Sci. 2018;7(2):819-839.
36. Pandit R, Phadke A, Jagtap A. Antidiabetic effect of *Ficus religiosa* extract in streptozotocin-induced diabetic rats. J Ethnopharmacol. 2010;128(2):462-6.
37. Girija K, Lakshman K, Udaya C, Sachi GS, Divya T. Antidiabetic and anti-cholesterolemic

- activity of *Amaranthus* species. Asian Pac J Trop Biomed. 2011;1(2):133-8.
38. Shanker K, Mohan GK, Mayasa V, Pravallika L. Antihyperglycemic effect of biosynthesized silver nanoparticles in diabetic rats. Mater Lett. 2017;195:240-4.
39. Joseph B, Priya M. Review on nutritional and pharmacological properties of guava (*Psidium guajava* Linn.). Int J Pharma Bio Sci. 2011;2(1):53-69.
40. Kafle A, Mohapatra SS, Reddy I, Chapagain M. Review on medicinal properties of *Psidium guajava*. J Med Plants. 2018;6(4):44-7.
41. Gupta GK, Chahal J, Arora D. *Psidium guajava* Linn.: current research and future prospects. J Pharm Res. 2011;4(1):42-6.
42. Jang M, Jeong SW, Cho SK, Ahn KS, Lee JH, Yang DC, et al. Anti-inflammatory effects of *Psidium guajava* leaves. J Med Food. 2014;17(6):678-85.
43. Dakappa SS, Adhikari R, Timilsina SS, Sajjekhan S. Review on medicinal plant *Psidium guajava* Linn. J Drug Deliv Ther. 2013;3(2):162-8.
44. Metwally AM, Omar AA, Ghazy NM, Harraz FM, El Sohafy SM. Monograph of *Psidium guajava* leaves. Pharmacogn J. 2011;3(21):89-104.
45. Rishika D, Sharma R. Pharmacological activity of *Psidium guajava* in management of disorders. Int J Pharm Sci Res. 2012;3(10):3577-84.
46. Mittal P, Gupta V, Kaur G, Garg AK, Singh A. Phytochemistry and pharmacological activities of *Psidium guajava*. Int J Pharm Sci Res. 2010;1(9):9-19.
47. Beidokhti MN, Eid HM, Villavicencio ML, Jäger AK, Lobbens ES, Rasoanaivo PR, et al. Antidiabetic potential of *Psidium guajava* using multiple assays. J Ethnopharmacol. 2020;112877.
48. Zahin M, Ahmad I, Aqil F. Antioxidant and antimutagenic potential of *Psidium guajava* leaf extracts. Drug Chem Toxicol. 2017;40(2):146-53.