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Tuem SRDepartment of Biochemistry,
University of Douala, P.O. BOX
24157 Douala, Cameroon**Ndomou M**Department of Biochemistry,
University of Douala, P.O. BOX
24157 Douala, Cameroon**Manz KJC**Department of Biochemistry,
University of Douala, P.O. BOX
24157 Douala, Cameroon**Nchoutpouen NM**Department of Biochemistry,
University of Douala, P.O. BOX
24157 Douala, Cameroon**Gouado I**Department of Biochemistry,
University of Douala, P.O. BOX
24157 Douala, Cameroon**Corresponding Author:****Ndomou M**Department of Biochemistry,
University of Douala, P.O. BOX
24157 Douala, Cameroon

Effect of aqueous and methanolic extracts of *Solanum aethiopicum* Linn Gilo (*Solanaceae*) leaves on body weight and Glycemia in rats with alloxan-induced diabetes

Tuem SR, Ndomou M, Manz KJC, Nchoutpouen NM and Gouado I

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Abstract

The aim of this study was to evaluate effects of aqueous and methanolic leaves extracts of *Solanum aethiopicum* Linn Gilo on hyperglycemia and body weight in rats. Leaves were dried, crushed to obtain powder that were used to prepare extracts. The extracts underwent phytochemical screening and administered to alloxan diabetic transformed rats at 200 and 300 mg/kg body weight. Chemical analysis of extracts revealed presence of flavonoids, terpenoids, saponins, polyphenols, alkaloids, tannins and cardiac glycosides. Measurements of fasting blood glucose showed a hypoglycemic effect of aqueous extracts which stood at -61.18% and -61.38% respectively for 200 and 300 mg/kg body weight against -59.50% and -60.60% for methanolic extracts. The reduction rate was -55.65% for glibenclamide, a reference antidiabetic drug. It could be concluded that aqueous and methanolic extracts of the leaves of *Solanum aethiopicum* Linn gilo, could be used to manage body weight under hyperglycemia and treatment of diabetes.

Keywords: *Solanum aethiopicum*, diabetes, Alloxan, blood sugar, body weight

1. Introduction

Diabetes is a heterogeneous group of metabolic diseases whose main feature is chronic hyperglycemia resulting from a defect in insulin secretion (type -1) or insulin action (type-2), or both at the same time [1]. In addition, diabetes can be favored by disorders of the use of glucose in muscle tissue cells, hereditary and environmental factors as well as by other pathologies [1]. The logical consequence of this disease is a high mortality rate. According to the International Diabetes Federation, one person dies of diabetes every 6 seconds in the world, more than AIDS, tuberculosis and malaria. From 422 million diabetics in 2017 in the worldwide. It is estimated that by 2045 it will reach 545 million [2]. 15.5 million people have diabetes in Africa. In Cameroon, diabetes is a serious health problem. It is estimated that about 6% of people have diabetes [3]. Diabetes management currently relies on the use of injectable and oral antidiabetic drugs such as sulfonamides and glitinides. However, several incidents causing an undesirable condition or numerous treatment-related side effects have been reported. In addition, there is insufficient access to these drugs in many developing countries, such as Cameroon, as a result of weak economic systems [4]. To overcome this problem, many research focus on plants. Plants have been shown to have antidiabetic activity, such as *Allium sativum* bulb and *Solanum aethiopicum* Linn fruit [5]. *Solanum aethiopicum* LINN is a large group of Solanaceae consisting of four cultivars: Kumba, Gilo, Shum and Aculeatum. Each cultivar is subdivided into subgroups. The Gilo subgroup "Gnangnan", whose French name is bitter eggplant, is a rare cultivar on the local level. *S. aethiopicum* has a high nutritional potential. In addition to this nutritional potential, the vegetable has medicinal properties [6-7-8]. The hypoglycemic activity of *S. aethiopicum* has certainly been demonstrated in fruit [5]. However, at the extend of our knowledge, no study has highlighted the effects of leaves' extract of *Solanum aethiopicum* on diabetes. Knowing that leaves are the ultimate sites of biosynthesis and storage of secondary metabolites responsible for the biological properties of the plant [9]. In this study, the effect of aqueous and methanolic leaves' extracts of *Solanum aethiopicum* Linn GILO on blood sugar and body weight on *Wistar* rats evaluated.

2. Material and methods

2.1 Plant material

Fresh leaves of *Solanum aethiopicum* Linn GILO used in this work were harvested during the raining season (June - July 2021) at Bonepoupa village, Nkam Divison, Littoral Region of Cameroon (4°4'6" N latitude NORD et 10°1'60" longitude Est). The sample were identified at the Cameroon National Herbarium in Yaounde under the number 43008 / HNC compared to the WESTPHAL sample number 9046. After harvest, the leaves were washed with tap water. Drying was done in an airy room until the leaves were dry. They were then crushed and the dark green powder was used for extraction into appropriate solvents (water and methanol).

2.2 Preparation of extracts

2.2.1 Aqueous extract

500 g of leaves powder were poured in 2 L of distilled water. The mixture was boiled for 20 minutes and cooled at room temperature. The mixture was filtered using filter paper. The residue obtained from the filtrate was then dried in an oven at 37 ° C for 2 days. The dry residue was stored in amber glass pillboxes at +4°C [10].

2.2.2 Methanolic extract

The amount of 500 g leaves powder was macerated in a flask containing 2 liters of pure methanol for 48 hours. The resulting mixture was filtered and the residue was extracted twice in 1L of the same solvent. Filtrate was collected in the same vessel and concentrated in a brand rotary evaporator. Extract was allowed to dry at 37°C for two days in an oven and the final residue was obtained stored +4°C in amber glass pillboxes [11].

2.3 Phytochemical screening of extracts

A phytochemical screening was realized on *Solanum aethiopicum* Linn GILO methanolic and aqueous leaves extract to determine the presence of flavonoids, polyphenols, tannins, terpenoids, alkaloids, saponosides, cardiac glycosides, anthocyanines and mucilages [12, 13].

2.4 Animal experimentation

Albino Wistar male rats aged two and a half months and weighing 180 to 200 g were used for the experiment. Pregnant or lactating females were excluded from the study. Rats were obtained from the Department of Animal Biology at the Faculty of Sciences of the University of Douala. They were divided in groups of 5 rats. Each group were introduced in a polyethylene cage. The cages were covered with stainless steel wire mesh. A thick layer of chips was put at the bottom

of the cage and renewed every two days. Rats were subjected to a 2-week acclimation under a 12/12h light/dark cycle. During this period, they had free access to water and food. These animals experimentation were carried out in strict compliance with the principles of the Declaration of Helsinki.

2.5 Induction of type 1 diabetes

Diabetes was induced by intraperitoneal injection of alloxane monohydrate (98%) at a dose of 150 mg / kg body weight. After injection, the rats were returned to cages where they had free access to food and a 5% (w/v) solution of glucose to be drink overnight to avoid hypoglycemic shock. Hyperglycemia was detected after 72 hours and rats with blood glucose level greater or equal to 200 mg/dL were considered as diabetic and were included in our study [14]. On day 4th, rats were force-fed after 12h of fasting. A two-hour hypoglycemic test was then performed. Blood glucose levels of the rats were measured each week using glucometer (ONE TOUCH ULTRA) Body weight was recorded using a precision scale. The experiment lasted for five weeks.

2.6 Experimental design

The Wistar rats were divided into seven groups of 5 each:

- Group I: Normal control rats administered NaCl 0,9 % daily for 5 weeks;
- Group II: diabetic control rats (NDT) administered NaCl 0,9 % daily for 5 weeks;
- Group III: diabetic rats (TDTM) administered glibenclamide (3 mg/ kg) daily for 5 weeks;
- Group IV: diabetic rats (EAI) administered aqueous extract 200 mg/kg daily for 5 weeks;
- Group V: diabetic rats (EAI) administered aqueous extract 300 mg/kg daily for 5 weeks;
- Group VI: diabetic rats (MEI) administered methanolic extract 200 mg/kg daily for 5 weeks;
- Group VII: diabetic rats (MEII) administered methanolic extract 200 mg/kg daily for 5 weeks

2.7 Statistical analysis

All analysis were carried in triplicates and data expressed as means ± standard deviation. One way analysis of variance and Duncan's multiple range test (DMRT) were carried out to assess significant differences between means ($P < 0.05$) using SPSS version 20 software.

3. Results

3.1 Chemical screening

The Table 1 shows the results of the phytochemical screening.

Table 1: Phytochemical screening of *Solanum aethiopicum* Linn GILO leaves extracts.

Compounds	Aqueoux extract	Methanolic extract
Flavonoids	+	+
Polyphenols	+	+
Alkaloids	+	+
Tannins	+	+
Anthraquinones	+	-
Cardiac glycosides	+	+
Mucilages	+	+
Saponins	+	-
Terpenoids	+	-

(+): Present, (-): Absent

Table I shows that both aqueous and methanolic extracts of *S. aethiopicum* Linn GILO contain tannins, flavonoids, polyphenols, mucilages, alkaloids and cardiac glycosides. Anthraquinones, saponins and terpenoids are absent in

methanolic extract.

3.2 Hypoglycemic test

Results of the hypoglycemic test are shown in table II.

Table 2: Rate blood glucose during the hypoglycemic test

Groups	Time (min)				
	0	60	GL1 (%)	120	GL2 (%)
AEI	252.66±8.87 ^b	130.16±6.86 ^c	-48.48	98.08±7.67 ^b	-61.18
AEII	319.41±4.03 ^a	229.0±4.15 ^b	-28.30	123.33±2.64 ^b	-61.38
MEI	291.83±3.11 ^b	162.58±4.86 ^c	-44.28	118.16±3.03 ^b	-59.50
MEII	310.75±3.05 ^a	217.16±4.47 ^b	-30.11	122.41±3.00 ^b	-60.60
NDT	295.66±8.05 ^b	384.75±6.36 ^a	+30.12	435.25±6.55 ^a	+47.20
TDTM	276.83±5.29 ^b	180.41±6.19 ^c	-34.82	122.75±5.72 ^b	-55.65
Control	105.25±7.27 ^b	95.33±3.86 ^c	-9.42	84.91±6.65 ^c	-19.31

EAI: diabetic rats administered aqueous extract 200 mg/kg daily for 5 weeks; EAI: diabetic rats administered Aqueous extract 300 mg/kg daily for 5 weeks; MEI: diabetic rats administered methanolic extract 200 mg/kg daily for 5 weeks; MEII: diabetic rats administered methanolic extract 200 mg/kg daily for 5 weeks; NDT: diabetic control rats administered NaCl 0,9 % daily for 5 weeks; TDTM: diabetic rats administered glibenclamide (3 mg/ kg) daily for 5 weeks Control: normal control rats administered NaCl 0,9 % daily for 5 weeks; GL1: Loss rate of glycemia after 60 minutes; GL2: Loss rate of glycemia after 120 minutes; Column values with different letters in superscript are significantly ($p < 0.05$) different. $n=5$.

Glibenclamide and the various extracts lower glycemia with a reduction rates more than -61% for both 200 and 300 mg/kg of the aqueous extract against -59.50% and -60.60% for the same doses of methanol extract for glibenclamide the

reduction rate was -55.65%.

3.3 Effects of of extracts on Blood glucose

Changes in blood glucose over five weeks are shown in table III.

Table III: Rate changing in blood glucose following treatment with *S. aethiopicum* Linn GILO

Groups	0	W1	W2	W3	W4	W5
AEI	252.66±3.87	-64.74 % ^b	-65.86 % ^b	-69.75 % ^{ba}	-65.96 % ^b	-69.17% ^{ab}
AEII	319.41±4.03	-72.27 % ^a	-70.80 % ^b	-73.11 % ^a	-72.57 % ^a	-75.27 % ^a
MEI	291.83±3.11	-62.14 % ^b	-66.36 % ^b	-67.53 % ^b	-68.65 % ^{ba}	-64.68 % ^b
MEII	310.75±3.05	-54.84 % ^b	-66.45 % ^b	-66.96 % ^b	-72.14 % ^a	-74.32 % ^a
NDT	295.66±2.05	+9.07 % ^d	+14.85 % ^d	+25.70 % ^d	+35.48 % ^d	+50.03 % ^d
TDTM	276.83±1.29	-66.52 % ^b	-66.70 % ^b	-68.24 % ^b	-63.12 % ^b	-62.45 % ^b
Control	105.25±3.27	-20.83 % ^c	-23.51 % ^c	-19.23 % ^c	-14.64 % ^c	-25.26 % ^c

EAI: diabetic rats administered Aqueous extract 200 mg/kg daily for 5 weeks; EAI: diabetic rats administered Aqueous extract 300 mg/kg daily for 5 weeks; MEI: diabetic rats administered methanolic extract 200 mg/kg daily for 5 weeks; MEII: diabetic rats administered methanolic extract 200 mg/kg daily for 5 weeks; NDT: diabetic control rats administered NaCl 0,9 % daily for 5 weeks; TDTM: diabetic rats administered glibenclamide (3 mg/ kg) daily for 5 weeks Control: normal control rats administered NaCl 0,9 % daily for 5 weeks; Column values with different letters in superscript are significantly ($p < 0.05$) different. $n=5$.

S. aethiopicum Linn GILO extracts reduced hyperglycemia more than did glibenclamide. Reduction rates are the following: -69.17% and -75.27% for the aqueous extracts; -64.68% and -74.32% for the methanolic extracts and -62.45% for glibenclamide.

3.3 Effect of extracts on body weight

All diabetic rats have reduced body weight three days after induction of permanent hyperglycemia with alloxan. Figure 1 shows that administration of extracts unlike glibenclamide reduce growth of rats. Growth rates were 24.20% maximum for extracts and 33.03% for glibenclamide.

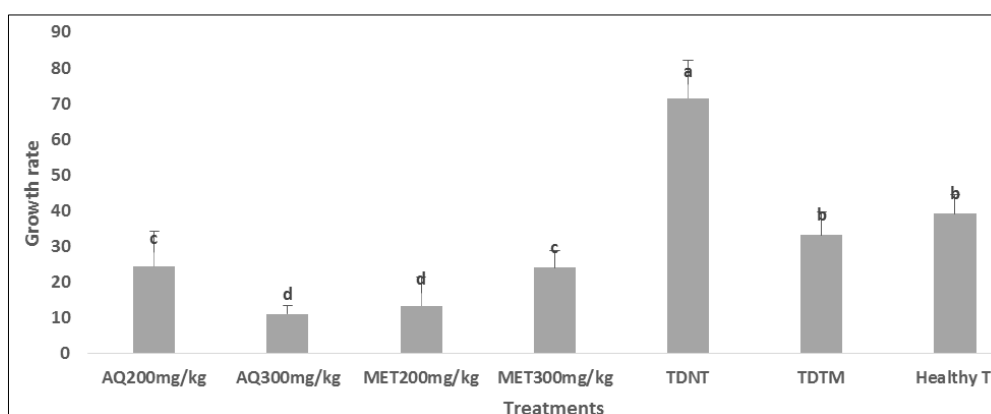


Fig 1: Effects of treatment on rat's growth rate

AQ200mg/kg: diabetic rats administered Aqueous extract 200 mg/kg daily for 5 weeks; AQ300mg/kg: diabetic rats administered Aqueous extract 300 mg/kg daily for 5 weeks; MET200mg/kg: diabetic rats administered methanolic extract 200 mg/kg daily for 5 weeks; MET300mg/kg: diabetic rats administered methanolic extract 200 mg/kg daily for 5 weeks; TDNT: diabetic control rats administered NaCl 0,9 % daily for 5 weeks; TDTM: diabetic rats administered glibenclamide (3 mg/ kg) daily for 5 weeks; Healthy T: normal control rats administered NaCl 0,9 % daily for 5 weeks; Column values with different letters in superscript are significantly ($p < 0.05$) different. $n=5$.

4. Discussion

The phytochemical screening revealed the presence of flavonoids, tannins, saponins, polyphenols, mucilages, alkaloids and cardiac glycosides in aqueous extracts of *S. aethiopicum* Linn GILO. Anthraquinones, saponins and terpenoids are absent in methanolic extract. This might be due to compound's affinity with distilled water. Being more polar than methanol, water is capable of extracting more compounds than does methanol [15]. Similar results were obtained by Sabatino *et al.* [16] who found that fruits of *Solanum aethiopicum* were rich in saponins, alkaloids, tannins, and flavonoids. However, all these compound are reported to possess hypoglycaemic effects [17].

Regarding the effect of extracts on hyperglycemia caused by alloxan, the results show the hypoglycaemic power of these extracts. Opeyemi *et al.* [5], Okafor *et al.* [17] reported that fruits and the methanolic extracts of the leaves of *solanum aethiopicum* decrease blood sugar. This action would be linked to the action or the combination of action of the various secondary metabolites present [18]. The different extracts used could decrease hyperglycemia and regulate blood glucose levels by different mechanisms like muscle transport of glucose. In diabetics, insulin action is greatly reduced and this disturbance is due to a defect in glucose transport [19]. In contrast, increased expression of GLUT-4 in muscle reduces hyperglycemia and increases insulin sensitivity in diabetics [20]. Flavonoids such as quercetin stimulate the translocation of GLUT-4 and thus glucose transport in C2C12 myotubes via the AMPK pathway [16]. Alloxan has been shown to induce diabetes by acting on the Na^+/K^+ ATPase sodium pump. Cardiac glycosides are capable of inhibit the Na^+/K^+ ATPase sodium pump by acting like hypoglycaemic sulphonamides [9]. Indeed, hypoglycaemic sulfonamides bind to a specific receptor on the pancreatic β -cell membrane in the vicinity of the dependent potassium channel ATP and cause its closure. This will cause a membrane depolarization of β cells with opening of the voltage-dependent calcium channels and an influx of Ca^{2+} thus triggering by exocytosis the extrusion of insulin secretion granules [9].

Finally, with regard to the effect of the extracts on body weight gain, the results show that our extracts not only allow the recovery of body weight but above all make it possible to maintain and regulate weight gain. Mbegbu *et al.* [21] have shown that a diet rich in dietary fiber can reduce body weight gain. Ayodele *et al.* [6] showed that fruits and leaves of *Solanum aethiopicum* have dietary fiber. It has also been suggested that polyphenols may induce control of weight gain by inhibiting digestion and absorption of carbohydrates and lipids, resulting in reduced digestion and absorption of these macronutrients and caloric intake. Numerous studies have highlighted the ability of polyphenols to inhibit the key

enzymes of carbohydrate digestion (alpha-amylase and alpha-glucosidase) and pancreatic lipase [22, 23]. The inhibition of these enzymes by polyphenols results in reduced digestion and absorption of macronutrients resulting in decreased caloric intake and therefore control of body weight gain.

5. Conclusion

The results of the present study depict that Leaves extracts of *Solanum aethiopicum* Linn GILO have many types of secondary compounds. Oral Administration of the Leaves extracts of *Solanum aethiopicum* Linn GILO reduce blood sugar, regulate and control rat body weight gain. These results suggest that these extracts can be used in the treatment of Diabetes.

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