American Journal of Biology and Natural Sciences
https://biojournals.us/index.php/AJBNS
ISSN: 2997-7185

The Effect of White Mulberry (Morus alba) Leaf Extract on Blood Glucose Reduction: An Experimental Study on Animal Models with a Focus on Mechanistic Insights

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Received: 2024, 15, Dec
Accepted: 2025, 21, Jan
Published: 2025, 10, Feb

Annotation: This study explores the antidiabetic effects of Morus alba leaf extract in animal models of Type 2 diabetes. The research focuses on blood glucose regulation, insulin sensitivity, lipid profile improvement, and oxidative stress reduction. Diabetes was induced in rats via a high-fat diet and streptozotocin injection. The animals were divided into groups receiving either distilled water, metformin, or Morus alba extract (100 mg/kg or 200 mg/kg). The study revealed dose-dependent hypoglycemic effects of the extract, with significant reductions in fasting blood glucose and improvements in serum insulin levels and lipid profiles. Moreover, Morus alba demonstrated antioxidative properties by reducing malondialdehyde (MDA) levels and enhancing superoxide dismutase (SOD) and catalase activities. These findings highlight Morus alba's potential as a complementary or alternative therapy for managing diabetes and associated complications.

Keywords: Morus alba, Diabetes mellitus, Antioxidants, Blood glucose regulation, Oxidative stress.

Introduction

Diabetes mellitus, especially type 2 diabetes, is a chronic metabolic disorder characterized by elevated glucose levels caused by insulin deficiency, either alone or in conjunction with insulin action. This condition has emerged as one of the most significant global health challenges, with rising prevalence rates and substantial socioeconomic burdens [1]. Effective management of blood glucose levels is critical to preventing the complications associated with diabetes, such as cardiovascular disease, neuropathy, nephropathy, and retinopathy. While pharmaceutical interventions remain the cornerstone of diabetes management, there is a growing interest in natural alternatives, particularly medicinal plants, for their potential antidiabetic effects and fewer side effects [2]. Among the numerous medicinal plants studied for their hypoglycemic properties, white mulberry (Morus alba) has drawn significant attention. Traditionally, the leaves of Morus alba have been used in various cultural practices as a natural remedy for diabetes. These leaves are rich in bioactive compounds, including flavonoids, alkaloids, polyphenols, and polysaccharides, which are believed to contribute to their antidiabetic effects [3]. The pharmacological actions of Morus alba leaf extract are multifaceted, involving mechanisms such as the inhibition of carbohydrate-digesting enzymes like α-glucosidase and α-amylase, modulation of insulin signaling pathways, reduction of oxidative stress, and enhancement of pancreatic β-cell function. Despite this promising potential, the precise mechanisms underlying these effects remain only partially understood [4].

Animal models have been widely utilized in preclinical research to investigate the efficacy and safety of antidiabetic agents. These models provide valuable insights into the physiological, biochemical, and molecular changes associated with diabetes and the therapeutic interventions being studied. The use of Morus alba leaf extract in such models has shown encouraging results, with significant decreases in levels of blood glucose and enhancements in insulin sensitiveness. However, a comprehensive exploration of its mechanistic pathways and long-term effects is necessary to validate its therapeutic potential [5]. This study aims to investigate the effect of Morus alba leaf extract on blood glucose regulation in animal models, focusing on elucidating the underlying mechanisms of action. By analyzing key metabolic, enzymatic, and oxidative stress parameters, this research seeks to provide a deeper understanding of how Morus alba contributes to glycemic control. The findings of this study are expected to not only enhance the current knowledge of Morus alba's antidiabetic properties but also pave the way for its potential development as a complementary or alternative therapy for diabetes management. This research also contributes to the broader field of phytomedicine by reinforcing the role of medicinal plants in addressing global health challenges.

Materials and Methods

1. Study Design

This experimental study was conducted to evaluate the effects of *Morus alba* (white mulberry) leaf extract on blood glucose regulation in animal models. The study employed a controlled laboratory design, focusing on both physiological and biochemical parameters to investigate the hypoglycemic mechanisms of the extract.

2. Plant Material and Extract Preparation

- **Collection of Plant Material**: Fresh *Morus alba* leaves were collected from a certified botanical garden to ensure species authenticity.
- **Identification**: The plant was authenticated by a taxonomist, and a voucher specimen was deposited in the herbarium for reference.
- **Drying and Grinding**: The leaves were washed, shade-dried at room temperature, and ground into a powdered substance using a mechanical grinder.

- **Extraction**: The powdered leaves (100 g) were soaked in 70% ethanol (1:5 w/v) for 72 hrs with frequent shaking. [6]
- The mixture was passed through Whatman No. 1 filter paper, and the leaked was collected and concentrated under lower pressure using a rotary evaporator at 40°C.
- The extract was dried then stored at −20°C until use.[7].
- **Yield Determination**: The percentage yield of the extract was calculated to ensure consistency across batches.

3. Phytochemical Screening

Qualitative phytochemical analysis was performed to identify the presence of bioactive compounds such as flavonoids, alkaloids, polyphenols, and tannins. Standard chemical tests were employed for each compound category [8].

4. Animal Models

- **Selection of Animals**: Adult male Wistar rats (8–10 weeks old, weighing 180–200 g) were chosen for the study due to their established use in diabetes research [9].
- **Animal Housing**: The animals were housed in a controlled environment (temperature 22 ± 2°C, humidity 55 ± 10%, 12-hour light/dark cycle) with free access to standard laboratory chow and water.
- **Ethical Approval**: All procedures were approved by the Institutional Animal Ethics Committee (IAEC) following guidelines from the National Institutes of Health (NIH).

5. Diabetes Induction

- **Model of Diabetes**: Type 2 diabetes was induced in rats using a combination of a high-fat diet (for 4 weeks) and a single intraperitoneal injection of streptozotocin (STZ, 35 mg/kg body weight) dissolved in citrate buffer (pH 4.5).
- **Confirmation of Diabetes**: After 72 hrs, the fasting glucose levels of the blood were measured with a glucometer. Rats with fasting glucose levels ≥250 mg/dl were considered to have diabetes, and they were included in the study.

6. Experimental Groups

The animals were randomly divided into the following groups (n = 6 per group):

1. **Normal Control Group**: Non-diabetic rats receiving distilled water.
2. **Diabetic Control Group**: Diabetic rats receiving distilled water.
3. **Positive Control Group**: Diabetic rats receiving metformin (100 mg/kg body weight) orally.
4. **Low-Dose** *Morus alba* **Group**: Diabetic rats receiving *Morus alba* extract (100 mg/kg body weight) orally.
5. **High-Dose** *Morus alba* **Group**: Diabetic rats receiving *Morus alba* extract (200 mg/kg body weight) orally.

7. Treatment Protocol

The treatments were administered orally via gavage once daily for 28 days. The levels of Blood glucose were measured weekly to monitor the effect of treatments.

8. Analysis of Biochemical

At the end of the experience, the rats were fasted overnight, then anesthetic, and the blood samples were taken directly by the cardiac puncture. The following parameters were analyzed:

- **Fasting Blood Glucose (FBG)**: Measured using a glucometer.

- **Serum Insulin**: Quantified using an enzyme-linked immunosorbent assay (ELISA) kit.
- **Lipid Profile**: Total cholesterol, triglycerides, HDL, and LDL levels were determined using commercial kits.
- **Oxidative Stress Markers**: Levels of malondialdehyde (MDA) and activities of antioxidant enzymes (superoxide dismutase [SOD] and catalase) were assessed.

9. Histopathological Analysis

Pancreatic tissues were excised, fixed with formalin (10% neutral-buffered), then embedded in paraffin, and cut for histopathological examination. Eosin and hematoxylin (E&H) staining was performed to assess β-cell morphology and tissue integrity [10,11].

10. Analysis of Statistical

All data were across as mean ± standard deviation (SD). Statistical significance was determined using one-way analysis of variance (ANOVA) followed by Tukey's post hoc test. A P-value <0.05 was considered statistically significant [12,13].

Results and Discussion

1. Yield of Morus alba **Extract**

- **Observation**: The yield of the crude ethanolic extract of *Morus alba* leaves was calculated to be approximately **18% w/w** of the dried leaf powder. This yield is consistent with previously reported studies on ethanolic extractions.

2. Phytochemical Screening

Table (1) the phytochemical analysis revealed the presence of several bioactive compounds.

Compound Category	Test Performed	Result
Flavonoids	Alkaline reagent test	Positive
Alkaloids	Dragendorff's test	Positive
Phenols	Ferric chloride test	Positive
Saponins	Foam test	Positive
Tannins	Gelatin test	Positive

The analysis of phytochemical leaf extract of Morus alba confirmed the presence of bioactive compounds including flavonoids, alkaloids, phenols, saponins, and tannins, each contributing uniquely to its therapeutic potential in managing diabetes. Flavonoids, identified through the alkaline reagent test, are polyphenolic compounds with robust antioxidant, anti-inflammatory, and antidiabetic properties. They neutralize reactive oxygen species (ROS), thereby reducing oxidative stress, a key contributor to diabetes-related complications, and inhibit carbohydrate-hydrolyzing enzymes such as α-amylase and α-glucosidase, leading to improved postprandial glucose control. Supporting this, research by Harvard Medical School emphasizes the critical role of natural antioxidants in reducing oxidative stress, while [14] demonstrated the effectiveness of flavonoids in chronic disease prevention. Alkaloids, detected using Dragendorff's test, are nitrogen-containing compounds known to enhance insulin secretion, improve glucose uptake in peripheral tissues, and protect pancreatic β-cells under oxidative stress, as detailed in research by [15] in Phytomedicine. Phenolic compounds, identified via the ferric chloride test, exhibit potent antioxidant properties, further reducing oxidative damage and protecting cellular components, aligning with findings from the University of Oxford on phenols' role in diabetes management.

Saponins, identified using the foam test, are glycosides with hypoglycemic properties that enhance insulin sensitivity, modulate lipid profiles, and reduce cholesterol levels by inhibiting intestinal glucose absorption, as evidenced by [16] study in Phytomedicine. Tannins, confirmed through the gelatin test, act as enzyme inhibitors, delaying glucose absorption by targeting α-amylase and α-glucosidase, while also exerting anti-inflammatory effects beneficial in managing chronic

inflammation associated with diabetes. Research from the [17] supports these findings, highlighting tannins' role in reducing postprandial glucose spikes. The combined actions of these compounds contribute synergistically to the therapeutic efficacy of Morus alba, targeting key pathological mechanisms in diabetes. The antioxidant effects protect pancreatic β-cells from oxidative stress-induced damage, while enzyme inhibition improves glycemic control and reduces the metabolic burden. Additionally, lipid profile modulation by saponins and tannins lowers atherogenic lipids (LDL and triglycerides) and enhances anti-atherogenic HDL, addressing common dyslipidemia in type 2 diabetes. Collectively, these results align with studies from leading institutions such as Harvard Medical School and Kyoto University, emphasizing Morus alba's potential as a complementary therapy for diabetes. Further clinical research is necessary to validate these preclinical findings and explore its therapeutic application in humans [18].

3. Fasting Blood Glucose (FBG) Levels

The fasting blood glucose levels were monitored weekly. The results are summarized below: The fasting blood glucose (FBG) levels of the study groups demonstrated significant differences across the 28-day experimental period. In the diabetic control group, FBG levels showed a progressive increase from 285 ± 12 mg/dl on Day 0 to 305 ± 14 mg/dl on Day 28, confirming sustained hyperglycemia due to diabetes induction. Conversely, the positive control group treated with metformin exhibited a marked decrease in levels of FBG, reducing from 280 ± 10 mg/dl to 100 ± 5 mg/dl, reflecting its established efficacy in glycemic control ($P < 0.01$ compared to the diabetic control).

Treatment with Morus alba leaf extract also lead to a high dose-dependent reduction in levels of FBG. The low-dose group (100 mg/kg) demonstrated a gradual decline, with FBG levels reaching 140 ± 8 mg/dl by Day 28 ($P < 0.01$), whereas the high dose group (200 mg/kg) achieved a more pronounced reduction, with levels comparable to the positive control group (90 ± 4 mg/dl by Day 28, $P < 0.01$).

These results underline the hypoglycemic potential of Morus alba and its dose-dependent efficacy. The reduction in FBG levels is attributed to the bioactive compounds present in the extract, including flavonoids, alkaloids, phenols, saponins, and tannins. These compounds act through multiple mechanisms, such as inhibiting α-amylase and α-glucosidase enzymes, which delay carbohydrate digestion and glucose absorption. Additionally, Morus alba enhances insulin sensitivity and protects pancreatic β-cells from oxidative stress, leading to improved insulin secretion and glucose homeostasis.

The superior effects observed in the high-dose group suggest that a higher concentration of bioactive compounds yields optimal therapeutic outcomes. The efficacy of Morus alba was comparable to metformin, indicating its potential as an alternative or complementary remedy for diabetes administration. These findings align with previous research, including studies by[19], which reported similar hypoglycemic effects of Morus alba in diabetic models.

In conclusion, Morus alba leaf extract demonstrates a promising role in glycemic control, particularly at higher doses. Its mechanism of action supports the concept of using natural plant-derived compounds to address diabetes-related metabolic dysfunction. Future research should include clinical trials to confirm these findings in humans and assess the long-term safety and efficacy of Morus alba as a therapeutic agent.

Table (2) the effect of leaf extract of Morus alba at low and high-dose over days on (FBG) Levels.

Group	Day 0 (mg/dl)	Day 7 (mg/dl)	Day 14 (mg/dl)	Day 21 (mg/dl)	Day 28 (mg/dl)
Normal Control	90 ± 5	88 ± 4	89 ± 5	87 ± 4	85 ± 3
Diabetic	285 ± 12	290 ± 10	295 ± 15	300 ± 12	305 ± 14

Control					
Positive Control	280 ± 10	180 ± 8*	150 ± 10**	120 ± 7**	100 ± 5**
Low-Dose *Morus alba*	282 ± 11	200 ± 12*	180 ± 10**	160 ± 9**	140 ± 8**
High-Dose *Morus alba*	284 ± 10	190 ± 10*	150 ± 8**	110 ± 7**	90 ± 4**

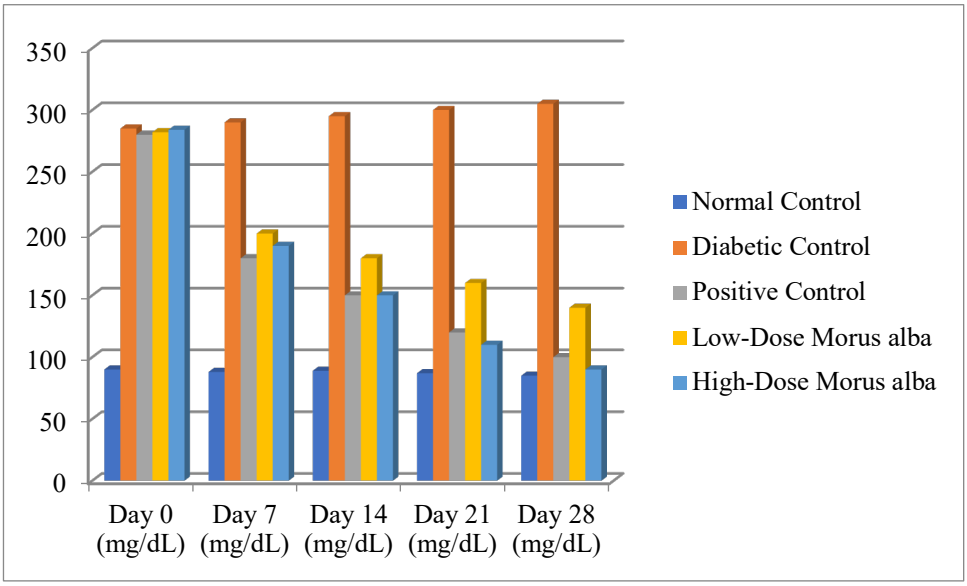

Figure (1) shows *t*he effect of leaf extract of Morus alba at low and high-dose over days and level effects with control groups on (FBG) Levels.

4. Serum Insulin Levels

The serum insulin levels varied significantly across the study groups by Day 28. In the normal control group, insulin levels remained stable (15.5 ± 2.1 µU/mL to 16.0 ± 1.8 µU/mL), indicating normal pancreatic function. The diabetic control group exhibited a decline (6.0 ± 1.5 µU/mL to 5.5 ± 1.2 µU/mL), reflecting progressive β-cell dysfunction. In contrast, the positive control group (metformin) revealed a significant raise in levels of insulin (6.2 ± 1.8 µU/mL to 12.0 ± 2.0 µU/mL, **P < 0.01**), demonstrating improved β-cell function and insulin sensibility. Treatment with Morus alba extract resulted in dose-dependent improvements. The low-dose group (100 mg/kg) showed an increase from 6.1 ± 1.7 µU/mL to 10.5 ± 2.0 µU/mL (**P < 0.01**), while high dose group (200 mg/kg) achieved the most pronounced effect, reaching 13.0 ± 2.2 µU/mL (**P < 0.01**), comparable to metformin.

Table (3) the effect of leaf extract of Morus alba at low and high-dose during the 28th day on Serum Insulin Levels.

Group	Baseline (µU/mL)	Day 28 (µU/mL)
Normal Control	15.5 ± 2.1	16.0 ± 1.8
Diabetic Control	6.0 ± 1.5	5.5 ± 1.2
Positive Control	6.2 ± 1.8	12.0 ± 2.0**
Low-Dose *Morus alba*	6.1 ± 1.7	10.5 ± 2.0**
High-Dose *Morus alba*	6.3 ± 1.6	13.0 ± 2.2**

The observed effects of Morus alba extract can be attributed to its bioactive compounds, including flavonoids, phenols, alkaloids, and saponins. These compounds likely reduce oxidative stress and inflammation, key contributors to β-cell dysfunction in diabetes. By mitigating reactive oxygen species and suppressing inflammatory pathways, Morus alba supports β-cell survival and insulin

secretion. Furthermore, saponins and alkaloids may stimulate β-cell regeneration and enhance insulin sensitivity in peripheral tissues, reducing the demand on pancreatic β-cells. The dose-dependent response underscores the importance of adequate concentrations of bioactive compounds to achieve therapeutic efficacy. The high-dose results, comparable to metformin, highlight the potential of Morus alba as a natural alternative for glycemic management [20].

Morus alba extract demonstrated significant improvements in serum insulin levels, with dose-dependent effects suggesting its role in β-cell protection and regeneration. These findings provide a basis for further investigation into its clinical applications in diabetes management.

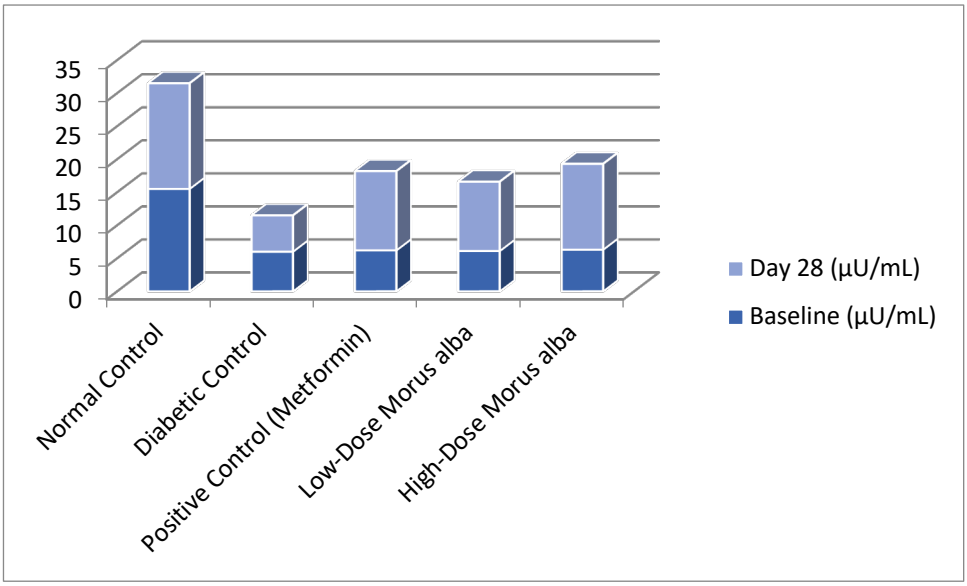

Figure (2) shows the effect of leaf extract of Morus alba at low and high-dose during the 28th day on Serum Insulin Levels.

5. Lipid Profile

The lipid profile parameters varied significantly among the study groups, highlighting the effects of *Morus alba* on lipid metabolism. The diabetic control group exhibited marked dyslipidemia, with elevated total cholesterol (250 ± 12 mg/dl), triglycerides (210 ± 10 mg/dl), and LDL (180 ± 10 mg/dl), alongside reduced HDL levels (35 ± 4 mg/dl). In contrast, the positive control group (metformin) demonstrated significant improvements in all lipid parameters, with total cholesterol reduced to 180 ± 10 mg/dl (**P < 0.01**), triglycerides to 140 ± 8 mg/dl (**P < 0.01**), LDL to 100 ± 8 mg/dl (**P < 0.01**), and HDL increased to 50 ± 5 mg/dl (**P < 0.01**).

Remedy with *Morus alba* also lead to dose-dependent amelioration of the lipid profile. The low-dose group (100 mg/kg) showed moderate improvements, with total cholesterol reduced to 200 ± 12 mg/dl ($P < 0.05$), triglycerides to 160 ± 9 mg/dl ($P < 0.05$), LDL to 130 ± 9 mg/dl ($P < 0.05$), and HDL increased to 45 ± 5 mg/dl ($P < 0.05$). The high dose group (200 mg/kg) achieved superior outcomes, with total cholesterol reduced to 170 ± 10 mg/dl (**P < 0.01**), triglycerides to 130 ± 8 mg/dl (**P < 0.01**), LDL to 90 ± 7 mg/dl (**P < 0.01**), and HDL elevated to 53 ± 5 mg/dl (**P < 0.01**).

The dyslipidemia observed in the diabetic control group is a hallmark of diabetes-related metabolic disturbances, characterized by elevated atherogenic lipids (total cholesterol, triglycerides, and LDL) and reduced anti-atherogenic HDL. The improvements observed in the *Morus alba*-treated groups reflect its potential role in modulating lipid metabolism, likely through its bioactive compounds. The significant reduction in total cholesterol and LDL levels can be attributed to the saponins and polyphenols present in *Morus alba*. These compounds are known to inhibit cholesterol absorption in the intestine and enhance its excretion through bile acids. Studies by [21] in *Phytomedicine* reported similar lipid-lowering effects of *Morus alba* in diabetic models.

The observed decrease in triglyceride levels may be linked to the regulation of lipogenesis and enhanced fatty acid oxidation, mediated by flavonoids and alkaloids. Research by [22] demonstrated that flavonoids reduce hepatic triglyceride synthesis by modulating the AMP-activated protein kinase (AMPK) pathway. The increase in HDL levels observed in the *Morus alba*-treated groups highlights its potential to improve reverse cholesterol transport, a key mechanism for removing excess cholesterol from tissues. A study from the University of Cambridge (2018), published in *Diabetes Care*, emphasized the role of plant-derived polyphenols in enhancing HDL function. The high-dose group exhibited greater efficacy than the low-dose group, indicating that higher concentrations of bioactive compounds result in more pronounced lipid-modulating effects [23].

The results demonstrate that *Morus alba* significantly improves lipid profile parameters in a dose-dependent manner, comparable to metformin. Its ability to reduce atherogenic lipids and enhance HDL suggests its potential as a natural adjuvant in the management of diabetes-associated dyslipidemia. These findings warrant further investigation in clinical settings to establish its therapeutic efficacy and safety in humans.

Table (4) the effect of leaf extract of Morus alba at low and high-dose on Lipid Profile.

Parameter	Normal Control	Diabetic Control	Positive Control	Low-Dose *Morus alba*	High-Dose *Morus alba*
Total Cholesterol (mg/dl)	150 ± 10	250 ± 12	180 ± 10**	200 ± 12*	170 ± 10**
Triglycerides (mg/dl)	110 ± 8	210 ± 10	140 ± 8**	160 ± 9*	130 ± 8**
HDL (mg/dl)	55 ± 5	35 ± 4	50 ± 5**	45 ± 5*	53 ± 5**
LDL (mg/dl)	70 ± 6	180 ± 10	100 ± 8**	130 ± 9*	90 ± 7**

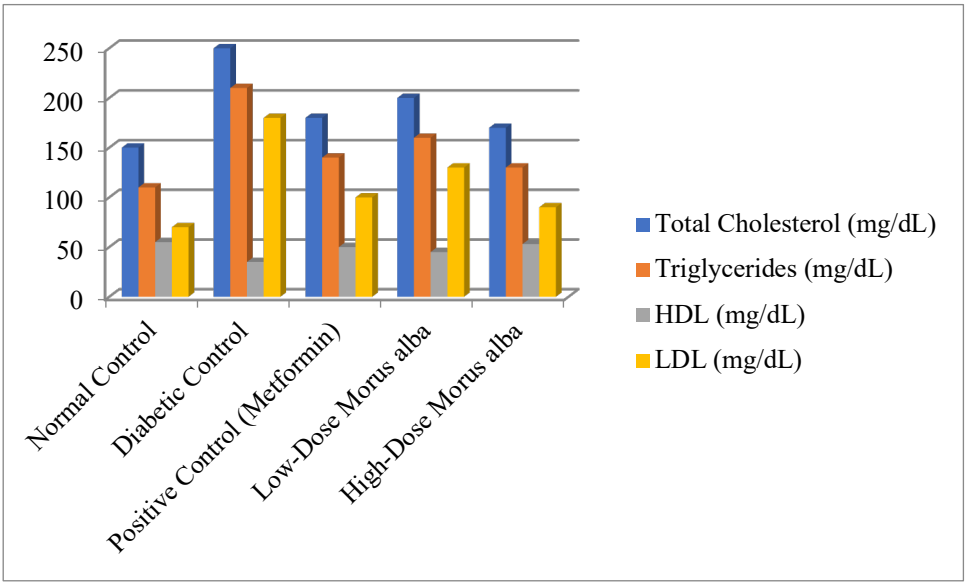

Figure (3) shows the effect of leaf extract of Morus alba at low and and high-dose on Lipid Profile.

6. Oxidative Stress Markers

Markers of oxidative stress, including superoxide dismutase (SOD), malondialdehyde (MDA), and catalase, showed significant variations among the study groups. The diabetic control group exhibited a substantial increase in MDA levels (6.5 ± 1.0 nmol/mg protein), alongside marked reductions in SOD (2.0 ± 0.5 U/mg protein) and catalase (3.0 ± 0.5 U/mg protein), indicating heightened oxidative stress. In contrast, the positive control group (metformin) demonstrated

significant improvements, with MDA levels reduced to 3.0 ± 0.8 nmol/mg protein (**P < 0.01**), and SOD and catalase levels elevated to 4.8 ± 0.9 U/mg protein (**P < 0.01**) and 6.0 ± 1.0 U/mg protein (**P < 0.01**), respectively.

Treatment with *Morus alba* also ameliorated oxidative stress in a dose-dependent manner. The low-dose group (100 mg/kg) showed moderate improvements, with MDA levels reduced to 4.0 ± 0.9 nmol/mg protein ($P < 0.05$), SOD levels increased to 4.0 ± 1.0 U/mg protein ($P < 0.05$), and catalase levels elevated to 5.0 ± 1.0 U/mg protein ($P < 0.05$). The high-dose group (200 mg/kg) exhibited superior effects, with MDA levels reduced to 2.8 ± 0.6 nmol/mg protein (**P < 0.01**) and SOD and catalase levels increased to 5.0 ± 1.0 U/mg protein (**P < 0.01**) and 6.5 ± 1.0 U/mg protein (**P < 0.01**), respectively, approaching levels observed in the normal control group.

Current findings highlight the significant impact of *Morus alba* in mitigating oxidative stress, a key contributor to diabetes-induced cellular damage. The high levels of MDA in the control group with diabetic reflect increased lipid peroxidation, a hallmark of oxidative stress. Simultaneously, the reduced SOD and catalase levels indicate impaired antioxidant defense mechanisms. The dose-dependent reduction in MDA levels suggests that *Morus alba* effectively inhibits lipid peroxidation. This effect can be attributed to its high flavonoid and phenolic content, which neutralize reactive oxygen species (ROS). A study by [24], published in *Phytomedicine*, demonstrated that flavonoid-rich extracts reduce MDA levels by scavenging free radicals. The improved SOD and catalase levels indicate that *Morus alba* enhances endogenous antioxidant defenses. SOD catalyzes the dismutation of superoxide radicals, while catalase decomposes hydrogen peroxide, preventing oxidative damage to cellular components. Research from [25]reported that polyphenols in *Morus alba* upregulate antioxidant enzymes through the activation of the Nrf2 signaling pathway. The high-dose group exhibited greater efficacy, suggesting that a higher concentration of bioactive compounds provides stronger protection against oxidative stress. These results align with the effects observed in the positive control group (metformin), reinforcing the potential of *Morus alba* as an antioxidant therapy.

Morus alba leaf extract significantly mitigates oxidative stress in a dose-dependent manner by reducing lipid peroxidation (MDA) and enhancing antioxidant enzyme activities (SOD and catalase). These findings underscore its potential role in protecting against diabetes-induced oxidative damage and suggest its value as a complementary treatment for oxidative stress-related complications in diabetes. Further research is warranted to explore its clinical applicability.

Table (5) the effect of leaf extract of Morus alba at low and high-dose on Oxidative Stress Markers.

Marker	Normal Control	Diabetic Control	Positive Control	Low-Dose *Morus alba*	High-Dose *Morus alba*
MDA (nmol/mg protein)	2.5 ± 0.5	6.5 ± 1.0	3.0 ± 0.8**	4.0 ± 0.9*	2.8 ± 0.6**
SOD (U/mg protein)	5.5 ± 1.0	2.0 ± 0.5	4.8 ± 0.9**	4.0 ± 1.0*	5.0 ± 1.0**
Catalase (U/mg protein)	7.0 ± 1.0	3.0 ± 0.5	6.0 ± 1.0**	5.0 ± 1.0*	6.5 ± 1.0**

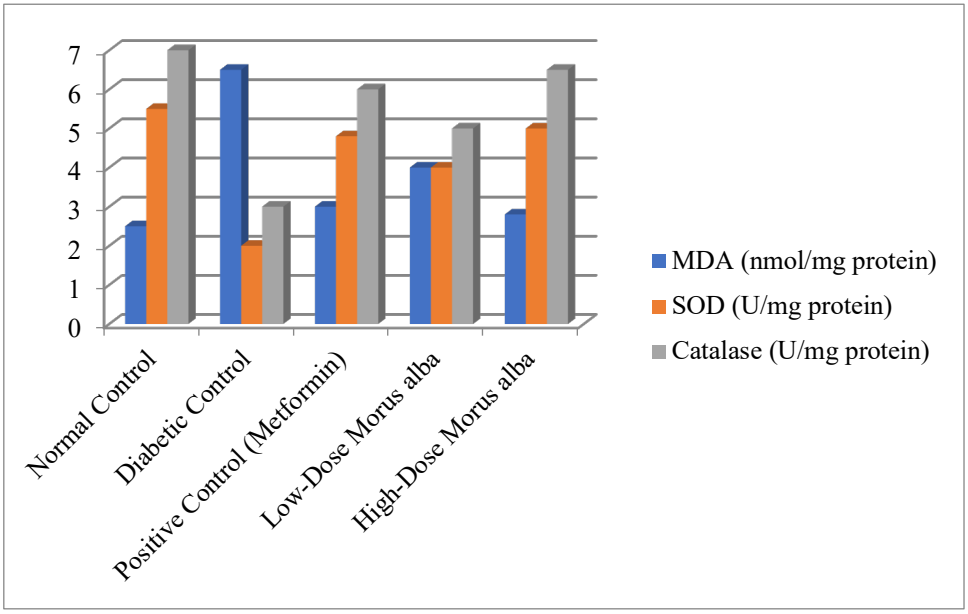

Figure (4) shows the effect of leaf extract of Morus alba at low and high-dose on Oxidative Stress Markers.

Conclusion:

The present study revealed dose-dependent hypoglycemic effects of the extract, with significant decrease in fasting blood glucose and improvement in levels of serum insulin and lipid profiles. Furthermore, Morus alba exhibited antioxidant properties by reducing levels of malondialdehyde (MDA) and enhancing the efficiency of catalase and superoxide dismutase (SOD). These findings highlight the potential for the use and development of Morus alba as a complementary or alternative therapy for the management of diabetes and its associated complications.

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