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Evaluation of Therapeutic Potential of Medicinal Plant in the Management of Diabetes

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ABSTRACT

Diabetes mellitus is a chronic metabolic disorder that has become a major global health burden due to its progressive complications and rising prevalence. It is associated with long-term damage to vital organs, including the heart, kidneys, eyes, and nerves, thereby contributing significantly to morbidity and mortality worldwide. Although several synthetic anti-diabetic are currently available, their long-term use is often accompanied by adverse effects such as hypoglycemia, gastrointestinal disturbances, and reduced therapeutic efficacy. These limitations highlight the urgent need for safer, more effective alternatives to improve diabetes management. In this context, medicinal plants have emerged as promising candidates, as they not only help regulate blood glucose but also offer additional health benefits with fewer side effects compared to conventional drugs. Among the medicinal plants investigated for antidiabetic potential, *Cinnamomum cassia* and *Terminalia catappa* have attracted considerable attention. These plants are rich in bioactive phytochemicals such as cinnamaldehyde, flavonoids, tannins, and terpenoids, which demonstrate hypoglycemic, antioxidant, and β -cell rejuvenate properties. Animal model studies have shown that these plants can effectively lower blood glucose and enhance insulin sensitivity, thereby protecting against diabetes-induced complications. The growing interest in medicinal plants reflects their potential as safer and multifunctional therapeutic options. By integrating these natural agents into diabetes management strategies, it may be possible to achieve better glycemic control while minimizing adverse effects. These results strongly indicate the potential of medicinal plant as complementary therapeutic agents, supporting progressive efforts to combine medicinal plants into diabetes management strategies.

Keywords: Diabetes mellitus, *Cinnamomum cassia*, *Terminalia catappa*, Alloxon, Wistar Rats.

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INTRODUCTION

Diabetes mellitus is an extensive group of metabolic disorders marked by continually elevated blood sugar levels. This condition can arise from either insufficient insulin production, or compromised body's reaction to insulin, or both at the same time. Additionally the disease are abnormalities in protein and lipid metabolism, which are directly related to insulin failure, and imbalances in electrolyte and mineral homeostasis. (1) Fatigue, polyuria, polydipsia, polyphagia, weight loss, and blurred eyesight are typical signs of diabetes. Chronic hyperglycemia may also be associated with decreased growth and more susceptibility to specific illness. The non-ketotic hyperosmolar syndrome or hyperglycemia with ketoacidosis are acute, possibly lethal outcomes of untreated diabetes.(2) Diabetes mellitus might not seem to be an immediate threat to life, but if it is untreated, it can cause long-term damage to cells and tissues, which can eventually affect how well important organs work. The vascular system, retina, heart, kidneys, and peripheral nerves are frequently affected by long-term issues.(3)

Diabetes is common and continues to rise in common. Approximately 463 million individuals aged 20-79 worldwide have diabetes in 2019, and that number is expected to increase to 700 million by 2045. It is concerning to consider that the number of people with undiagnosed diabetes is nearly equal. It is estimated that the age-adjusted prevalence will increase from 9.3 to 10.9% globally by 2045. Even more shocking are the numbers of people who have impaired glucose tolerance, which were 7.5% in 2019 and are expected to increase to 8.6% in 2045. In undeveloped nations, the proportion of type 1 to type 2 varies from 5: 95% to 15% in Western people.(4)

The pancreas uses specialized endocrine cells found in the islets of Langerhans to create the two important hormones, glucagon and insulin. In order to reduce plasma glucose by promoting the production of glycogen, beta (β) cells produce and secrete insulin, which facilitates the uptake of glucose into skeletal muscle, adipose tissue, and hepatic cells.(5) In contrast, alpha (α) cells increase blood glucose levels by triggering glycogenolysis, which results in the production of glucagon, a hormone necessary for glycemic control. Interestingly, erythrocytes and brain tissues use glucose without the supervision of insulin.(6)

People with diabetes mellitus usually around twice as much on medical care. Diabetes mellitus Increase the chance of dying early up to double. Trends indicate that rates will rise frequently or continuously. Pancreatic cells cannot create enough insulin when a person has type 1 diabetes. Insulin resistance, a disorder in which cells cannot respond efficiently to insulin, is the first sign of type 2 diabetes.(7) Insulin injections can help manage type 1 diabetes. Maintaining a nutritious diet, controlling weight, and engaging in physical activity are all part of treating type 2 diabetes.(8)

Type 2 diabetes affects 90% of patients with diabetes mellitus. People with type 2 diabetes frequently suffer from high blood pressure, which significantly raises their risk of cardiovascular disease when they have diabetes. (9) People with the condition should take good care of their feet and eyes and control their blood pressure. For obese or fatty people, weight loss or less surgery is a successful approach.(10)

The aim of this study, While individual antidiabetic effects of these plants have been studied, the combined effect in an alloxan-induced model. This study will scientifically validate their use as a safe and effective treatment option for type 2 diabetes

MATERIALS AND METHOD

Collection of materials

Cinnamomun cassia bark and *Termenalia catappa linn.* leave extract was purchased as a gift sample from Amsar PVT LTD in Indore. I bought a glibenclamide tablet from Imperial Pharma, Shop No.125, L.G Godhra Highway, Madhumilan Square, Dawa Bazar, M.Y., Murai Mohalla, Indore, Madhya Pradesh 452001. Alloxon Monohydrate was provide by Institute and purchased from Sisco Research Laboratories Pvt. Ltd. Plant Site 2: H-4, MIDC, Taloja – 410208, Maharashtra. India.

Group of Animals

Thrity six Wistar rats weighing about 150-200 g. The animals were housed in cages with filter tops under controlled conditions of 12 h light/dark cycle, 50% humidity and 28°C. They were maintained on a standard pellet at diet and water ad libitum. All experimental procedures were conducted following approval from the Institutional Animal Ethics Committee (IAEC) and adhered to the guidelines for the care and use of laboratory animals as stipulated by the Committee for the Purpose of Control and Supervision of Experiments on Animals (CPCSEA).

Experimental Design

To evaluate the antidiabetic activity of *Cinnamomum cassia* bark and *Terminalia catappa linn.* leave extracts in alloxan-induced animal model. The experimental study was conducted using Wistar rats, which were randomly divided into six groups, each consisting of six animals. Each group received its respective treatment once daily for a duration of 21 days. The composition of the experimental groups (n = 6 rats per group) are as follows:

Group 1 - Normal Control

Group 2 - Negative Control

Group 3 - Alloxon diabetic rats treated with Standard drug (3mg/kg glibenclamide)

Group 4 - Alloxon diabetic rats treated with *Cinnamomum cassia* bark extract (300mg/kg)

Group 5 - Alloxan diabetic rats treated with *Terminalia catappa linn.* leave extract (300mg/kg)

Group 6 - Alloxan diabetic rats treated with Polyherbal extract (*Cinnamomum cassia* bark extract 150mg/kg + *Terminalia catappa linn.* leave extract 150mg/kg).(11)

Induction of Diabetes in Animal

Alloxan monohydrate was used to design experimental diabetes in Wistar rats to test the effects of ethanolic plant extracts. A dose of 120 mg/kg of alloxan, dissolved in 0.9% cold normal saline, was injected into rats that had been fasted for 12 hours. To prevent a sudden drop in blood sugar (hypoglycemia), the rats were given 10% glucose solution to drink for the next 24 hours. After 72 hours of alloxan injection, their fasting blood glucose levels were measured. Only rats with blood glucose levels above 200 mg/dL were included in the study.

Collection of Blood Sample

Blood sampling was carried out through the tail vein in all experimental ratson day 0 (the day treatment began), as well as on the 7th, 14th, and 21st days and blood glucose levels were estimated using an electronic glucometer. Body weights were recorded individually on day 0 to 21.(12)

Following the end of the study protocol, the rats were fasted overnight prior to sample collection. The animals were sacrificed using diethyl ether anesthesia, 24 hours following the last dose administration. Blood samples were collected from the animals via cardiac puncture into blood collection tubes. Serum was obtained from the collected blood samples and used to analyses liver (ALT) and kidney (creatinine) function markers.(13)

The liver and pancreas tissues from each rat were excised and immediately fixed in 10% formalin for histopathological examination.(14)

Statistical Analysis: All experimental results, including body weight, fasting glucose levels, and biochemical indices, were reported as mean values with their respective standard deviations. Statistical significance was evaluated by one-way ANOVA, with Dunnett's test applied for multiple comparisons. Differences between groups were considered statistically significant at **P < 0.05** and **P < 0.001** levels.

1. Result and Discussion

Result

Fasting Blood Glucose(mg/dL)

Table 1: Fasting Blood Glucose

S. No.	Group	Day 0	Day 7	Day 14	Day 21
1.	Normal Control	88 ± 3	90 ± 4	89 ± 3	87 ± 2
2.	Negative Control	274 ± 8	288 ± 10	300 ± 12	312 ± 14

3.	Alloxon + Std. drug	276 ± 7	198 ± 9*	138 ± 7**	105 ± 6***
4.	Alloxon + CCB	273 ± 9	210 ± 10*	158 ± 8**	122 ± 6***
5.	Alloxon + TCL	275 ± 10	216 ± 9*	163 ± 8**	128 ± 7***
6.	Alloxon + (CCB + TCL)	272 ± 9	192 ± 8*	135 ± 7**	98 ± 5***

Key: FBG=Fasting blood glucose

All values are expressed as **Mean ± SEM (Standard Error of Mean)**, $n = 6$ rats per group.

Statistical comparison was made **against Negative Control group** (Alloxan-induced, untreated).

(*) $p < 0.05$ → Significant difference vs Negative Control

(**) $p < 0.01$ → Highly significant difference vs Negative Control

(***) $p < 0.001$ → Very highly significant difference vs Negative Control

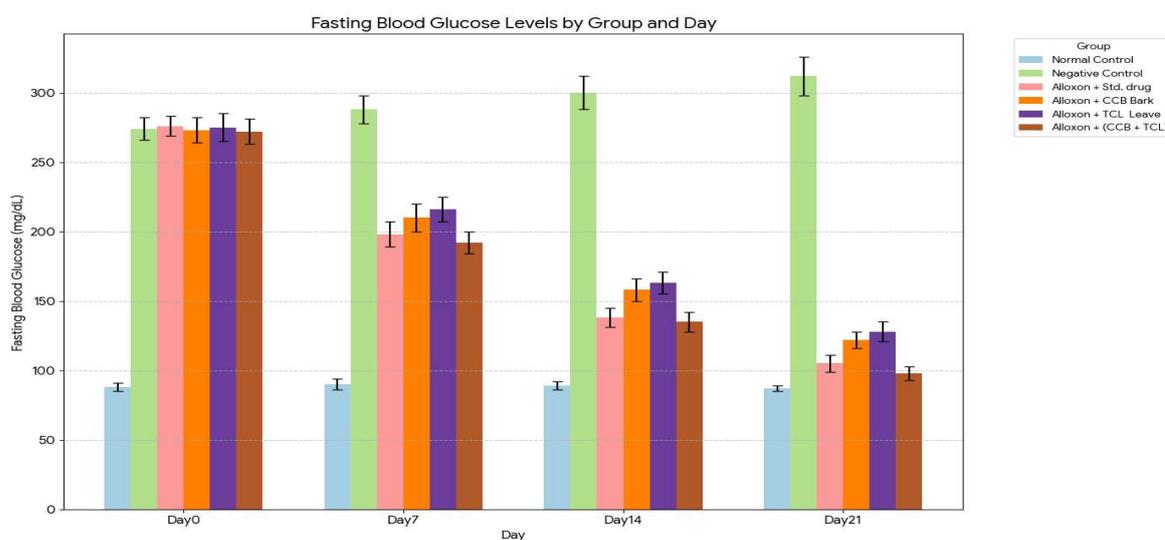


Figure 1: Fasting Blood Glucose(mg/dL)

Body Weight(g)

Table 2: Body Weight(g)

S. No.	Group	Day0	Day 21
1.	Normal Control	178 ± 4	192 ± 5
2.	Negative Control	182 ± 5	160 ± 6
3.	Alloxon + Std. drug	180 ± 4	188 ± 5**
4.	Alloxon + CCB	179 ± 5	183 ± 6*
5.	Alloxon + TCL	181 ± 4	185 ± 5*
6.	Alloxon + (CCB + TCL)	180 ± 5	190 ± 4***

All values are expressed as Mean ± SEM (Standard Error of the Mean), $n = 6$ rats per group.

Statistical comparisons are made against the Negative Control group (alloxan-induced diabetic, untreated).

(*) $p < 0.05$ → Significant improvement vs Negative Control

(**) $p < 0.01$ → Highly significant improvement vs Negative Control

(***) $p < 0.001$ → Very highly significant improvement vs Negative Control

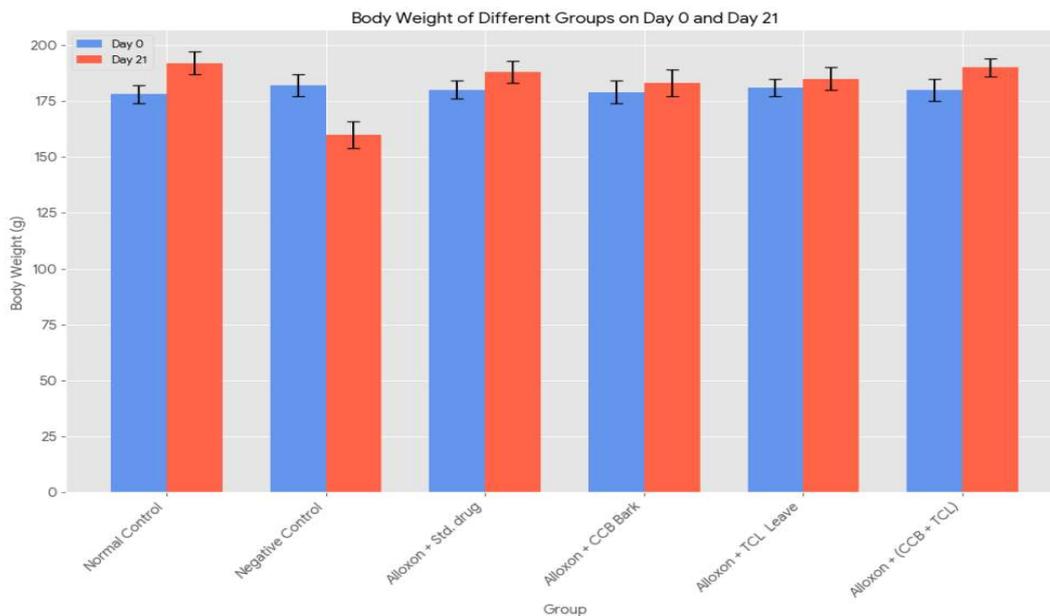


Figure 2: Body Weight(g)

Table 3: Biochemical Evaluation of Serum ALT and Serum creatinine

Biochemical Evaluation of Serum ALT and Serum creatinine

S. No.	Group	ALT (U/L)	Serum creatinine (mg/dl)
1.	Normal Control	42.3 ± 2.1	0.65 ± 0.05
2.	Negative Control	89.7 ± 3.4	1.43 ± 0.08
3.	Alloxon + Std. drug	51.5 ± 2.7**	0.82 ± 0.06**
4.	Alloxon + CCB	55.6 ± 2.9*	0.87 ± 0.07*
5.	Alloxon + TCL	58.1 ± 3.1*	0.90 ± 0.06*
6.	Alloxon + (CCB + TCL)	47.2 ± 2.3***	0.70 ± 0.05***

Key: ALT= Alanine amino transferase and Serum creatinine

All values are expressed as Mean ± SEM (n = 6 rats per group)

Statistical comparison was made against the Negative Control group (alloxan-induced, untreated).

(*) p < 0.05 → Significant improvement vs Negative Control

(**) p < 0.01 → Highly significant improvement vs Negative Control

(***) p < 0.001 → Very highly significant improvement vs Negative Control

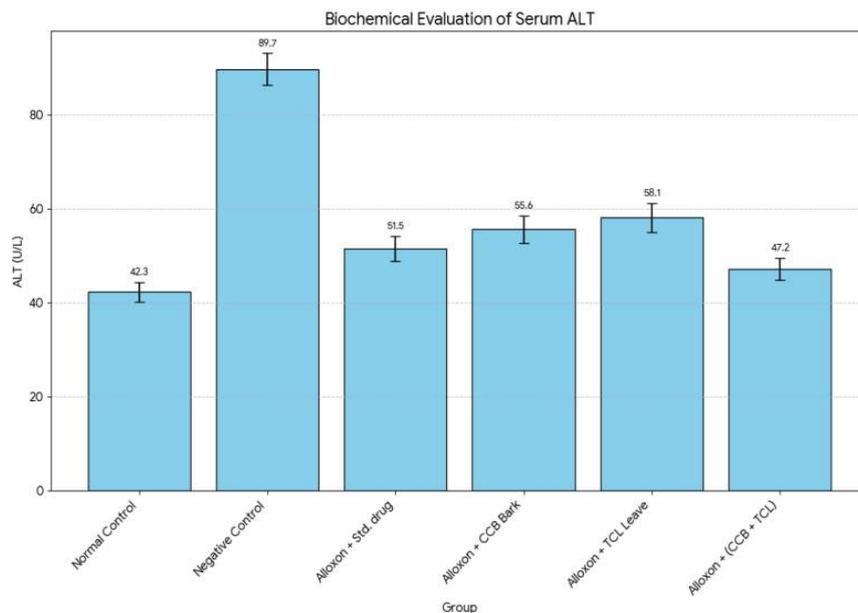


Figure 3: Serum ALT (U/L)

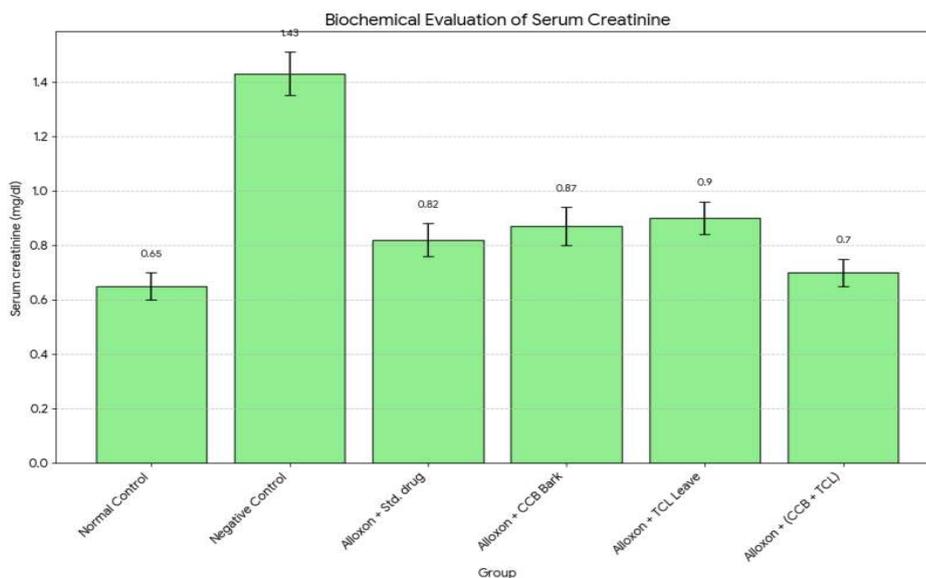


Figure 4: Serum Creatinine(mg/dl)

Histopathological Evaluation of Liver and Pancreas Tissue

Table 4: Histopathological Evaluation of Liver and Pancreas Tissue

S. No.	Group	Liver Histopathology	Pancreas Histopathology
1.	Normal Control	The liver tissue showed no cellular abnormalities, well-defined central veins, and intact hepatic cords. There were no indications of inflammation, steatosis, or necrosis.	Pancreatic tissue displayed normal cavity and well-preserved islets of Langerhans with abundant and intact beta-cells, indicating healthy endocrine and exocrine function.
2.	Negative Control	Hepatocellular necrosis, lipid	Pancreatic tissue showed severe

		alterations, and inflammation were among the notable signs of liver tissue harm. Hepatic structure was significantly damaged.	destruction of beta-cells with reduced or distorted islets of Langerhans. Marked necrosis, shrinkage, and degranulation were observed, confirming diabetic damage.
3.	Alloxon + Std. drug	Hepatocyte structure was better preserved and there was less fatty infiltration in liver sections, which indicated a slight improvement. There was little inflammation.	Pancreas showed rejuvenate of beta-cells with partially restored islets of Langerhans. Cellular integrity was improved, though not fully comparable to the normal control.
4.	Alloxon + CCB	The structure of the liver was repaired to a moderate degree. Hepatocytes displayed better cellular organization and less vacuolation. The sinusoids and central vein looked relatively normal.	Pancreatic sections indicated moderate rejuvenate of beta-cells and partial reorganization of islets. Cellular vacuolation was reduced, suggesting protective effects of the extract.
5.	Alloxon + TCL	The liver displayed low fatty alterations, decreased necrosis, and enhanced hepatocyte integrity as indicators of tissue repair. The hepatic cords had greater strength.	Pancreatic sections showed improved islet morphology with partial rejuvenate of beta-cells. Compared to the standard group, restoration was noticeable but not as strong.
6.	Alloxon + (CCB + TCL)	The liver's histology showed synergistic hepatoprotection, with well-organized hepatic cells, little damage, and no noticeable inflammatory alterations.	Pancreatic sections displayed significant β -cell rejuvenate and restoration of islet architecture, suggesting a synergistic effect of the polyherbal extract.

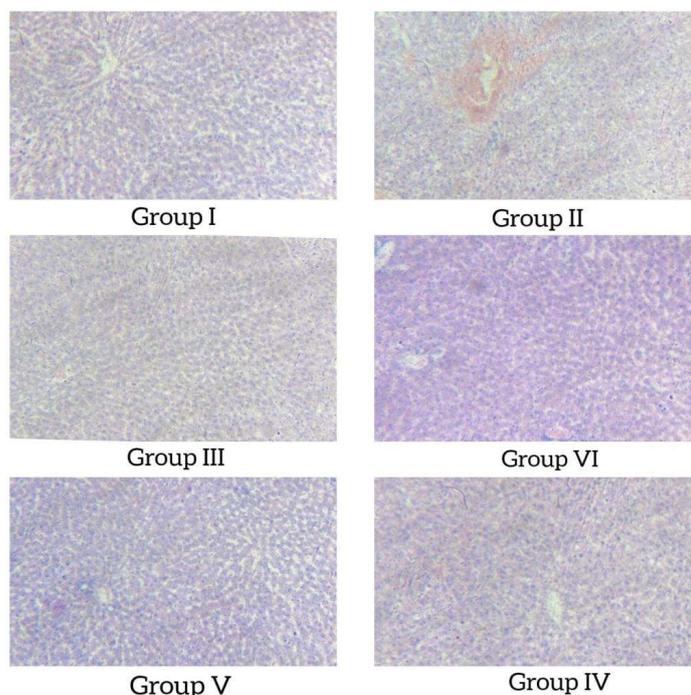


Figure 5: Histopathology of Liver Tissue

Group I = Normal Control, Group II = Negative Control, Group III = Alloxon + Std. Drug, Group IV = Alloxon + CCB Bark, Group V = Alloxon + TCL Leave, Group VI = Alloxon + (CCB + TCL)

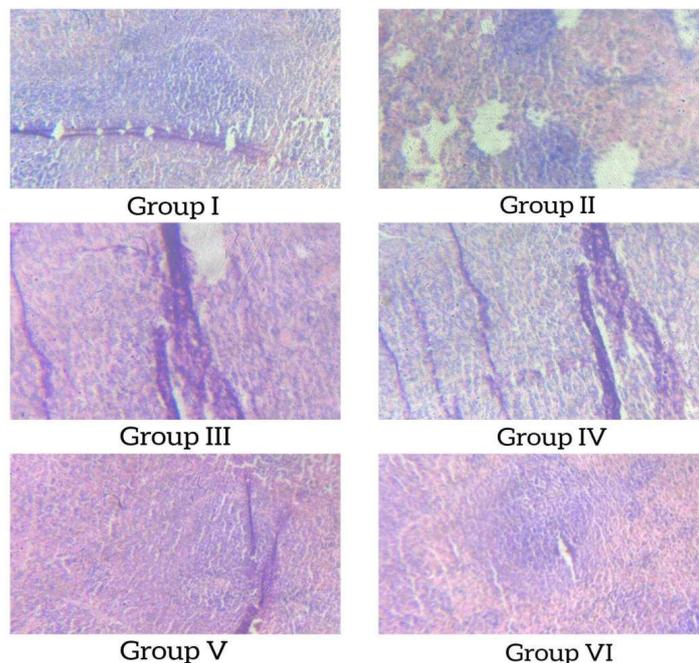


Figure 6: Histopathology of Pancreas Tissue

Group I = Normal Control, Group II = Negative Control, Group III = Alloxon + Std. Drug, Group IV = Alloxon + CCB Bark, Group V = Alloxon + TCL Leave, Group VI = Alloxon + (CCB + TCL)

DISCUSSION

A study on Wistar rats with alloxan-induced diabetes investigated the therapeutic effects of *Cinnamomum cassia* bark (CCB) and *Terminalia catappa* leaves (TCL). The research found that both extracts, rich in bioactive compounds like Cinnamaldehyde, flavonoids and tannins, significantly reduced blood glucose levels by improving insulin sensitivity and glucose uptake. A combination of CCB and TCL exhibited a synergistic effect, proving to be more effective than the individual extracts in controlling blood sugar and restoring body weight. The combined therapy also showed superior protective effects on the liver and kidneys, as indicated by normalized biochemical parameters and histopathological findings, including the rejuvenation of pancreatic β -cells. The study concluded that this polyherbal combination is a safe and promising intervention for managing diabetes due to its potent antidiabetic, hepatoprotective, and nephroprotective properties.

CONCLUSION

The ethanolic extracts of *Cinnamomum cassia* bark and *Terminalia catappa* leaves were found to be safe at doses up to 5000 mg/kg, with no observable acute toxicity. Phytochemical analysis confirmed the presence of multiple bioactive compounds with established antidiabetic potential. Both extracts significantly reduced fasting blood glucose, prevented weight loss, improved liver and kidney function markers, and partially restored hepatic and pancreatic histology in alloxan-induced diabetic rats. Notably, the combination of both extracts exhibited a synergistic effect, producing near-normal glucose levels, marked organ protection, and β -cell rejuvenate. These findings suggest that polyherbal formulations of CCB and TCL could serve as promising, safe, and effective alternatives or adjuncts to conventional antidiabetic therapies. The results highlight that Ayurvedic approaches using herbal formulations may provide better, safer, and more holistic management of diabetes compared to allopathic interventions, owing to their multi-targeted mechanisms and minimal side effects.

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