Original Article

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Hypoglycemic Effect of Aloe Vera Gel in High-Fat Diet-Induced Rats: A Comparative Study

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Abstract

Background: Hyperglycemia commonly accompanies high-fat diet–induced metabolic disorders and plays a crucial role in the development of insulin resistance. Natural products such as Aloe vera has been reported to possess potential hypoglycemic properties, but comparative evidence with standard drugs is limited. To evaluate the hypoglycemic effect of Aloe Vera gel in high-fat diet–induced rats and to compare its effect with atorvastatin.

Materials and methods: This experimental animal study was conducted in the Department of Pharmacology and Therapeutics, Sir Salimullah Medical College, Dhaka, from February 2023 to January 2024. Thirty healthy adult male Long Evan rats were randomly divided into five groups (n=6 each): Normal control, high-fat diet control, Aloe Veragel–treated, atorvastatin-treated and combination-treated groups. Hyperglycemia was induced by a high-fat diet. Aloe Vera gel (300 mg/kg) and atorvastatin (10 mg/kg) were administered orally. After 42 days, fasting blood sugar levels were measured. Data were analyzed using one-way ANOVA followed by Bonferroni test.

Results: The high-fat diet control group showed significantly higher fasting blood sugar levels compared to the normal control group ($p<0.001$). Aloe Vera gel significantly reduced fasting blood sugar levels compared to the hyperlipidemic control group ($p<0.001$). Atorvastatin alone did not show a significant hypoglycemic effect. The combination-treated group showed a greater reduction in fasting blood sugar compared to the hyperlipidemic control and atorvastatin-treated groups.

Conclusion: Aloe Vera gel exhibited a significant hypoglycemic effect in high-fat diet–induced rats. Its effect was superior to atorvastatin alone and combination therapy provided additional benefit. Aloe Vera may be considered a potential natural agent for the management of diet-induced hyperglycemia.

Key words: Aloe Vera; Atorvastatin; Fasting blood sugar; High-fat diet; Hypoglycemic effect.

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Introduction

Hyperglycemia is a major metabolic abnormality commonly associated with obesity, insulin resistance and dyslipidaemia and it plays a vital role in the development of type 2 diabetes mellitus.[1] Persistent elevation of fasting blood sugar contributes to both microvascular and macrovascular complications, thereby increasing morbidity and mortality worldwide.[2] High-fat diet intake has been identified as an important environmental factor leading to insulin resistance, impaired glucose utilization and progressive deterioration of glycemic control.[3] As a result, diet-induced metabolic disorders are increasingly used as experimental models to study the pathophysiology of hyperglycemia and to evaluate potential and safe therapeutic agen.[4]

Hyperlipidemia and hyperglycemia frequently coexist and share common underlying mechanisms, including insulin resistance and altered lipid metabolism.[5] Elevated circulating lipids impair insulin signaling pathways, resulting in reduced glucose uptake by peripheral tissues and increased hepatic glucose production.[6] Experimental research indicates that prolonged intake of a high-fat diet results in dyslipidaemia and increased fasting blood glucose levels, closely resembling the metabolic abnormalities found in individuals with metabolic syndrome and type 2 diabetes mellitus.[7]

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Atorvastatin is a widely prescribed lipid-lowering agent used for the prevention of cardiovascular diseases. It acts by inhibiting HMG-CoA reductase, a key enzyme in cholesterol biosynthesis and has been shown to reduce serum triglyceride and LDL levels effectively.[8] Although atorvastatin is primarily indicated for dyslipidaemia, its effects on glucose metabolism remain controversial. Several studies have reported that long-term statin therapy may be associated with altered glucose homeostasis and an increased risk of new-onset diabetes.[9,10] These concerns have led researchers to investigate safer and more natural treatment options that can improve metabolic parameters without considerable adverse effects.

Aloe Vera, known as "secret plant originated from ancient Egypt is a medicinal plant that has been traditionally used for various therapeutic purposes, including wound healing, anti-inflammatory activity, antifungal activity, hypoglycemic or antidiabetic effects, anticancer, immunomodulatory and gastrointestinal disorders.[5] In recent years, Aloe Vera has attracted considerable attention for its potential role in the management of metabolic diseases. The plant contains several biologically active constituents such as polysaccharides, phytosterols, flavonoids, and antioxidants, which have been reported to exert hypoglycemic, hypolipidemic, and insulin-sensitizing effects.[11] Fresh aloe juice from the inner leaf parenchyma contains 96% water, polysaccharides (Mucilage) consisting mainly of D-glucose and D-mannose, tannins, steroid, enzymes, plant hormones, amino acids, vitamins and minerals.[12] Experimental studies have demonstrated that Aloe Vera gel supplementation can significantly reduce fasting blood glucose levels and improve insulin sensitivity in animal models of diet-induced and chemically induced diabetes.[13,14]

Furthermore, the combined use of conventional lipid-lowering agents with natural products may offer additional metabolic benefits. Improvement of lipid abnormalities by statins may reduce lipotoxicity, while natural agents such as Aloe Vera may directly enhance glucose utilization and insulin action.[9] This combined approach may provide better glycemic control in conditions where hyperglycemia and dyslipidaemia coexist.

Considering the growing burden of diet-related metabolic disorders and the limitations associated with long-term pharmacotherapy, the present study was designed to evaluate the hypoglycaemic effect of aqueous Aloe Vera gel in high-fat diet-induced rats and to compare its effect with atorvastatin alone and in combination. The use of an experimental animal model allows controlled evaluation of biochemical changes and provides a scientific basis for future clinical research on natural hypoglycaemic agents.

Materials and methods

This experimental animal study was conducted at the Department of Pharmacology and Therapeutics of Sir Salimullah Medical College, Dhaka, in collaboration with the Institute of Nutrition and Food Science (INFS) Dhaka University. The overall study, including planning, procurement, preparation, and data analysis, was carried out over a period of twelve months from February 2023 to January 2024. Ethical approval was obtained and all procedures followed institutional guidelines for animal care.

A total of 30 healthy adult male Long Evans rats, aged 10–12 weeks and weighing approximately 180–200 grams, were used. The animals were procured from the Animal House of the Department of Pharmacy, Jahangirnagar University, Savar, Bangladesh. Diseased or unhealthy rats were excluded. Rats were housed in standard metallic cages under controlled laboratory conditions (Temperature 22 ± 2°C, relative humidity 50–60%, 12-hour light/dark cycle) and allowed to acclimate for one week prior to experimentation. Cages were cleaned regularly, and proper hygiene was maintained throughout the study.

The rats were randomly assigned into five groups (n=6 per group) for the 42-day experimental treatment period:

- Group A (Normal Control): Fed standard pellet diet and distilled water ad libitum.
- Group B (High-Fat Diet Control): Fed high-fat diet (HFD) and distilled water ad libitum.
- Group C (Aloe Vera treated): Fed HFD for the first two weeks, followed by oral administration of aqueous Aloe Vera gel (300 mg/kg body weight) along with HFD for the remaining four weeks.

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- Group D (Atorvastatin treated): Fed HFD for the first two weeks, followed by oral administration of atorvastatin (10 mg/kg body weight) along with HFD for the remaining four weeks.
- Group E (Combination Therapy): Fed HFD for the first two weeks, followed by oral administration of both Aloe Vera gel (300 mg/kg) and atorvastatin (10 mg/kg) along with HFD for the remaining four weeks.

The high-fat diet was freshly prepared daily using 40% edible coconut oil and 60% Vanaspati ghee. Fresh Aloe Vera leaves were manually washed, gel extracted, homogenized, and stored at 8°C until use. The gel was administered orally at a dose of 300 mg/kg body weight daily.

To assess the hypoglycemic effect of Aloe Vera, Fasting Blood Sugar (FBS) levels were measured in all five groups. After the 42-day treatment period, rats were fasted for 18 hours with free access to water. Animals were anesthetized with chloroform and approximately 3–5 ml of blood was collected via cardiac puncture. Blood samples were allowed to clot for 30 minutes, then centrifuged to separate serum. Serum FBS was measured using standard biochemical methods and values were expressed in mg/dl.

Data were expressed as mean ± Standard Deviation (SD). Comparisons among groups were performed using one-way analysis of variance (ANOVA) followed by Bonferroni post hoc test. Statistical analysis was performed using SPSS version 26. A p-value of <0.05 was considered statistically significant.

Results

A total of 30 healthy adult male Long Evans rats were included in this study and divided into five groups, with six rats in each group. These comprised a normal control group (Group A) a hyperlipidemic control group (Group B), an aqueous Aloe Vera gel–treated group (Group C), an atorvastatin-treated group (Group D) and a combination therapy group receiving both Aloe Vera gel and atorvastatin (Group E).

The mean serum fasting blood sugar levels are presented in Table-I. Group A (Normal Control) had a mean FBS of 4.95 ± 0.52 mg/dl, whereas a markedly higher level of 6.80 ± 0.24 mg/dl was observed in the hyperlipidemic control group (Group B). In contrast, treatment with Aloe vera gel (Group C) reduced the mean FBS level to 4.53 ± 0.29 mg/dl. The atorvastatin-treated group (Group D) showed a mean FBS level of 6.42 ± 0.26 mg/dl, while the combination therapy group (Group E) demonstrated a lower mean value of 5.22 ± 0.23 mg/dl.

Table I Comparison of serum FBS (mg/ dl) in rats among different groups after completion of 42- day experiment (n=30)

Variable	Group A (n=6) Mean ± SD	Group B (n=6) Mean ± SD	Group C (n=6) Mean ± SD	Group D (n=6) Mean ± SD	Group E (n=6) Mean ± SD	p-value
S. FBS (mg/dl)	4.95±0.52	6.80±0.24	4.53±0.29	6.42±0.26	5.22±0.23	0.0001
	Group A vs Group B					0.0021**
	Group A vs Group C					0.371^{ns}
	Group A vs Group D					0.0001**
	Group A vs Group E					1.000^{ns}
	Group B vs Group C					0.00021**
	Group B vs Group D					0.536^{ns}
	Group B vs Group E					0.0001**
	Group C vs Group D					0.00011**
	Group C vs Group E					0.013*
	Group D vs Group E					0.00012**

Data were express mean ± SD. One-way ANOVA followed by Bonferroni test was performed to compare between groups. p-value <0.05* and <0.001** were accepted as significant and highly significant respectively.

Statistical analysis revealed that the mean serum FBS levels in Groups A, C, and E were significantly lower compared to the hyperlipidemic control group (Group B) (ANOVA, p< 0.001) (Figure-1). No significant difference was observed between Group B and Group D, whereas Aloe Vera–treated rats showed a significant reduction in FBS compared to atorvastatin-treated rats.

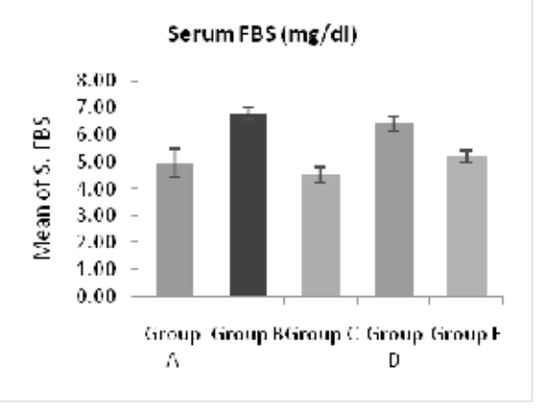

Figure 1 Bar diagram showing the serum FBS level in different groups

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Discussion

The present experimental animal study was conducted to evaluate the hypoglycaemic effect of aqueous Aloe Vera gel in high-fat diet-induced rats and to compare its effect with atorvastatin alone and in combination therapy. High-fat diet feeding is known to induce metabolic alterations including insulin resistance, impaired glucose homeostasis and hyperglycemia, thereby serving as a suitable experimental model for evaluating hypoglycaemic agents.[15] In this study, the hyperlipidemic control group demonstrated a significantly higher Fasting Blood Sugar (FBS) level compared to the normal control group, indicating successful induction of diet-related metabolic disturbance.

Administration of aqueous Aloe Vera gel resulted in a significant reduction of serum FBS levels compared to the hyperlipidemic control group. This finding is consistent with earlier experimental studies reporting the glucose-lowering effect of Aloe vera.[16,17] The hypoglycaemic action of Aloe Vera has been attributed to the presence of biologically active constituents such as polysaccharides, phytosterols, flavonoids and saponins, which are known to improve insulin sensitivity, enhance peripheral glucose uptake, and reduce hepatic glucose output.[18,19]

In contrast, atorvastatin treatment alone did not produce a significant reduction in fasting blood sugar levels when compared with the hyperlipidemic control group. This observation suggests that atorvastatin exerts its primary pharmacological action on lipid metabolism rather than directly influencing glucose regulation. Although statins have been reported to have variable effects on glucose homeostasis, their role in glycemic control remains limited and inconsistent.[11,20]

The combination-treated group, receiving both Aloe Vera gel and atorvastatin, showed a significant reduction in serum FBS levels compared to the hyperlipidemic control and atorvastatin-treated groups. This finding suggests a possible additive effect of Aloe Vera on glycemic control when used alongside atorvastatin. The improvement in fasting blood sugar observed in the combination group may be due to simultaneous correction of lipid-induced insulin resistance by atorvastatin and the direct hypoglycaemic action of Aloe Vera.[9,21]

Overall, the results of the present study indicate that aqueous Aloe Vera gel possesses significant hypoglycaemic activity in high-fat diet-induced rats. Its effect was found to be superior to atorvastatin alone and comparable to combination therapy in improving fasting blood glucose levels. These findings support the potential role of Aloe Vera as an effective natural agent for the management of diet-induced hyperglycemia.

Limitation

The study was conducted on a small sample size with a short experimental duration. Only fasting blood sugar was assessed, and other glycemic parameters were not included. As this was an animal study, the findings cannot be directly applied to humans.

Conclusion

Aloe vera gel significantly lowers fasting blood sugar levels in high-fat diet–induced hyperlipidemic rats independent of hypoglycemic drugs. Atorvastatin shows lipid-lowering–mediated indirect effects on glucose levels, while combination therapy produces additive benefits. These findings support the therapeutic potential of Aloe vera as a natural adjunct in metabolic syndrome management.

Recommendation

Studies with a larger sample size, longer duration, and additional glycemic parameters are recommended. Clinical trials are needed to confirm its efficacy and safety in humans.

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Contribution of authors

TMS-Conception, design, acquisition of data, drafting & final approval.

NA-Interpretation of data, critical revision & final approval.

SS-Data analysis, interpretation of data, critical revision & final approval.

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TS-Interpretation of data, drafting & final approval.

SD-Interpretation of data, drafting & final approval.

NA-Acquisition of data, drafting & final approval.

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Disclosure

The authors declared no conflict of interest.

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