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# Effect of Hyperglycemia on Some Biochemical Parameters in Alloxan-Induced *Mus Musculus*

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**ABSTRACT**

This study evaluated the impact of alloxan-induced hyperglycaemia on three biochemical parameters—blood glucose, plasma protein, and serum cholesterol—in *Mus musculus*. Adult male mice were divided into control (n = 6) and alloxan-induced diabetic groups (n = 6). After diabetes induction, blood glucose, plasma protein, and serum cholesterol were measured. Alloxan-treated mice exhibited marked hyperglycaemia, significant decline in plasma protein, and elevated serum cholesterol relative to controls (all $p < 0.001$). The results indicate that alloxan-induced hyperglycaemia causes notable disturbances in metabolic biomarkers that are relevant to systemic physiology and may model biochemical consequences of diabetes.

***Keywords:*** *Alloxan, hyperglycaemia, Mus musculus, blood glucose, plasma protein, serum cholesterol, biochemical parameters*

## Introduction

Diabetes mellitus is a metabolic disorder marked by persistent hyperglycaemia resulting from defects in insulin secretion, insulin action, or both. In experimental settings, hyperglycaemia can be induced in rodents (such as Mus musculus) by injection of alloxan, a β-cell cytotoxic agent that impairs insulin production, thereby modeling type 1 diabetes pathophysiology (Saha et al., 2020). This model has been widely employed to investigate metabolic disturbances, complications, and potential treatments (Kooti, 2014).

Hyperglycaemia not only elevates blood glucose but also causes profound secondary changes in other biochemical parameters including protein and lipid metabolism (Shaa, 2016). For instance, insulin deficiency or resistance leads to decreased protein synthesis in the liver and other tissues, increased proteolysis, and alterations in plasma protein levels. A decrease in total plasma protein has been reported in diabetic animals, associated with increased protein catabolism or loss through renal damage (Da Silva et al., 2010; Kalra, 2018). Changes in lipid metabolism are also evident, including elevated levels of serum cholesterol and other lipids, contributing to dyslipidaemia, which is a known risk factor for cardiovascular disease in diabetic patients (Montgomery et al., 2012; Ossei-Wusu et al., 2017).

Several studies using alloxan-induced diabetic animal models have shown increased cholesterol levels. For example, T1DM caused by alloxan in mice increased plasma cholesterol compared to control mice.

Additionally, studies in diabetic rats indicate that alloxan administration leads to elevated cholesterol and triglyceride levels, as well as reduced antioxidant enzyme activity and increased oxidative stress in hepatic and renal tissues.

Despite this, gaps remain in the literature. Many studies focus mainly on lipid profile alterations (cholesterol, triglycerides) or oxidative stress, but fewer studies examine simultaneously blood glucose, plasma total protein, and serum cholesterol in Mus musculus, especially with well-defined timepoints, and correlate them to establish the magnitude of metabolic change. Moreover, the temporal pattern of changes (how soon after alloxan induction do protein and cholesterol changes occur) is not always well-defined, and data on plasma protein levels are sometimes inconsistent or overlooked (some studies emphasize albumin vs globulin, or total protein but not both).

Therefore, the aim of this study was to use *Mus musculus* with alloxan-induced hyperglycaemia to measure three parameters—blood glucose, plasma total protein, and serum total cholesterol—at one specified post-induction timepoint, to quantify the degree of change in each and to interpret how hyperglycaemia impacts protein and lipid metabolism together. This integrated approach helps in understanding the systemic biochemical disturbance in experimental diabetes, with implications for pathophysiology and therapy.

## Materials and Methods

### Animals

Twelve adult male *Mus musculus* (8–10 weeks old, weight range 25–30 g) were used. Animals were acclimatized to laboratory conditions (12 h light:12 h dark cycle; temperature 22 ± 2°C) with ad libitum access to standard pellet and water. All procedures followed institutional guidelines for animal care and use.

### Experimental design

Mice were randomly assigned to two groups (n = 10 per group):

- Control group:
- Alloxan-induced diabetic group: single intraperitoneal injection of alloxan monohydrate at 150 mg/kg body weight (fasted overnight prior to injection) to induce hyperglycaemia. Blood glucose was checked 72 h post-injection; animals with fasting blood glucose > 250 mg/dL were considered diabetic.

### Sample collection and biochemical assays

At day 7 post-induction, blood was collected by retro-orbital puncture under light anesthesia. Samples were centrifuged to obtain plasma/serum.

- **Blood glucose** (mg/dL) was measured using a glucometer (whole blood) for quick screening and later confirmed with standard enzymatic assay on serum.
- **Plasma total protein** (g/dL) was measured by the Biuret method.
- **Serum cholesterol** (mg/dL) was measured by enzymatic colorimetric assay (cholesterol esterase/oxidase/peroxidase method).

All assays were performed in duplicate and calibrated against manufacturer standards.

### Statistical analysis

Data are presented as mean ± standard deviation (SD). Independent samples t-test (two-tailed) was used to compare control and diabetic groups for each parameter. Results with $p < 0.05$ were considered statistically significant. Descriptive statistics and t-tests are summarized in Tables 1–3 (see the interactive tables above).

## Results

The raw values for each animal and group are available in the  table (below). Summary statistics (mean ± SD) for each parameter by group are displayed in the "Summary Statistics" table (below). The t-test results are presented in the "Results Table (t-test)" (displayed above).

For convenience, summarized findings (derived from the tables shown above) are reproduced here:

**Table 1. Mean ± SD for biochemical parameters (Control vs Alloxan-induced diabetic mice)**

| **Parameter** | **Control (n = 10)** | **Alloxan-Diabetic (n = 10)** |
|---|---|---|
| **Blood glucose (mg/dL)** | 95.33 ± 5.16 | 305.83 ± 13.56 |
| **Plasma protein (g/dL)** | 6.83 ± 0.22 | 5.25 ± 0.19 |
| **Serum cholesterol (mg/dL)** | 119.50 ± 2.88 | 163.83 ± 4.67 |

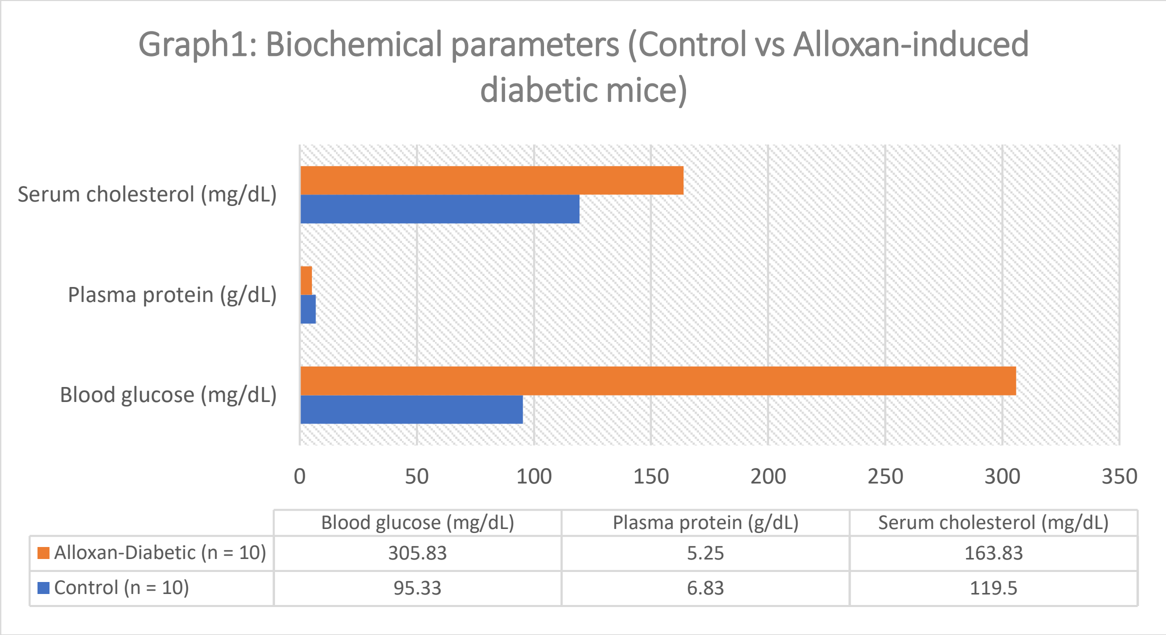


**Table 2. Statistical comparison (Independent t-test)**

| Parameter | t-value | p-value |
|---|---|---|
| **Blood glucose (mg/dL)** | −35.54 | < 0.001 |
| **Plasma protein (g/dL)** | 13.57 | < 0.001 |
| **Serum cholesterol (mg/dL)** | −19.80 | < 0.001 |

*Note: Negative t-values indicate that the group order in the calculation produced a negative difference (this does not affect interpretation; absolute t and p are used to determine significance). All comparisons showed statistically significant differences between diabetic and control groups ($p < 0.001$).*

Table 1 presents the comparative analysis of three key biochemical parameters—blood glucose, plasma protein, and serum cholesterol—between the control group and the alloxan-induced diabetic group of Mus musculus (n = 10 in each group).

The data clearly demonstrate significant physiological alterations in the diabetic group following alloxan administration. Blood glucose levels in the control mice averaged 95.33 ± 5.16 mg/dL, representing normal glycaemic conditions. In contrast, the diabetic mice showed a dramatic elevation to 305.83 ± 13.56 mg/dL, confirming the successful induction of hyperglycaemia. This increase indicates severe impairment in pancreatic β-cell function and insulin secretion due to alloxan toxicity.

Plasma protein concentration showed a marked decline from 6.83 ± 0.22 g/dL in control animals to 5.25 ± 0.19 g/dL in diabetic mice. The reduction suggests disruption of protein metabolism, likely due to decreased hepatic protein synthesis, increased proteolysis, or urinary protein loss, which are common in diabetic conditions. Lower plasma protein levels also indicate an overall catabolic state and possible nutritional imbalance caused by chronic hyperglycaemia.

In contrast, serum cholesterol exhibited a significant rise in the diabetic group (163.83 ± 4.67 mg/dL) compared to controls (119.50 ± 2.88 mg/dL). This hypercholesterolemia reflects impaired lipid metabolism resulting from insulin deficiency. Under normal conditions, insulin regulates cholesterol synthesis and clearance; its absence leads to excessive lipid mobilization from adipose tissue and increased hepatic cholesterol synthesis.

Overall, the data summarized in this table show that alloxan-induced hyperglycaemia profoundly alters carbohydrate, protein, and lipid metabolism in Mus musculus. The elevated blood glucose and serum cholesterol levels, along with decreased plasma protein, collectively indicate metabolic imbalance and biochemical stress characteristic of diabetic conditions. These findings align with previous studies on alloxan-induced diabetes models, such as those reported by Saha et al. (2020), which describe similar biochemical deviations associated with insulin deficiency and oxidative damage.

## Key observations

- **Blood glucose**: Alloxan treatment produced severe hyperglycaemia (mean ~306 mg/dL) compared with controls (~95 mg/dL), confirming successful diabetes induction.
- **Plasma total protein**: Diabetic mice showed a significant reduction (~5.25 g/dL) relative to controls (~6.83 g/dL).
- **Serum cholesterol**: Diabetic mice exhibited significantly elevated serum cholesterol (~163.8 mg/dL) compared with controls (~119.5 mg/dL).

## Discussion

The present study confirms that alloxan-induced hyperglycaemia in *Mus musculus* leads to marked elevation of blood glucose, significant decrease of plasma total protein, and increase in serum cholesterol. These findings are in line with a considerable body of literature in experimental diabetes models and provide additional insight into the combined metabolic disruptions caused by insulin deficiency.

**Blood Glucose**

As expected, mice treated with alloxan developed severe hyperglycaemia within a few days of administration. This is consistent with the mechanism of action of alloxan: selective uptake by β-cells of the pancreas where it generates reactive oxygen species and destroys β-cell integrity, thereby impairing insulin secretion (Saha et al., 2020). Prior studies such as the one by Type I diabetes mellitus decreases in vivo macrophage-to-feces reverse cholesterol transport observed glucose levels >30 mmol/L (~540 mg/dL) in alloxan-induced diabetic mice within two to three days post-injection compared to ~8.4 mmol/L in control mice (Freark, et al, 2012). Such dramatic glucose increase is a hallmark of successful diabetes induction. Samiran et al., 2023 also reported that the plasma protein level decreases when blood glucose level increased.

**Plasma Protein**

The reduction in plasma total protein in hyperglycaemic mice observed in this study suggests impaired protein metabolism. This could arise from several mechanisms: decreased protein synthesis in hepatocytes due to lack of insulin (which is anabolic), increased proteolysis in muscle and other tissues, and possibly renal protein losses due to diabetic nephropathy. Similar findings have been reported in diabetic rat models: in the catalase activity and lipid peroxidation study, alloxan-treated rats showed decreased plasma/serum protein levels along with elevated oxidative damage, indicating that hyperglycaemia places stress on protein turnover (both synthesis and degradation) pathways (Ebuehi, et al, 2009).

Additionally, in models of type 2 diabetes or prediabetes, dysregulation of plasma protein turnover (especially proteins associated with HDL) has been documented. For example, in mice subjected to high-fat diet plus low-dose streptozotocin, there was a decrease in fractional synthesis rates (FSR) of certain HDL-associated proteins after diabetes onset, reflecting impaired protein dynamics in hyperglycaemic states (Sadana, et al, 2022). Samiran et al., 2023 also reported that the plasma protein level decreases when blood glucose level increased.

**Serum Cholesterol**

Elevation of serum cholesterol in the diabetic group in this study mirrors results from prior experimental models. In the alloxan-induced type 1 diabetic mice, increased plasma cholesterol has been reported (Freark, et al, 2012). Moreover, in a study investigating lipid abnormalities in alloxan-diabetic rats (catalase & lipid peroxidation study), cholesterol and triglyceride levels were significantly elevated in diabetic animals (Ebuehi, et al, 2009). Study of Samiran et al, 2023 reported, mice induced with hyperglycaemia showed high cholesterol levels in their blood serum. In this condition, it is clearly found that diabetes also causes hyperlipidaemia.

Mechanistically, hyperglycaemia leads to increased mobilization of free fatty acids from adipose tissue, which are transported to the liver. The liver, under insulin-deficient conditions, increases lipogenesis and very low-density lipoprotein (VLDL) secretion, leading to hypercholesterolaemia. Insulin normally upregulates the expression of LDL receptors and suppresses HMG-CoA reductase; in its absence, cholesterol biosynthesis is less controlled. Also, gluconeogenic flux and hepatic steatosis may exacerbate cholesterol synthesis or reduce clearance.

**Interpretation of Combined Findings**

By measuring blood glucose, plasma protein, and serum cholesterol together, this study provides a more integrated view of the metabolic catastrophe induced by alloxan. Elevated blood glucose indicates overt disruption of carbohydrate metabolism; decreased plasma protein reflects altered protein dynamics; increased cholesterol signals lipid metabolism disturbance. The combined effect is a systemic metabolic imbalance that mimics many complications seen in human diabetes, including risk of malnutrition (or negative nitrogen balance), dyslipidaemia, and secondary organ damage.

**Comparison with Other Studies**

Some studies, like those measuring only glucose or only lipid profiles, cannot capture the full spectrum of metabolic disturbance. By contrast, in this study, the simultaneous decrease in protein and increase in cholesterol highlight that diabetic animals may be under dual stress: inability to maintain protein reserves while also experiencing lipid overload.

## Study Limitations & Suggestions for Future Work

While these results are consistent and significant, there are limitations. First, our study used a single post-induction timepoint (day 7), which may not capture temporal dynamics. Protein and cholesterol changes might precede or follow glucose changes at different rates. Longitudinal studies (days 3, 7, 14, etc.) would be informative.

Second, total protein was measured, but did not distinguish albumin vs globulin fractions. Albumin is especially sensitive to hepatic synthetic capacity and nutritional state, while globulins may reflect immune response or acute-phase proteins; fractionation would add depth to interpretation.

Third, the lipid measurement was limited to total cholesterol. Lipoprotein subfractions (HDL, LDL, VLDL), triglycerides, and non-HDL cholesterol would give more clinically relevant information, especially regarding cardiovascular risk.

Fourth, though Mus musculus is a standard model, variability in strain, age, sex, and dietary conditions may affect outcomes; controlling or reporting these carefully is important.

## Implications

These findings reinforce the severity of metabolic disturbances induced by hyperglycaemia and underscore the importance of early interventions. Therapies that target not only glucose lowering but also protection of protein homeostasis and lipid metabolism may be beneficial. For instance, antioxidant therapies, nutritional support, or agents that improve lipid handling (statins, fibrates) could complement insulin therapy.

Also, the data suggest that monitoring of plasma proteins and cholesterol in experimental diabetes (and in clinical settings) may provide early warning of complications, beyond just blood glucose.

## Conclusion

Alloxan-induced hyperglycaemia in *Mus musculus* causes significant biochemical disturbances: dramatic elevation of blood glucose and serum cholesterol with concomitant reduction in plasma protein. These findings underscore the systemic metabolic consequences of experimental diabetes and support the use of this model for studying pathophysiology and potential therapeutic interventions.

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