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# Anti-hyperglycemic effect of *Momordica charantia* green fruit extract

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***Abstract***
*Type 1 diabetes was a destruction of beta cells ultimately leading to a lack of insulin production. In rural African communities, approximately 80% of the population continue used herbal medicine to control or treat diabetes. The main objective of this work was to experimentally verify the action of the green fruit of Momordica charantia on induced diabetes and its safety. For this purpose, the composition of the fruit was determined by phytochemical screening and aqueous extraction by the maceration method. The efficacy of the extracts was tested in Wistar rats rendered diabetic by the injection of five doses of streptozotocin at 40 mg/kg body weight. Then the rats were treated with the fruit extract for 28 consecutive days at 10mg/L. The dosage of biochemical parameters such as glycaemia, triglycerides, cholesterols, serum creatinine and hemogram were carried out on blood samples. The histological study was made after fixation of the pancreas with formalin and staining of the sections with Hematoxylin-Eosin. The toxicity of the extract was evaluated by larval toxicity test and acute and subchronic oral toxicity tests.*
*Phytochemical analysis of Momordica charantia green fruit powder revealed alkaloids, triterpenes, steroids, mucilages, flavonoids, reducing compounds and saponosides. The toxicity tests of the extract showed an absence of cytotoxic activities at the renal, hepatic and hematological levels.*
*For the efficacy test, the extract lowered hyperglycemia, hypertriglyceridemia, increased HDL cholesterolemia and corrected hypercreatinineemia and hyperleukocytosis due to diabetes. In histology, the extract corrected the cell damage of pancreatic Langerhans islets observed in diabetes. These effects would be due to the secondary metabolites present in the fruit.*
*In conclusion, the green fruit extract of Momordica charantia has shown anti-diabetic activities, was non-toxic and restored damaged Langerhans islets of pancreas.*
***Keywords:*** *Diabetes, Momordica charantia, green fruit, Benin.*

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## I. INTRODUCTION

Several plants were used empirically for primary health care by people although these plants still suffer from the lack of scientific research. The reason was the high cost of modern synthetic drugs, but also this use was particularly based on the idea that plants were a natural means of treatment without risk[1,2]. Several reasons explained the use of complementary natural medicine despite the progress of treatments and the knowledge disponible on the disease. These included the incidence of adverse effects of synthetic drugs, the insufficiency of health infrastructure in developing countries[3–5] , especially Benin. Many medicinal plants were now used by traditional medicine to treat many conditions, including diabetes and its complications. This was the case of Momordica Charantia, or bitter melon or African cucumber whose extracts from the different organs (stem, leaf, fruit, seed) displayed various medicinal properties, in particular anti hyperglycemic [5,6]. This plant of the

Cucurbitaceae family widely found in the tropical and subtropical regions of the world and often used in the countries of South Asia, South America and the Orient as a vegetable or medicinal plant. Several studies reported the effects of this plant on metabolic phenomena linked to diabetes[6]but also on anti-inflammatory and cytotoxic activities[7–11].

Diabetes was a major public health problem due to its significant and growing prevalence on the one hand, and its socio-economic impact on the other[3]. Like other autoimmune diseases, it increased since the second half of the 20th century, and apart from its impact on mortality, it caused many disabilities, through its complications in different organs[12]. Diabetes was a chronic disease that occurs when the pancreas did not produce enough insulin or when the body was unable to use the insulin it produces effectively. Insulin was a blood sugar regulating hormone. Hyperglycemia (too high concentration of glucose in the blood) was a common effect of uncontrolled diabetes, which over time leaded to serious damage to many parts of the body, especially nerves and blood vessels. [13]. Diabetes was manifested by an increased need to urinate, which becomes frequent and occurs night and day, with abundant urine (polyuria); increased thirst (polydipsia); weight loss despite an increased appetite; severe fatigue or blurred vision. Its major consequences were blindness, kidney failure, myocardial infarction, stroke and amputation of the lower limbs[13].

According to global estimates, 1.5 million deaths were directly caused by diabetes in 2019[13]. The latest estimates from the International Diabetes Federation (FID/IDF), revealed that the number of diabetics in Africa will almost triple between 2017 and 2045, rising from 16 million to 41 million[14]. In Benin (Cotonou), a survey carried out in 2002 revealed a prevalence of diabetes of 3.3%[15].

Type 1 diabetes, formerly called insulin-dependent or juvenile diabetes, mainly affected children and young adults (WHO 2021). Type 1 diabetes touched approximately 9 million people worldwide[13]. It affects approximately 1 million children and adolescents with an incidence that increases annually by 3% in younger and younger children[4]. Type 1 diabetes was characterized by the inability of pancreatic cells to respond to the demand for insulin secretion due to an almost complete loss of these cells[13,16]. This was a progressive autoimmune destruction of the beta cells of the pancreas islets responsible for the endogenous secretion of insulin ensuring glucose homeostasis under physiological conditions[17]. Pancreatic beta cell mass was destroyed at disease onset, the autoimmune process was markedly advanced when hyperglycaemia appears with nearly 70% of beta cell mass destroyed[17–19]. The development of autoantibodies directed against these islets would be explained by a loss of regulation of immunity, exposure to environmental factors or even genetic predispositions[20,21].

Several previously cited studies showed the anti-hyperglycemic activity of Momordica charantia fruit juice, but no clarification has been made on the effect of the aqueous extract of the green fruit of this plant on type 1 diabetes and its effect on pancreatic cells. The use of the variety of Momordica charantia from Benin still sufferd from a lack of scientific investigations as to its hypoglycemic and antidiabetic properties and as to its effect on the β cells of pancreatic Langerhans islets the during type 1 diabetes. This work aims to address these concerns.

## II. MATERIAL AND METHODS

**Plant materials**

The green fruit of M. charantia was collected in November 2021 in the south-eastern part of Benin, precisely in Sèmè-Kpodji in the department of Ouémé. The plant was identified in the National Herbarium of Benin at the University of Abomey-Calavi, (Momordica charantia L. Cucurbitaceae).

**Preparation of the fruit extract**

The samples were spread out in a cold drying room (22°C) for about 14 days, after which the samples were brittle and were practically anhydrous. Then the dry samples were reduced to powder using an electric grinder. The powders thus obtained were sieved with a sieve with a diameter of 710 µm. The extraction of the total chemical principles was made according to the method of maceration for a comparison of the activities to be determined. To obtain the macerated, the mixture of 50g of drug with 500mL of distilled water was left in continuous agitation for 48 hours. Then filtered as before and the filtrate obtained was concentrated to dryness using a rotavapor at 40°C. The extraction was repeated 10 times on the same quantity of 50g powder.

Finally, the various dry residues obtained were weighed and the yield was calculated according to the expression:

$$Yield\ (\%) = \frac{Mass\ of\ dry\ extract}{Initial\ mass\ of\ powder}\ X\ 100$$

**Phytochemical analysis**

The phytochemical screening was based on the differential reactions (coloration and precipitation) of the main groups of chemical compounds contained in M. charantia according to the classic method of Houghton and Raman (1998)[22–24]and which was widely used in the literature with success [23, 25]. This analysis included the

search for alkaloids, polyphenolic compound, quinone derivatives, saponosides, steroid triterpenoids, cyanogenic derivatives, mucilages, coumarins, reducing compound, anthracene derivatives and cardiotonic heterosides.

**Larval toxicity test**

Artemia salina eggs were incubated in seawater until hatching of young larvae (48 hours). A stock solution of the extract was prepared by dissolving 200 mg of extract in 4 mL of distilled water, i.e. a concentration by weight of 50 mg/mL. Ten (10) successive half (1/2) dilutions of the stock solution with seawater were carried out. A defined number of larvae (16) was introduced into each dilution. All the solutions as well as control solutions containing no active substance were left under stirring for 24 hours. Macroscopic counting of the number of surviving larvae in each solution was used to assess toxicity. If deaths were observed in the control medium, the data are corrected by the Abbott formula:

$$\%\ death = \frac{test - control}{control} x100$$

The dose-response data were log-transformed and the LC50 was thus determined by linear regression.

**Animal material**

Male Wistar Rats of approximately 132-218 g in weight were obtained from the animal facility of the National Agricultural University of Ketou. The monitoring of the rats was done in plastic cages with beds of wood shavings and in a suitable room (light/dark cycle of 12:12 hours and temperature: 25∘C). Animals were divided into experimental groups of 5 rats each and were fed a commercial diet of normal rat pellets (35% carbohydrate, 25% protein, 7% fat and 3% vitamins)[25] and water ad libitum.

**Ethics Statement**

The study was approved by the National Research Ethic review Boards of Benin. The Wistar rats used in this study were handled according to the institutional animal safety guidelines (Animal facility, National School of Applied Biosciences and Biotechnologies, National University of Sciences, Technologies, Engineering and Mathematics, Benin).

**Induction of type I diabetes**

Induction of diabetes in rats was done by intraperitoneal administration of five low doses (40 mg/kg body weight) of streptozotocin (Sigma Chemicals, ref S1301G) after an overnight fast[27]. Streptozotocin (STZ ) was previously dissolved daily in 0.1 M citrate buffer, pH 4.5). Control animals were injected with citrate buffer. After the 5 days of injection of STZ to the rats, the rats were left in the breeding conditions for 7 days. This period corresponded to the time of rise in blood sugar. The animals considered to be diabetic were those whose blood sugar level was greater than 1.5 g/L[26].

**Toxicity**

Acute oral toxicity

An acute toxicity test (AOT) was performed as recommended by the Organization for Economic Co-operation and Development guideline 423 for the testing of chemicals[27]. Two groups of rats were formed, namely the control group and the test group. Each group consists of five female wistar rats. Each animal in the control group received by force gavage and in a single dose of distilled water and the animals in the test group received by force gavage and in a single dose 2000 mg / kg body weight of the aqueous extract of Daniellia oliveri. Animals were observed carefully for four hours and then daily for 14 days. They were weighed and the blood was collected by orbital puncture at the start of the experiment and then after 14 days[28,29].

Sub-chronic oral toxicity

The test group for sub-chronic oral toxicity (TSC) consisted of three Wistar rats which received by force gavage the aqueous extract of Uvaria chamae at 200 mg / kg body weight, daily for 28 consecutive days[30]. They were weighed and blood was collected by orbital puncture at the start of the experiment and then after 28 days[28,29].

**Efficiency test**

The extract of the green fruit of Momordica charantia was orally administered to diabetic rats at a dose of 10 mg/kg body weight for 28 consecutive days (four weeks) starting from the 7th day (one week) of induction diabetes. Diabetic and non-diabetic controls did not receive the extract.

**Weight, biochemical and hematological assays**

The Wistar rats were weighed and blood samples were taken in fluoride, dry and EDTA tubes, at the level of the retro-orbital sinus, throughout this period of experimentation.

Several biochemical parameters were measured according to the tests. Uremia, creatinine and transaminases were assayed for toxicity testing. Blood sugar, urea, creatinine, cholesterol, triglycerides and transaminases were measured during the efficacy test. Blood glucose, cholesterols and triglycerides were measured using the peroxidase colorimetric method. Transaminases were assayed by enzymatic kinetics. The complete blood count was performed using blood coulter count KX21.

**Histopathological analysis**

At the end of the experiment, the animals were dissected. The pancreas were removed, fixed in 10% buffered formalin, and embedded in paraffin. The specimen's sections (5 µm) were mounted on glass slides, deparaffinated, and hydrated. For histological analysis, sections were stained with hematoxylin and eosin (H&E), following a standard protocol[31]. The pictures were taken at 400X magnification.

**Statistical Analysis**

The results of the biological parameters were expressed as the mean ± 2 times the standard error on the mean (Mean ± 2 SEM). For each parameter in toxicity tests, the results of days 14 or days 28 were compared with those of Day 0 using the Mann Whitney test. For each parameter in efficay tests, the results of days 12, 17, 22 or days 28 were compared with those of Day 0 using the Dunn's multi-comparison test. The significance level was set at 5%. The graphs were drawn using Graphpad software.

## III. RESULTS

***Chemical composition of the green fruit of M. charantia***

*The results of the phytochemical screening of green fruit was summarized in Table 1:*

**Table I:** Phytochemical screening of the green fruit of *M. charantia*

| *Chemical groups* | *Green fruit* |
|---|---|
| Catechic tannins | - |
| Gallic tannins | - |
| Flavonoids | + |
| Leuco-Anthocyanins | - |
| Anthocyanins | - |
| Alkaloids | ++ |
| Reducing compounds | - |
| Mucilage | + |
| Saponosides | + |
| Cyanogenic derivatives | - |
| Triterpenes | ++ |
| Steroids | ++ |
| Coumarins | - |
| Quinone derivatives | - |
| Free anthracenes | - |
| C-Geosides | - |
| O-Hétérosides | - |
| Cardiotonic derivatives | + |

This table showed that the green fruit of the species studied was very rich in secondary metabolites (7 groups). However, it did not contain toxic chemical groups, namely cyanogenic derivatives, which allowed it safety orally use. But the presence of cardenolides in the extract, constituted a brake on the frequent use without prescription.

**Cytotoxic activity of extracts**

Larval toxicity

Figure 1 showed the result of the larval toxicity test

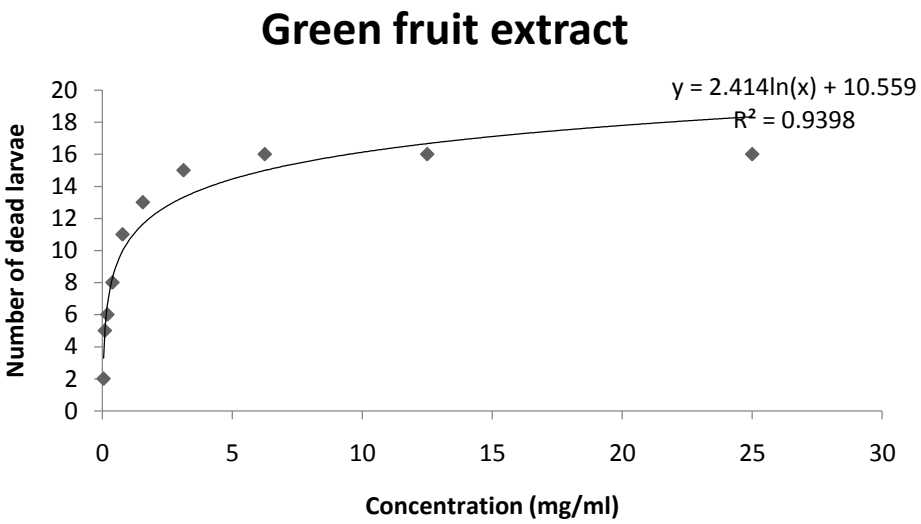



**Figure 4**: Sensitivity curve of larvae to green fruit extract

The extract of the green fruit of M. charantia show no toxicity in the range of concentrations analyzed (LC50 = 0.34 ± 0.05 mg/mL). This value is well above the set toxicity limit which was 0.1 mg/mL[23,32,33].

Acute and subchronic oral toxicity of M. charantia

Table II presented the results of the toxicity tests

***Table II** : Acute and subchronic oral toxicity of M. charantia*

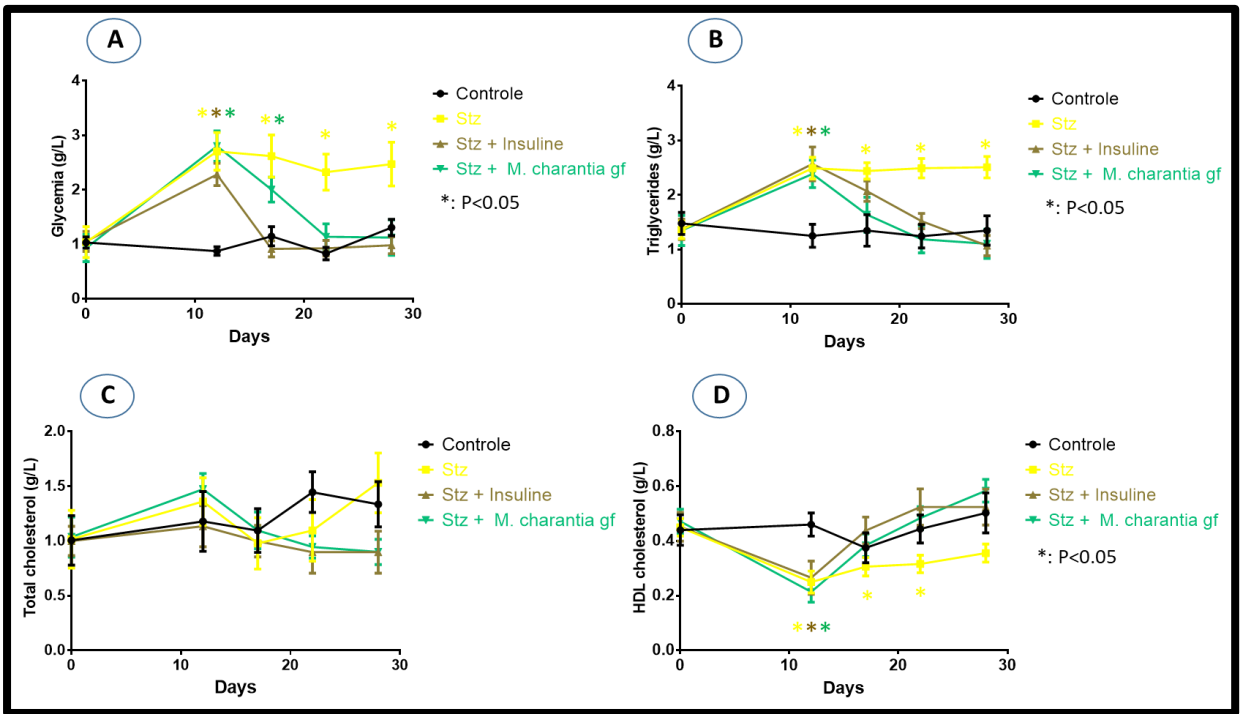
| *Toxicity tests* | *Acute* | | | *Subchronic* | | |
|---|---|---|---|---|---|---|
| Parameters | Day 0 | Day 14 | P value | Day 0 | Day 28 | P value |
| Body weight (g) | 132 ± 15 | 156 ± 17 | 0.2 | 189 ± 19 | 218 ± 23 | 0.2 |
| Creatininaemia (mg/L) | 9 ± 1 | 7 ± 1 | 0.2 | 7 ± 1 | 7 ± 1 | 0.9 |
| Transaminase AST (U/L) | 110 ± 21 | 83 ± 17 | 0.2 | 63 ± 9 | 44 ± 4 | 0.2 |
| Transaminase ALT (U/L) | 71 ± 16 | 78 ± 20 | 0.7 | 44 ± 10 | 48 ± 8 | 0.7 |
| Blood leukocyte count (G/L) | 10.4 ± 1.5 | 11.7 ± 2.1 | 0.4 | 12.0 ± 1.3 | 12.1 ± 2.1 | 0.9 |

In acute oral toxicity test, on day 0, the weight of the rats was 132 ± 15 g, the serum creatinine was 9 ± 1 mg/L, the ASAT and ALAT transaminases were respectively 110 ± 21 U/L and 71 ± 16 U/L, the mean number of blood leukocytes was 10.4 ± 1.5 G/L. These different parameters did not change significantly on day 14, indicating an absence of physical, renal, hepatic and immune functions disturbances of the rats. This result suggested an absence of toxicity of the extract in the acute state. In subchronic oral toxicity test, on day 0, the weight of the rats was 189 ± 19 g, the serum creatinine was 7 ± 1 mg/L, the ASAT and ALAT transaminases were respectively 63 ± 9 U/L and 44 ± 10 U/L, the mean number of blood leukocytes was 12.0 ± 1.3 G/L. These different parameters did not change significantly on day 28, indicating an absence of physical disturbances, renal, hepatic and immune functions of the rats. This result suggested an absence of toxicity of the extract in the sub-chronic state.

**Efficacy of M. charantia green fruit extract**

Effect of M. charantia green fruit extract on carbohydrate and lipid metabolism

The evolution of blood glucose, triglyceridemia, total and HDL cholesterolemia in the different groups of rats was shown in Figure 2.



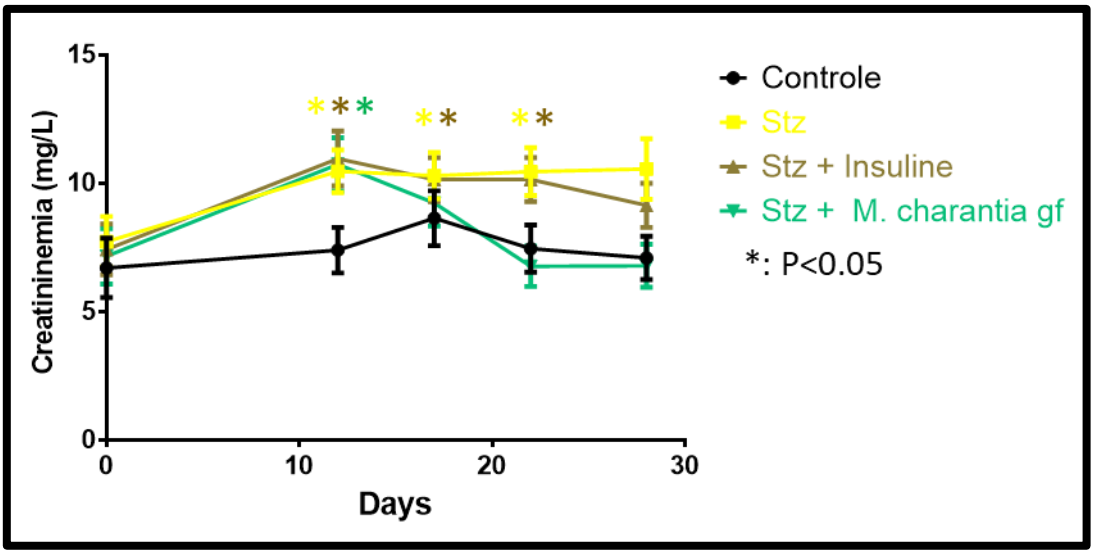

Legend : green fruit (gf) ; streptozotocin (Stz)

**Figure 2 :** Blood glucose, triglyceridemia, total and HDL cholesterolemia in diabetic rats and controls

The glycaemia (figure 2A) varied from 0.88 ± 0.10 to 1.05 ± 0.11 g/L in the various groups of rats at day 0. It increased significantly with a peak at D12 following the treatment of rats with streptozotocin, thus creating diabetes.Then, glycaemia dropped significantly and returned to normal from day 17 in the group treated with insulin, at day 22 in the group treated with green fruit extract of M. charancia. Hyperglycaemia remained at day 28 in the untreated diabetic group. In the control group not treated with streptozotocin, glycaemia was normal throughout the experimental period. The triglyceridemia (figure 2B) varied from 1.34 ± 0.28 to 1.48 ± 0.18 g/L in the various groups of rats on Day 0. It increased significantly with a peak at day 12 following treatment of the rats with streptozotocin. It then fell significantly and returned to its normal values from day 17 in the groups treated with insulin and in the group treated with the green fruit extract of M. charancia. Hypertriglyceridemia persisted at day 28 in the untreated diabetic group. In the control group, triglyceridemia was normal throughout the experimental period.The total cholesterolemia (figure 2C) varied from 1.00 ± 0.27 to 1.16 ± 0.16 g/L in the various groups of rats on D0. It did not vary significantly in the various groups. The HDL cholesterolemia (figure 2D) varied from 0.41 ± 0.04 to 0.48 ± 0.04 g/L in the various groups of rats on day 0. It fell significantly with a peak at day 12 following treatment of the rats with streptozotocin, thus creating HDL hypocholesterolemia.It then increased gradually and returned to its normal values from day 17 in the group treated with insulin and in the groups treated with green fruit extracts of M. charancia. In the untreated diabetic group, HDL cholesterol returned to normal values on day 28. In the untreated control group, HDL cholesterolemia did not vary significantly during the experiment.

**Effect of M. charantia green fruit extract on kidney function**

The effect on renal function was evaluated by the evolution of serum creatinine in the various groups of rats. The results were shown in Figure 3.



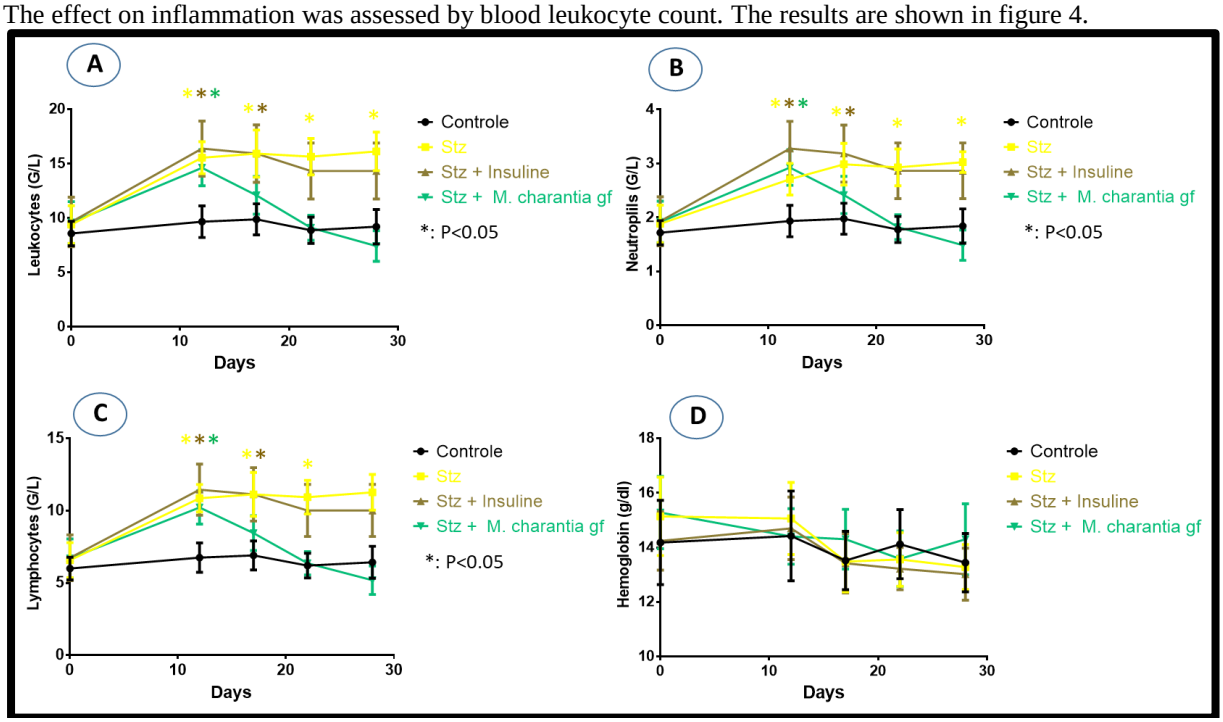

Legend : green fruit (gf) ; streptozotocin (Stz)

**Figure 3:** Evolution of serum creatinine in groups of rats

Serum creatinine varied from 6.7 ± 1.0 to 7.7 ± 0.9 mg/L in the various groups of rats on D0. It increased significantly with a peak at day 12 following treatment of the rats with streptozotocin, indicating renal suffering.Then, it gradually decreased to return to its initial values at day 17 in the group treated with green fruit extract and at day 28 in the group treated with insulin. Serum creatinine did not decrease in the untreated diabetic group. It did not vary significantly in the non-diabetic control group.

Effect of M. charantia green fruit extract on inflammation

The effect on inflammation was assessed by blood leukocyte count. The results are shown in figure 4.




Legend: green fruit (gf) ; streptozotocin (Stz)

**Figure 4:** Evolution of total blood leukocytes, neutrophilis and eosinophilis

The number of blood leukocytes (figure 4A) varied from 8.6 ± 1.0 to 9.6 ± 2.0 G/L in the various groups of rats on day 0. It increased significantly with a peak at day 12 following treatment of the rats with streptozotocin, indicating inflammation. It then decreased gradually and returned to its initial values at day 17 in the group treated with green fruit extract and at days 22 in the group treated with insulin. In the group of untreated diabetic rats, the hyperleukocytosis persisted at day 28. In the non-diabetic control group, the number of blood leukocytes did not vary significantly during the experiment. The number of polynuclears (figure 4B) varied from 1.7 ± 0.2 to 1.9 ± 0.46 G/L in the various groups of rats on day 0. It increased significantly with a peak at

day 12 following treatment of the rats with streptozotocin, indicating acute inflammation. It then decreased gradually and returned to its initial values on day 17 in the groups treated with extract of green fruits and on day 22 in the groups treated with insulin. In the group of untreated diabetic rats, hyperneutrophilia persisted at day 28. In the non-diabetic control group, the number of neutrophils did not vary significantly during the experiment. The number of blood lymphocytes (figure 4C) varied from 6.0 ± 6.7 to 9.6 ± 1.4 G/L in the various groups of rats on day 0. It increased significantly with a peak at day12 following the treatment of rats with streptozotocin, indicating chronic inflammation. It then decreased gradually and returned to its initial values on day 17 in the group treated with green fruit extract and on day 22 in the group treated with insulin. In the group of untreated diabetic rats, the hyperlymphocytosis persisted on day 28. In the non-diabetic control group, the number of blood lymphocytes did not vary significantly during the experiment.The hemoglobin (figure 4D) level varied from 13.6 ± 1.0 to 15.3 ± 1.2 g/dL in the various groups of rats on day 0. It did not vary significantly in the various diabetic or non-diabetic groups during the experiment, indicating an absence of disturbances in erythrocyte parameters.

**Effet of M. charantia green fruit extract on Langerhans islets of the Pancreas**

The effect of the extract on the pancreatic islets of Langerhans of diabetic rats was shown in Figure 5.

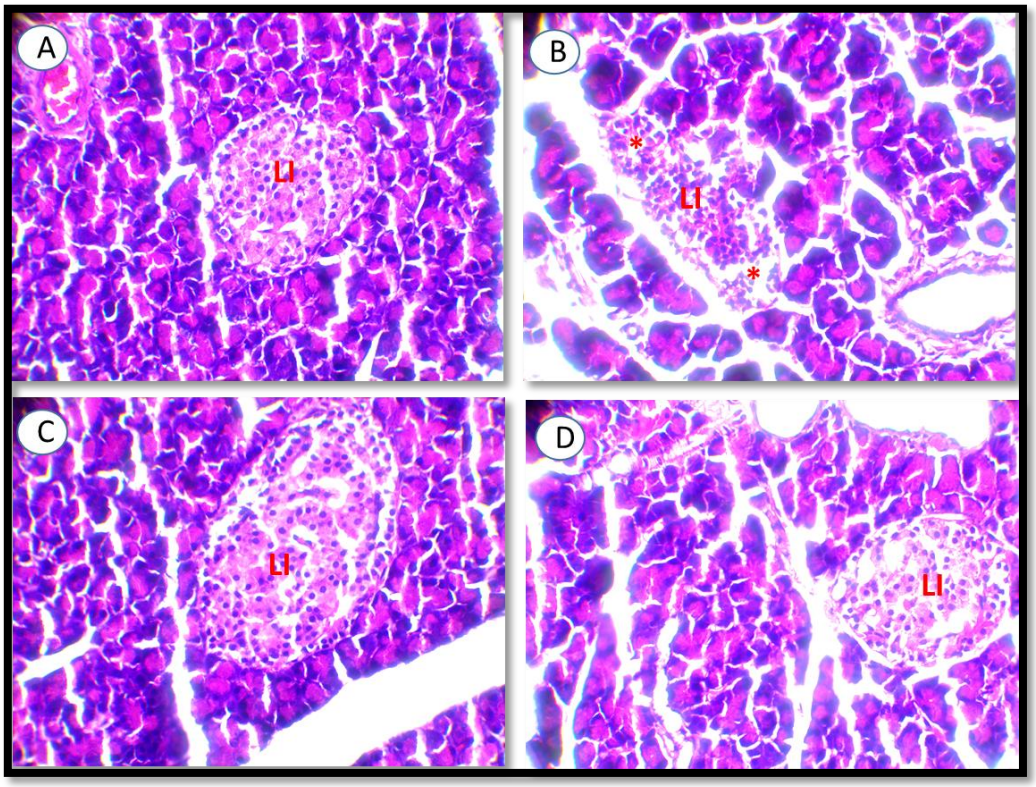



***Figure 5:*** *Histology of the pancreas (magnification 400x)*

In the controls (figure 5A), the Langerhans islets (LI) were typical and were well surrounded by pancreatic serous acini. In rats treated with streptozotocin (figure 5B), the islets of Langerhans were altered by cellular necroses (asterix). In rats treated with streptozotocin, then insulin (figure C) or green fruit extract (figure D), the architecture of the of Langerhans islets were restored.

## IV. DISCUSSION

Momordica charantia was a plant used in traditional medicine to treat diabetes[8,10,34–38]. In this work, we explored the effect of the aqueous extract of its green fruit on glucose and lipid metabolism, kidney function and inflammation in a model of type 1 diabetes in wistar rats. The safety of this green fruit was also tested. For this purpose, the photochemical screening of the green fruit carried out showed alkaloids, triterpenes, steroids, mucilages, flavonoids, reducing compounds and saponosides. This composition, which is like that described by Gurav et al.[39,40].

Green fruit extract like insulin lowered blood sugar in rats made diabetic to streptozotocin. This result could justify the traditional use of the plant. It could justify certain functions attributed to this plant, namely inhibition of intestinal absorption, preservation of insulin secretion by pancreatic β cells, stimulation of glucose

utilization by skeletal muscles, suppression of key enzymes of gluconeogenesis and the stimulation of key enzymes of the Hexose monophosphate pathways[41].

In diabetes, disturbances of glucose metabolism were often accompanied by those of lipids. Thus, triglycerides, total cholesterol and HDL were analyzed. The aqueous extract of the green fruit of Momordica charantia corrected the disturbance of lipid parameters induced by diabetes. Indeed, it lowered the hypertriglyceridema caused by the administration of streptozotocin. It also corrected the drop in HDL cholesterol levels caused by the administration of streptozotocin. These results supported those of Chaturvedi et al. obtained with the methanoic extract of bitter melon in rats [42].

One of the consequences of diabetes was impaired kidney function. To this end, we evaluated the effect of the aqueous extract of the green fruit of Momordica charantia on the renal function of diabetic rats. The extract, better than insulin corrected the hypercreatinineemia induced by the administration of streptozotocin. Such protection of renal function was observed by water from the green hull of cocos nucifera which lowered serum urea and serum creatinine in a model of ethylene glycol-induced nephropathy[43].

Diabetes was also accompanied by inflammation. To this end, we evaluated the effect of the aqueous extract of the green fruit of Momordica charantia on blood leukocytes, following the induction of diabetes. The extract corrected the hyperleukocytosis induced by the administration of streptozotocin, thus showing anti-inflammatory activity. Also, it corrected neutrophilia and lymphocytosis induced by streptozotocin better than insulin, thus showing respectively an inflammatory activity of acute and chronic types. These results supported those of the literature which suggested an inhibitory action of the juice of this fruit on the proliferation of auto-reactive lymphocytes which destroy beta cells in type 1 diabetes[34].

To verify this hypothesis, we observed the effect of the aqueous extract of the green fruit of Momordica charantia on the architecture of the Langerhans islets which contained insulin-secreting beta cells. The extract corrected the cellular necroses observed in the Langerhans islets following the administration of streptozotocin. This suggested that it mediates the regeneration of pancreatic islet beta cells. These properties would be linked to the many secondary metabolites contained in the green fruit, including flavonoids and other antioxidants, which not only could limit oxidative damage to the Langerhans islets, but also promote the regeneration of beta cells[44,45].

In order to verify the specificity of action of the aqueous extract of the green fruit of Momordica charantia on blood inflammatory cells, we followed the evolution of the hemoglobin level in rats after the administration of streptozotocin. The extract did not alter the course of hemoglobin level indicating a lack of effect on red blood cells, another population of blood cells.

Finally, the safety of the extract was tested in vitro by the larval toxicity test and in vivo by the acute and subchronic oral toxicity tests in wistar rats. The extract did not disturb the physical condition of the rats, the weight of the rats not having been affected. The extract did not disturb renal function, serum creatinine did not show any abnormality. The extract did not alter liver function, AST and ALT transaminases did not change indicating an absence of hepatic cytolysis. The extract did not interfere with immune function, with total leukocyte count not changing in acute and subchronic oral toxicity tests. This absence of toxicity at the physical, renal, hepatic and immune levels was consistent with that obtained with the leaf sheath of sorghum bicolor, the roots of Cocos nucifera and the bark of Psorospermum febrifugum Spach which were anti-anaemic plants[28,46,47].

## V. CONCLUSION

This work showed the antidiabetic effect of the aqueous extract of the green fruit of Momordica charantia on type 1 diabetes. The extract lowered hyperglycemia, hypertriglyceridemia and increased HDL cholesterolemia in diabetes. It also improved kidney function and lowered both acute and chronic inflammation that were consequences of diabetes. These beneficial effects were not accompanied by toxicity of the extract either in vitro or in vivo and both in an acute and subchronic state. These encouraging results justified the use of the green fruit of Momordica charantia in traditional medicine and opened up prospects for its transformation into an inexpensive Improved Traditional Medicine (ITM) for the management of diabetes in poor countries.

**CONFLICTS OF INTEREST**

*The authors declared no conflicts of interest*

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**CONTRIBUTIONS OF THE AUTHOR:**

AAC; AE; AF; AKP; AC; SM; participated in the design of the study updated the research methodology and contributed to the drafting of the final document. AAC;HA; SM. coordinated the Phytochemical trial. AAC,

*AKP; AE; LJE; AY; TP. coordinated the Biochemical and histological tests. AAC and SM performed the statistical analysis. AAC; AE; SM; ADC and GJ reviewed the manuscript for submission.*

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