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Original article

Antidiabetic and Cardioprotective Potential of *Balanites aegyptiaca* Extract in Male Rabbits

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Abstract
This study evaluated the effects of *Balanites aegyptiaca* extract on glucose metabolism and lipid profile in male rabbits. Administration of the extract resulted in a significant reduction in plasma glucose (100.44 ± 3.76 mg/dl) compared to the control group (113.03 ± 1.243 mg/dl, $p < 0.05$). Glycated hemoglobin (HbA1c) levels also decreased markedly (3.1 ± 0.44%) relative to the control (4.6 ± 0.28%, $p < 0.05$), indicating improved long-term glycemic regulation. In addition, *Balanites aegyptiaca* supplementation significantly reduced total cholesterol (97.43 ± 3.110 mg/dl) and triglyceride levels (49.08 ± 2.862 mg/dl), while enhancing high-density lipoprotein (HDL) concentrations (50.0 ± 1.652 mg/dl) without significantly affecting low-density lipoprotein (LDL). These findings demonstrate that *Balanites aegyptiaca* exerts dual antidiabetic and cardioprotective effects by improving glucose homeostasis and modulating lipid metabolism. The extract's bioactive compounds may enhance insulin sensitivity and antioxidant defense mechanisms, contributing to reduced oxidative stress and lipid peroxidation. Further studies are recommended to identify the molecular pathways involved in its hypoglycemic and hypolipidemic activities.
Keywords. Balanites Aegyptiaca, Glucose Metabolism, Glycated Hemoglobin (HbA1c), Lipid Profile, Rabbits.

Introduction

Diabetes mellitus remains one of the foremost global health challenges, characterised by persistent hyperglycaemia, which promotes vascular complications, oxidative stress, and alterations in lipid metabolism [1]. Herbal-derived therapies have attracted increasing attention for their adjunctive potential in moderating glucose homeostasis and dyslipidaemia [2]. Among these, Balanites aegyptiaca (family Zygophyllaceae), commonly known as the desert date, has a long history of use in traditional African medicine for the management of hyperglycaemia and metabolic disorders. Phytochemical analyses indicate that multiple parts of the plant, including the mesocarp, seed kernel, leaves, and fruit shell, contain saponins, flavonoids, phenolic acids, and unsaturated fatty acids, which may contribute to its bioactivity [3].

Recent experimental evidence supports the anti-hyperglycaemic and lipid-modulating effects of B. aegyptiaca. For example, studies in diabetic rodent models demonstrate that aqueous extracts of the fruit or seed improve insulin secretion, reduce hepatic gluconeogenesis and glycogenolysis, and enhance antioxidant enzyme activities [4]. Meanwhile, investigations of its lipid-profile effects reveal significant reductions in total cholesterol and triglycerides alongside elevations in HDL-cholesterol in treated animals, suggesting a favourable impact on cardiovascular-related risk parameters [5]. Despite these promising findings, gaps remain: standardised dosing regimens, translation into glycated haemoglobin (HbA1c) outcomes, and the mechanistic pathways underpinning its antidiabetic and hypolipidaemic effects require further elucidation.

A very recent systematic review registered under PROSPERO (CRD42024587444) concluded that while B. aegyptiaca shows consistent glycaemic control in animals; human clinical trials are still lacking [6]. In light of this background, the present study seeks to investigate the effects of B. aegyptiaca extract on key glycaemic markers, plasma glucose, and HbA1c and lipid profile components in male rabbits. The findings aim to contribute both to the pre-clinical evidence base and support future translational work exploring this plant as a natural adjunct in metabolic disease management.

Materials and Methods

This study was conducted in July 2024 at the Department of Chemistry, Faculty of Science, Omar Al-Mukhtar University, in compliance with US-EPA (2004) and Libyan Ministry of Agriculture animal welfare guidelines. Mature fruits of *Balanites aegyptiaca* (L.) Delile (desert date) were collected from the Sebha region in southwestern Libya, authenticated at Sebha University, air-dried for two weeks, and ground into fine powder stored at 4°C until use.

Twenty healthy male rabbits were obtained from certified local farms and housed individually in stainless-steel cages under controlled temperature (22–26°C), humidity (40–70%), and a 12-hour light/dark cycle, with free access to food and water. The animals were divided into two groups (n=10): Group 1 received *B.*

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aegyptiaca extract orally (100 mg/kg body weight) on alternate days for six weeks [7], while Group 2 served as the control, receiving distilled water. Blood was collected at the end of treatment for biochemical analysis of glucose, HbA1c, total cholesterol, triglycerides, HDL-C, and LDL-C using enzymatic colorimetric kits (Biolabo SA, France).
Data were analyzed using Minitab 17 and GraphPad Prism 8, employing ANOVA followed by Tukey's test, with statistical significance set at $p < 0.05$.

Results

Treatment of male rabbits with *Balanites aegyptiaca* extract resulted in a significant decrease in plasma glucose and glycated hemoglobin (HbA1c) levels compared with the control group. As presented in Table 1 and Figures 1 and 2, plasma glucose dropped from 113.03 ± 1.24 mg/dl in the control group to 100.44 ± 3.76 mg/dl in the treated group ($p < 0.05$). Likewise, HbA1c levels were significantly reduced from 4.6 ± 0.28% to 3.1 ± 0.44% ($p < 0.05$). These findings indicate that *Balanites aegyptiaca* had a notable effect in improving glycemic control in male rabbits, demonstrating lower glucose concentrations and reduced long-term glycation of hemoglobin compared with untreated animals.

Table 1. Plasma glucose and HbA1c of male rabbits treated with Balanites aegyptiaca.

Parameter	Experimental groups	
	Control	Balanites aegyptiaca
Glucose (mg/dl)	113.03±1.243[a]	100.44±3.76[b]
HbA1c(%)	4.6±0.28[a]	3.1±0.44[b]

The means ± SE for each treatment group are provided; n = 5. When mean values within a row did not share a common superscript letter (a, b, or c), significant differences (p<0.05) were observed.

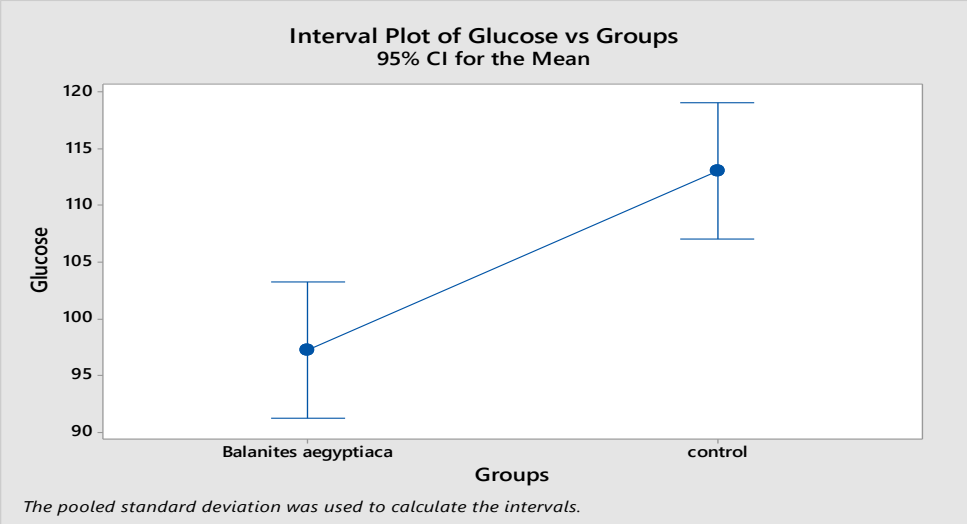

Figure 1. Changes in the weight of glucose levels in the treatment of male rabbits with Balanites aegyptiaca.

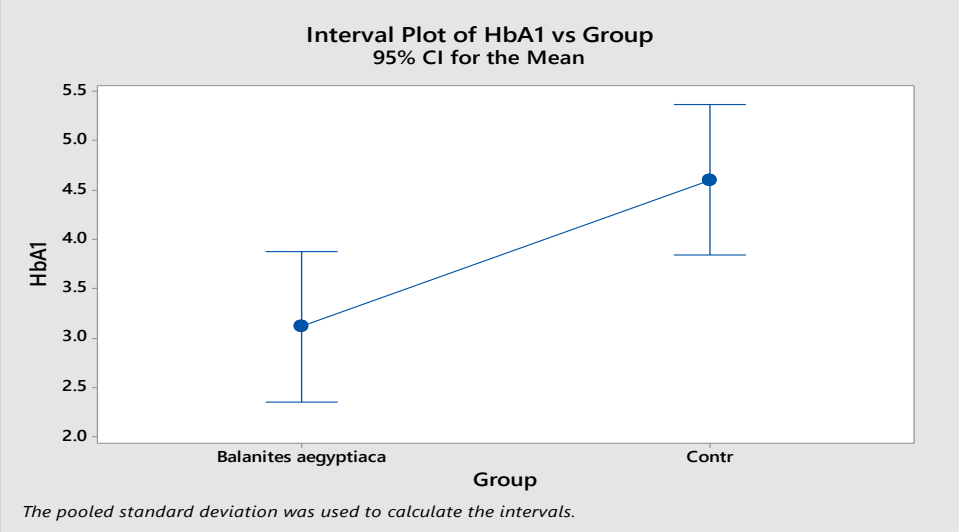

Figure 2. Changes in the weight of HbAc1 treatment of male rabbits with Balanites aegyptia.

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The results in (Table 2) and (Figures 3–6) show that treatment with *Balanites aegyptiaca* extract significantly improved the lipid profile of male rabbits compared with the control group. Total cholesterol levels decreased from 112.93 ± 2.19 mg/dl in the control group to 97.43 ± 3.11 mg/dl in the treated group ($p < 0.05$), while triglyceride (TG) levels dropped from 61.44 ± 2.27 mg/dl to 49.08 ± 2.86 mg/dl ($p < 0.05$). High-density lipoprotein (HDL) increased significantly from 46.0 ± 0.46 mg/dl in the control group to 50.0 ± 1.65 mg/dl in the treated group ($p < 0.05$). However, no significant change was observed in low-density lipoprotein (LDL) levels between the two groups. These findings indicate that *Balanites aegyptiaca* supplementation was associated with lower cholesterol and triglyceride concentrations and higher HDL levels, suggesting an overall improvement in lipid metabolism in treated rabbits compared with the control group.

Table 2. Plasma Cholesterol, triglycerides, high-density lipoprotein, low density lipoprotein of male rabbits treated with Balanites aegyptiaca.

Lipids Profile (mg/dl)	Experimental groups	
	Control	Balanites aegyptiaca
Cholesterol	112.93±2.197[a]	97.43±3.110[b]
TG	61.44±2.269[a]	49.08±2.862[b]
HDL	46.0 ±0.465[b]	50.0 ±1.652 [a]
LDL	60.77±0.562[a]	59.24±1.660[a]

For every treatment group, the values are shown as means ± SE; n = 5. The mean values within a row that did not share a common superscript letter (a, b, or c) showed significant differences ($p<0.05$).

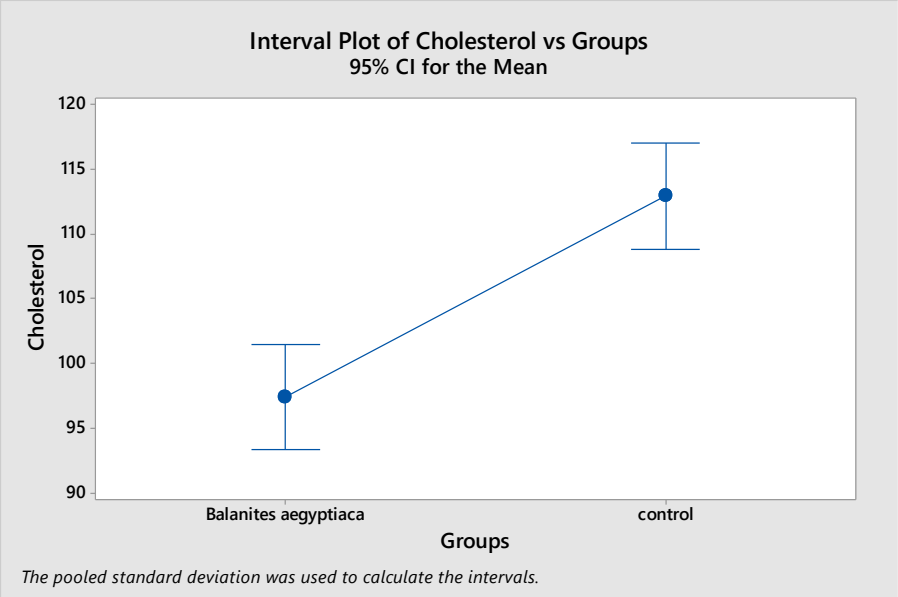

Figure 3. Results of treating male rabbits with Balanites aegyptiaca altered their total cholesterol (TC) levels.

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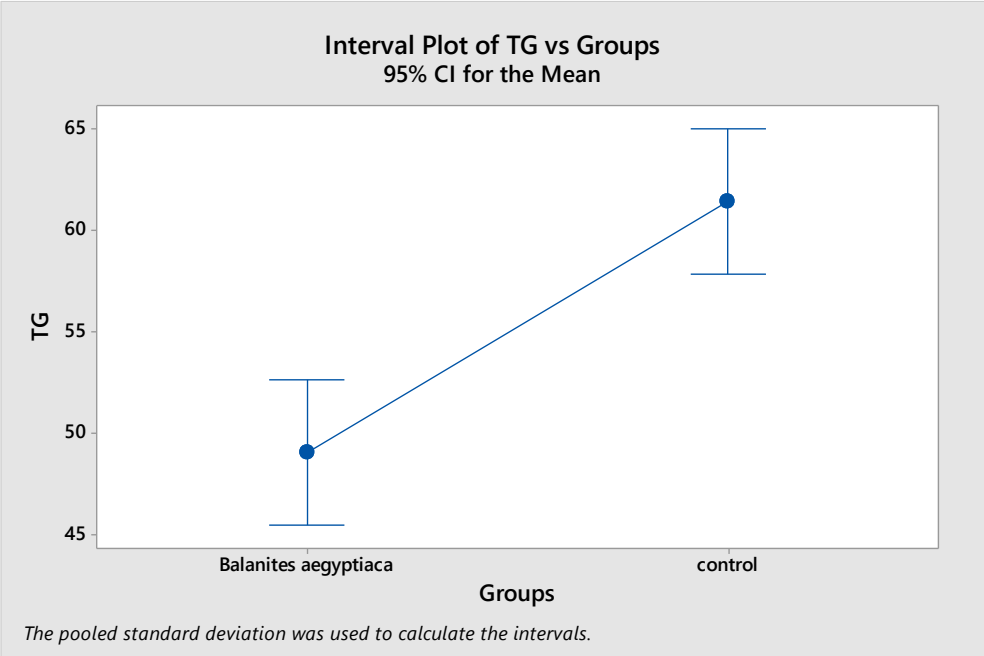

Figure 4. Triglyceride (TG) changes in male rabbits treated with Balanites aegyptiaca

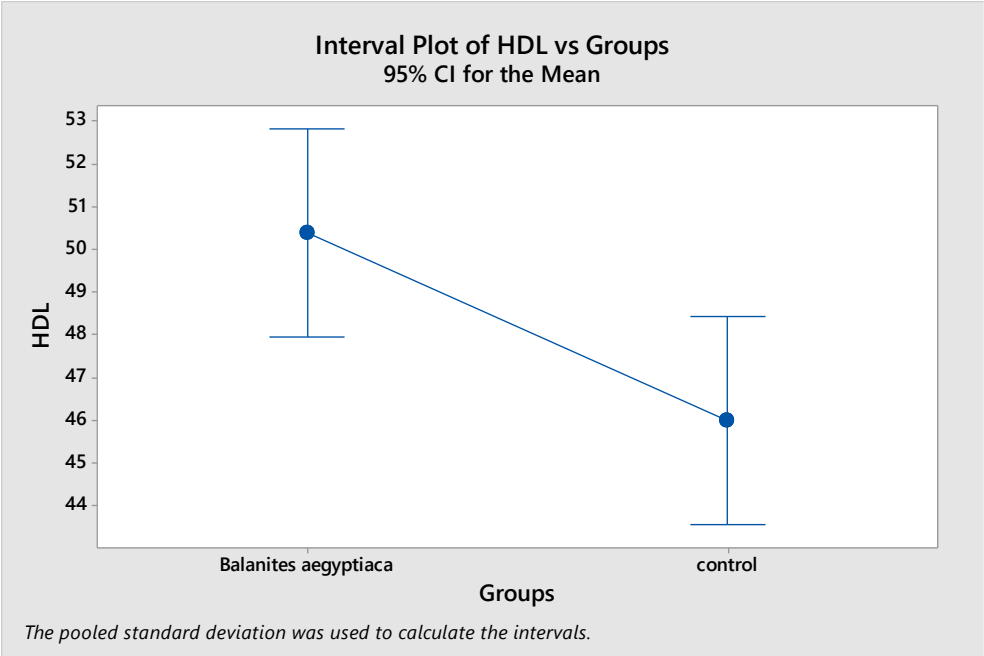

Figure 5. Differences in "high-density lipoprotein-cholesterol," "HDL-c," in blood plasma across male rabbits treated with Balanites aegyptiaca.

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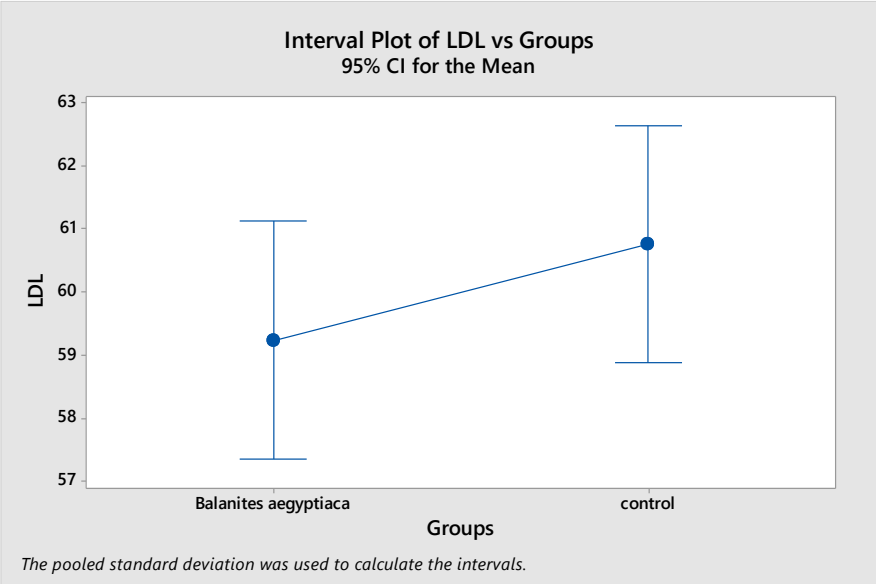

Figuer 6. Alterations in "low-density lipoprotein-cholesterol-cholesterol LDL-c in blood plasma when male rabbits are treated with Balanites aegyptiaca.

Discussion

The results from (Table 1) indicate a statistically significant reduction ($p < 0.05$) in fasting plasma glucose levels in rabbits treated with *Balanites aegyptiaca* extract compared to the control group. This finding suggests that *Balanites aegyptiaca* possesses hypoglycemic properties [8-20]**.** This effect may be attributed to the plant's rich content of saponins, flavonoids, and polyphenolic compounds, which are known to enhance insulin sensitivity, promote glucose uptake in peripheral tissues, and inhibit intestinal glucose absorption [21-30]. Recent studies confirm that these phytochemicals can modulate glucose metabolism by targeting key enzymes such as α-amylase and glucose-6-phosphatase [31-39]**.** In addition to reducing blood glucose, the treatment with *Balanites aegyptiaca* significantly decreased HbA1c levels in the control group and in the treated rabbits. Since HbA1c reflects average blood glucose levels over a period of 2–3 months, its reduction in the treated group confirms the sustained antihyperglycemic effect of *Balanites aegyptiaca* [9]. The decrease in HbA1c may also suggest an improvement in glycemic control and a reduction in glucose-mediated oxidative stress and protein glycation. These outcomes align with previous findings showing that *Balanites aegyptiaca* enhances pancreatic β-cell function and insulin secretion in diabetic models [40-45].

The changes illustrated in (Figure 1) and (Figure 2) further validate these biochemical findings, showing clear downward trends in both glucose and HbA1c levels following treatment. The graphical data suggest that the glycemic control effect is not only statistically significant but also biologically relevant. This supports the therapeutic potential of *Balanites aegyptiaca* in managing hyperglycemia and preventing complications associated with diabetes mellitus. It also aligns with global research efforts exploring plant-based interventions for metabolic disorders [46]. The plasma lipid profile of male rabbits treated with Balanites aegyptiaca showed significant improvements in several key lipid markers. The total cholesterol level was significantly reduced ($p < 0.05$) in the treated group compared to the control group. This hypocholesterolemic effect could be attributed to the high content of bioactive compounds in Balanites aegyptiaca, particularly saponins and polyphenols, which have been shown to bind cholesterol in the gastrointestinal tract, inhibit its absorption, and enhance its excretion. Furthermore, these compounds may modulate key enzymes involved in cholesterol biosynthesis, such as HMG-CoA reductase [47-50]**.** Triglyceride (TG) levels were also significantly lower in the Balanites aegyptiaca-treated rabbits versus the control group.

The reduction in TG may result from improved lipid metabolism and enhanced activity of lipoprotein lipase, an enzyme responsible for breaking down triglycerides in the bloodstream. The plant's antioxidant flavonoids may also prevent lipid peroxidation, which is often elevated in hyperlipidemic conditions. These findings support the use of Balanites aegyptiaca as a natural remedy for hypertriglyceridemia [51-53]**.** Interestingly, a significant increase in high-density lipoprotein (HDL) cholesterol was observed in the treated group compared to the control. HDL is often referred to as "good cholesterol" due to its protective role in cardiovascular health by mediating reverse cholesterol transport [54]**.** The observed HDL-raising effect of Balanites aegyptiaca may be attributed to its antioxidant constituents, such as α-tocopherol and flavonoids, which can upregulate apolipoprotein A1 expression and enhance HDL particle formation [55]. The low-density lipoprotein (LDL) cholesterol levels showed a slight, statistically nonsignificant decrease in the Balanites aegyptiaca group compared to the control. Although not significant, this mild reduction aligns with the plant's overall lipid-lowering trend. The minimal change in LDL may be due to dosage,

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treatment duration, or individual metabolic responses. Nonetheless, the combined reduction in total cholesterol and triglycerides with increased HDL suggests a favorable shift in the lipid profile, potentially lowering cardiovascular risk [56].

Conclusion

Administration of *Balanites aegyptiaca* extract to male rabbits resulted in a significant improvement in plasma lipid profile parameters. The extract effectively reduced total cholesterol and triglyceride levels while increasing HDL concentrations compared with the control group. These findings suggest that *Balanites aegyptiaca* may possess hypolipidemic properties and could be beneficial in promoting cardiovascular health through modulation of lipid metabolism. Further studies are recommended to explore its active components and potential therapeutic applications.

Conflict of interest. Nil

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