



Original Paper

<http://ajol.info/index.php/ijbcs>

<http://indexmedicus.afro.who.int>

Evaluation of the hypoglycemic activity of *Sclerocarya birrea* (a. rich.) hochst. produced in Chad

Thierry TOGDJIM^{1*}, Elie DOUGRIGUE¹, Al-lamadine MAHAMAT²,
Laurent KODJI¹, Aristide KEMORAL¹, Imar Djibrine SOUDY^{1,2} and
Mbaiguinam MBAILAO¹

¹ Faculty of Exact and Applied Sciences (FSEA), University of N'Djamena, BP: 1117 N'Djamena, Chad.

² Faculty of Human Health Sciences (FSSH), University of N'djamena, BP: 1117 N'Djamena, Chad.

³ Food Quality Control Center (CECOQDA), BP: 4486 N'Djamena, Chad.

*Corresponding author; E-mail: togdjim.thierry@gmail.com, Tel: (+235) 66 59 51 87.

Received: 03-01-2025

Accepted: 26-02-2025

Published: 28-02-2025

ABSTRACT

Diabetes is a chronic disease that occurs when the pancreas does not produce enough insulin or the body does not properly use the insulin it produces. Thus, the objective of this study was to evaluate the hypoglycemic activity of *Sclerocarya birrea* fruits, growing naturally in Chad. Three production sites par excellence for this plant were the subject of the field survey: Sarh, Koumra and Bongor and samples were taken from each site. Blood was collected from the distal end of the tail and deposited on a strip and mounted on a glucometer for glucose reading. Several results showed that the hypoglycemic activities the proportion of glucose in the blood is reduced in the Bongor 2 (121.33 ± 24.78^a) and Koumra1 (100 ± 10.58^a) groups after 45 min. However, Sarh 1 (99.33 ± 13.02^a), positive control (94 ± 6.24^a), Koumra2 (100.67 ± 9.86^a) and Bongor1 (118.67 ± 14.50^a) reduced blood glucose after 60 minutes. Koumra extract had significant hypoglycemic activity compared to Sarh and Bongor. Ultimately, *Sclerocarya birrea* extracts from the three localities reduced blood glucose levels and are important for the proper management of diabetes.

© 2025 International Formulae Group. All rights reserved.

Keywords: Hypoglycemic activities, fruits of *Sclerocarya birrea*, Chad.

INTRODUCTION

Diabetes is a disorder of energy metabolism attributed to low production of insulin, A hormone that causes a reduction in blood glucose level. This disease affects almost 10% of the world population (Zourhani, 2017). In 2021, diabetes affected more than 537 million people worldwide (or 1/10), including 61 million in Europe (Haoes, 2023). The World Health Organization (WHO) is

concerned about the exponential increase in cases of diabetes worldwide, and according to Al-Achi (2005) an increase of 5.4% is expected in 2025. Two main types of diabetes can be distinguished: insulin-dependent diabetes (IDD) most often affects children (Raccach, 2004; Calop and al., 2008) and non-insulin-dependent diabetes (NIDDM) generally begins after the age of 40 (Kebieche et Meraihi, 2009).

Generally, the treatment of diabetes is done with insulin, oral antidiabetics such as sulfonylureas, biguanides, α -glucosidase inhibitors and glinides (Sylla, 2023). In most Developing Countries (DCs), more than 80% of populations use traditional medicine to meet their primary health care needs (Abdelaziz, 2021). The main plant part used is fruit. Usage and analysis of the nutritional and mineral composition of the plant varies according the region. In south africa, the pulp of the sub species. Caffra, the pulp, is used as a sweetener (Kando et al., 2009) and to produce local beer or liquor (Shackleton, 2002).

In Senegal, the bark is used as an anti-odontalgic in dental neuralgia during chewing and for cavities in fillings in the form of pellets (Traoré, 2020). The root bark is indicated in the preparation of a decoction against syphilis, envenomations and snake bites (Traoré, 2020). For external use in general, the bark paste is used as an analgesic and anti-inflammatory for headaches when applied to the forehead added to shea butter, on the eyes for blepharitis (Ekoumou, 2003). In South Africa, the aqueous extract of the trunk bark showed a dose-dependent hypoglycemic activity in normoglycemic rats made diabetic by streptozotocin (Ojewole, 2004).

Traditional treatment of diabetes relies heavily on plants whose medicinal properties have been passed down from generation to generation. *Sclerocarya birrea* (A. Rich.) Hochst, also known as African plum, is a tree belonging to the Anacardiaceae family. Its fruit kernels are used to extract oil for export, mainly to the pharmaceutical industry (Faye et al., 2011).

Recent research on phenolic compounds in general, and flavonoids in particular, has increased due to their various physiological properties, such as antioxidant action (Hameg and Taleb, 2018), modulation of the activity of certain enzymes, vasculoprotective action (Vitor et al., 2004; Ghedira, 2005), anti-inflammatory action (Adiza, 2007) and anti-diabetic action (Adiza, 2007).

Most often, the active ingredients of traditional remedies are not elucidated. They

coexist in these remedies with other compounds which, in some cases, mask their beneficial actions (Karou, 2005). According to the literature, studies on the anti-diabetic effects of *Sclerocarya birrea* fruit are very limited. With this in mind, this study was initiated to assess the impact of the powdered fruits extracts his plant on blood sugar levels. The aim of the present work is to evaluate the hypoglycemic activity of *Sclerocarya birrea* fruits harvested in Chad.

MATERIALS AND METHODS

Plant material

The plant material consists of *Sclerocarya birrea* of fruits produced in three localities namely Sarh, Koumra and Bongor in the South of Chad. The identification of this species is made at the Research Institute for Livestock and Development (IRED)/Chad in N'Djamena (Figure 1 and 2).

Experimental animals

Preferably, the animals used in the experiment are 3- to 6-week-old Wistar rats with free access to water and food. These animals were acclimated to experimentally standard housing conditions (12 hours of light, 12 hours of darkness, and 28°C temperature) (Hunt, 1974; National Research Council (USA). 1979; Sheail, 1971). (Figure 3)

Sample collection

A pre-test study was carried out during a field visit. A pre-prepared survey sheet facilitated the collection of samples through the questions asked. Various samples of *Sclerocarya birrea* fruit were collected in the three localities (provinces). After sampling, the fruits were dried in the shade at a room temperature of 37°C for 2 weeks, then transported to the physicochemistry laboratory at the Centre de Contrôle de Qualité Denrées Alimentaires (CECOQDA) in N'Djamena/Chad for preservation. The fruits are then ground to powder using an electronic grinder, and the powder stored in a dry oven for further study.

Extraction method

The extraction method used is decoction. A sample of the powder mass (5 g) of *Sclerocarya birrea* was introduced into a flask containing a constant volume of 150 mL of distilled water. The mixture was kept at varying temperatures in a water bath, in accordance with the extraction protocol reference. After cooling, the extract was centrifuged at 1500 rpm for 10 minutes. The supernatant (filtrate) was then collected with filter paper and stored in a hermetically sealed sterile bottle for further experimental use (force-feeding the rats).

Extraction plan

An experimental design is used to carry out the extraction. The aim of this plan is to get the most out of our extraction, so as to obtain the best possible conditions.

To achieve this, the design of our work takes into account three (3) factors:

- Temperature (°C) ;
- Time(min) ;
- Mass ratio (m /v) in %.

A total of six (6) tests were carried out, two at each location, at the highest (95°C) and lowest (45°C) temperatures. (Figure 4)

Glucose solution

The solution used is glucose water (10%) at a dose of 2 g/kg body weight for gavage administration to experimental rats.

Measurement of basal blood glucose in normal rats

Prior to measuring basal blood glucose, the rats underwent a 12-h water fast. After this fasting time, the rats were weighed. A drop of blood was taken from the distal end of the tail and deposited on the range of a test strip mounted on an SD Codefree mg/dL glucometer for automatic blood glucose reading. Animals were divided into eight (08) groups of three (3) rats each and all treated for diabetes.

Studies of the hypoglycemic properties of *sclerocarya birrea* aqueous extracts in normal rats under orally-induced hyperglycemia

The test was carried out according to the Normand method (2023). Eight (8) groups of three (3) rats each, of both sexes, were formed into equal groups. To avoid pregnancy, males and females were not housed in the same cages. Rats fasted 12 hours before the start of the experiment, were weighed and marked with a marker on the tails for individual identification. Then, using a glucometer, the basal blood glucose level of each rat was taken at time T0, followed by the administration of glucose (10%) at a dose of 2 g/kg body weight to each rat of the treatment batch ($n=3$) and those of the control batch ($n=3$), in order to observe the evolution of blood glucose levels. After 15 minutes, blood glucose levels were collected from each rat in the groups. Each rat in the treatment group then received a solution of the aqueous extract of *Sclerocarya birrea* at a dose of 2 g/kg body weight. Rats in the control group received demineralized water at the same dose and rats in the positive control group received metformin reduces hyperglycemia without the risk of hypoglycemia unlike other antidiabetics, a reference substance. For the rest of the experiment, each rat's blood glucose was sampled every 15 min for 60 min, or 1 h.

Data analysis

Results were analyzed using STATGRAPHICS centurion XVI, Sigma Plot 11.0 software. The ANOVA test was used to compare mean values, correlations and glycemic parameters.

RESULTS

Determination of hypoglycemic properties of *Sclerocarya birrea* aqueous extracts in normal rats under orally induced hyperglycemia

Glycemic times of different treatment groups

From this study, it could be seen that there was a significant difference ($p<0.05$)

between the different blood glucose times in the negative control batch. Fifteen minutes after the fasting blood glucose level (124.3 mg/dL), there was a considerable increase (140.67 mg/dL) followed by remarkable decreases at times 30 and 45 respectively (115.33 mg/dL) and (110.66 mg/dL), but at T 60, blood glucose levels rose again (116 mg/dL). This indicates the time 15 minutes required for D-glucose to begin its absorption into the blood stream (Table 1).

The metformin-treated group also showed a remarkable increase in blood sugar at T15 (136.66 mg/dL), followed by a significant drop at T30, T45 and T60 (117 mg/dL), (103.33 mg/dL) and 94 mg/dL respectively. This shows that metformin acts at 60 minutes, effectively reducing blood glucose levels (Table 2).

Also, it can be noted that after the fasting blood glucose level (110 mg/dL), there was a sharp rise in blood glucose levels at the fifteenth minute. In addition, a sharp drop in blood glucose levels was observed at T30, T45 and T60 (110.33 mg/dL, 107 mg/dL and 99.33 mg/dL respectively). *S. birrea* extract acted at 60 minutes like the reference product, suggesting that the extract and metformin have a similar time of action on blood glucose (Table 3).

At times 30 ,45 and 60 minutes, the rats are in a hypoglycemic state, with a significant drop being respectively compared with time 15 minutes, or 135 mg/dL. It can be said that the extract of *Sclerocarya birrea* at 95°C reduced in record time the blood glucose level in the treated groups (Table 4).

The results of this study show that, as in previous analyses, blood glucose levels fall in decreasing order for times 30, 40 and 60. However, between the fasting time (116.33 mg/dL) and the blood glucose level after 15 minutes, there was a significant increase (143.67 mg/dL) (Table 5). Also, the present study showed an increasing difference in blood glucose levels between time T0 (121.67 mg/dL) and the postprandial time just after 15 minutes, or 135 mg/dL. At times 30, 45 and 60 min, blood glucose levels dropped significantly

(115.33 mg/dL), (104.67 mg/dL) and (100.67 mg/dL) respectively (Table 6). Furthermore, the group treated with *Sclerocarya birrea* extract showed a considerable increase in blood glucose at T15 (141.67 mg/dL), followed by a significant drop at T30, T45 and T60 (118 mg/dL), (107.67 mg/dL) and 99.67 mg/dL respectively (Table 7).

The results for the different blood glucose times are shown in Table 8. It can be seen that there was no significant difference ($p>0.05$) between the different blood glucose times in all rats of this whole group. However, fifteen minutes after glucose ingestion, normal physiology was observed with an increase in blood glucose (124.67 mg/dL), followed by a slight decrease noted at times 30, 45 and 60 respectively (128.33 mg/dL) and (121.33 mg/dL) and (118.67 mg/dL) (Table 8).

Comparison between treatment groups as a function of blood glucose time

At T0, there are significant differences among the eight (8) experimental groups. There are variations in blood glucose levels since the rats in these different groups are fasting and have normal physiological blood glucose values ranging from 96.67 mg/dL to 126.67 mg/dL (Table 9).

Blood glucose results at time 15 are shown in the table above. It can be seen that there is no significant difference ($p>0.05$) between the different blood glucose times in the rats of this groups.

However, there was a slight increase in blood glucose levels from 124.67 mg/dL to 143.67 mg/dL (Table 10).

At the thirtieth minute, there was a drop in peak blood glucose in the treatment group, ranging from 128.33 mg/dL to 110.33 mg/dL (Table 11).

At time 45 minutes, although there was no significant difference, blood glucose levels continued to fall in all treatment batches, from 121.33 mg/dL to 100 mg/dL, showing persistent hypoglycemia (Table 12).

In some batches, blood glucose levels fell, while in others, fasting blood glucose levels rose. At 60 minutes, blood glucose levels were still falling in all treatment batches, from

118.67 mg/dL to 94 mg/dL, showing persistent hypoglycemia in some and slight hyperglycemia in others. This can be explained by the time required for glucose absorption, which is relatively specific to the extraction parameters and the rats' own metabolism (Table 13).

Correlation between blood glucose levels

Figure 5 shows the different correlations between blood glucose levels. Heatmap correlation analysis (Figure 5) showed that 15 minutes after glucose ingestion, blood glucose values were highest in the Negative Control, Sarh 2, Koumra1, Koumra2,

Positive Control and Bongor1 groups. After 30 min, relative expression was slightly reduced in the Bongor1 and Bongor2 groups. However, it should be noted that the trend was reversed after 60 minutes. A remarkably deficient proportion of blood glucose was observed in batches Sarh1, Koumra1, positive control, Koumra2 and Bongor1 groups after 60 min. In addition, the proportion of glucose in blood was significantly reduced in the Bongor2 and Koumra1 groups after 45 min. These results indicate that Sarh1, Koumra1, positive control, Koumra2 and Bongor1 reduce blood glucose levels after 60 min, as do Bongor2 and Koumra1 after 45 min.



Figure 1: Photo of *S. birrea* seeds (source: Togdjim, 2022).



Figure 2: Photo of *S. birrea* fruit powder (source: Togdjim, 2022).



Figure 3: Rats in the laboratory of the Faculty of Medicine, Hôpital Mère et Enfant, Chad (source: Togdjim, 2023).



Figure 4: Aqueous extract of *Sclerocarya birrea* SARH, KOUMRA and BONGOR (source: Togdjim, 2023).

Table 1: Negative control group (D-glucose treatment + distilled water).

Duncan ^a	P=0,05		
Treatment	1	2	3
0 min		124,33±7,02 ^b	
15 min			140,67±8,14 ^c
30 min		115,33±3,21 ^{ab}	
45 min	110,66±8,50 ^a		
60 min		116±4,36 ^{ab}	

The results of the different blood glucose times are shown in Table 1. The different alphabets a, b and c indicate statistically significant differences between groups ($p<0.05$). 1,2 and 3 represent the different levels of significance designated by a,b and c.

Table 2: Positive control group (D-glucose + Metformin treatment).

Duncan ^a	P=0,05		
Treatment	1	2	3
0 min		119±6,93 ^b	
15 min			136,66±18,47 ^c
30 min		117±3,46 ^b	
45 min		103,33±2,31 ^{ab}	
60 min	94±6,24 ^a		

The results of the different blood glucose times are shown in the table above. The different alphabets a, b and c indicate statistically significant differences between the groups ($p < 0.05$). 1, 2 and 3 represent the different levels of significance designated by a, b and c.

Table 3: group Sarh 1 (D-glucose treatment + *Sclerocarya birrea* extract at 45°C).

Duncan ^a	P=0,05
Treatment	1
0 min	110±10 ^a
15 min	116,67±11,06 ^a
30 min	110,33±17,62 ^a
45 min	107±12,12 ^a
60 min	99,33±13,02 ^a

These statistical analyses show that there is no significant difference ($p > 0.05$) between the different blood glucose times in this group. 1 represents the level of meaninglessness designated by a.

Table 4: Sarh 2 group (D-glucose treatment + *Sclerocarya birrea* extract at 95°C).

Duncan ^a	P=0,05	
Treatment	1	2
0 min		122,67±5,51 ^{ab}
15 min		135±2,64 ^b
30 min	114,67±8,96 ^a	
45 min	110,66±9,16 ^a	
60 min	117,67±5,51 ^a	

The table above shows the results for the different blood glucose times. The different alphabets a, b and c indicate statistically significant differences between groups ($p < 0.05$). 1 and 2 represent the different levels of significance designated by a and b.

Table 5: Koumra 1 group (D-glucose treatment + *Sclerocarya birrea* extract at 45°C).

Duncan ^a	P=0,05	
Treatment	1	2
0 min	116,33±18,88 ^a	
15 min		143,67±7,77 ^b
30 min	108±8,54 ^a	
45 min	100±10,58 ^a	
60 min	94,33±6,35 ^a	

The results of the various blood glucose tests are shown in Table 5. The different letters indicate statistically significant differences between groups ($p < 0.05$). 1 and 2 represent the different levels of significance designated by a and b .

Table 6: Koumra 2 group (D-glucose treatment + *Sclerocarya birrea* extract at 95°C).

Duncan ^a	P=0,05	
Treatment	1	2
0 min		121,67±0,58 ^{ab}
15 min		142±7 ^b
30 min	115,33±20,26 ^a	
45 min	104,67±15,18 ^a	
60 min	100,67±9,86 ^a	

The table above shows the results for the different blood glucose times. The different alphabets indicate statistically significant differences between groups ($p < 0.05$). 1 and 2 represent the different levels of significance designated by a and b .

Table 7: Group Bongor 1 (D-glucose treatment + *Sclerocarya birrea* extract at 45°C).

Duncan ^a	P=0,05		
Treatment	1	2	3
0 min			126,67±9,07 ^{bc}
15 min			141,67±16,50 ^c
30 min			118±12 ^{abc}
45 min		107,67±11,06 ^{ab}	
60 min	99,67±12,50 ^a		

The results for the different blood glucose time points are shown in Table 7. The different letters indicate statistically significant differences between the groups ($p < 0.05$). 1,2 and 3 represent the different levels of significance designated by a,b and c..

Table 8: Group Bongor 2 (D-glucose treatment + *Sclerocarya birrea* extract at 95°C).

Duncan ^a	P=0,05
Treatment	1
0 min	96,67±14,36 ^a
15 min	124,67±32,93 ^a
30 min	128,33±15,37 ^a
45 min	121,33±24,78 ^a
60 min	118,67±14,50 ^a

These statistical analyses show that there is no significant difference ($p>0.05$) between the different blood glucose times in this group. 1 represents the level of meaningfulness designated by a.

Table 9 : Comparaison between treatment group at time 0 minute.

Duncan ^a	P=0,05
Traitement 1	2
Témoin négatif	124,33±7,02 ^b
Témoin positif	119±6,93 ^b
Sarh 1	110±10 ^{ab}
Sarh 2	122,67±5,51 ^b
Koumra 1	116,33±18,88 ^b
Koumra 2	121,67±0,58 ^b
Bongor 1	126,67±9,07 ^b
Bongor 2	96,67±14,36 ^a

The result for different blood glucose times are shown in table 9. The different letters indicate statistically significant differences between group ($p < 0.05$). 1 and 2 represent the different levels of significance designated by a and b .

Table 10: Comparison between treatment groups at time 15 minutes.

Duncan ^a	P=0,05
Treatment	1
Negative control	140,67±8,14 ^c
Positive control	136,66±18,47 ^a
Sarh 1	116,67±11,06 ^a
Sarh 2	135±2,64 ^a
Koumra 1	143,67±7,77 ^a
Koumra 2	142±7 ^a
Bongor 1	141,67±16,50 ^a
Bongor 2	124,67±32,93 ^a

These statistical analyses show that there is no significant difference ($p>0.05$) between the different blood glucose times in this group.

Table 11: Comparison between treatment group at time 30 minutes.

Duncan ^a	p=0,05
Treatment	1
Negative control	115,33±3,21 ^a
Positive control	117,33±3,46 ^a
Sarh 1	110,33±17,62 ^a
Sarh 2	114,67±8,96 ^a
Koumra 1	108,33±8,54 ^a
Koumra 2	115,33±20,26 ^a
Bongor 1	118,33±12 ^a
Bongor 2	128,33±15,37 ^a

Statistical analysis showed that there was no significant difference ($p>0.05$) between the different blood glucose times in this group. 1 represents the level of meaningfulness designated by a.

Table 12: Comparison between treatment group at time 45 minutes.

Duncan ^a	P=0,05
Treatment	1
Negative Control	110,66±8,50 ^a
Positive control	103,33±2,31 ^a
Sarh 1	107±12,12 ^a
Sarh 2	110,66±9,16 ^a
Koumra 1	100±10,58 ^a
Koumra 2	104,67±15,18 ^a
Bongor 1	107,67±11,06 ^a
Bongor 2	121,33±24,78 ^a

Statistical analysis showed that there was no significant difference ($p>0.05$) between the different blood glucose times in this group. 1 represents the level of meaningfulness designated by a.

Table 13: Comparison between treatment group at time 60 minutes.

Duncan ^a	P=0,05		
Treatment	1	2	3
Negative control			116±4,36 ^{bc}
Positive control	94±6,24 ^a		
Sarh 1		99,33±13,02 ^{ab}	
Sarh 2			117,67±5,51 ^{bc}
Koumra 1	94,33±6,35 ^a		
Koumra 2			100,67±9,86 ^{abc}
Bongor 1		99,67±12,50 ^{ab}	
Bongor 2			118,67±14,50 ^c

The different alphabets indicate statistically significant differences between groups ($p < 0.05$). 1,2 and 3 represent the different levels of significance designated by a,b and c.

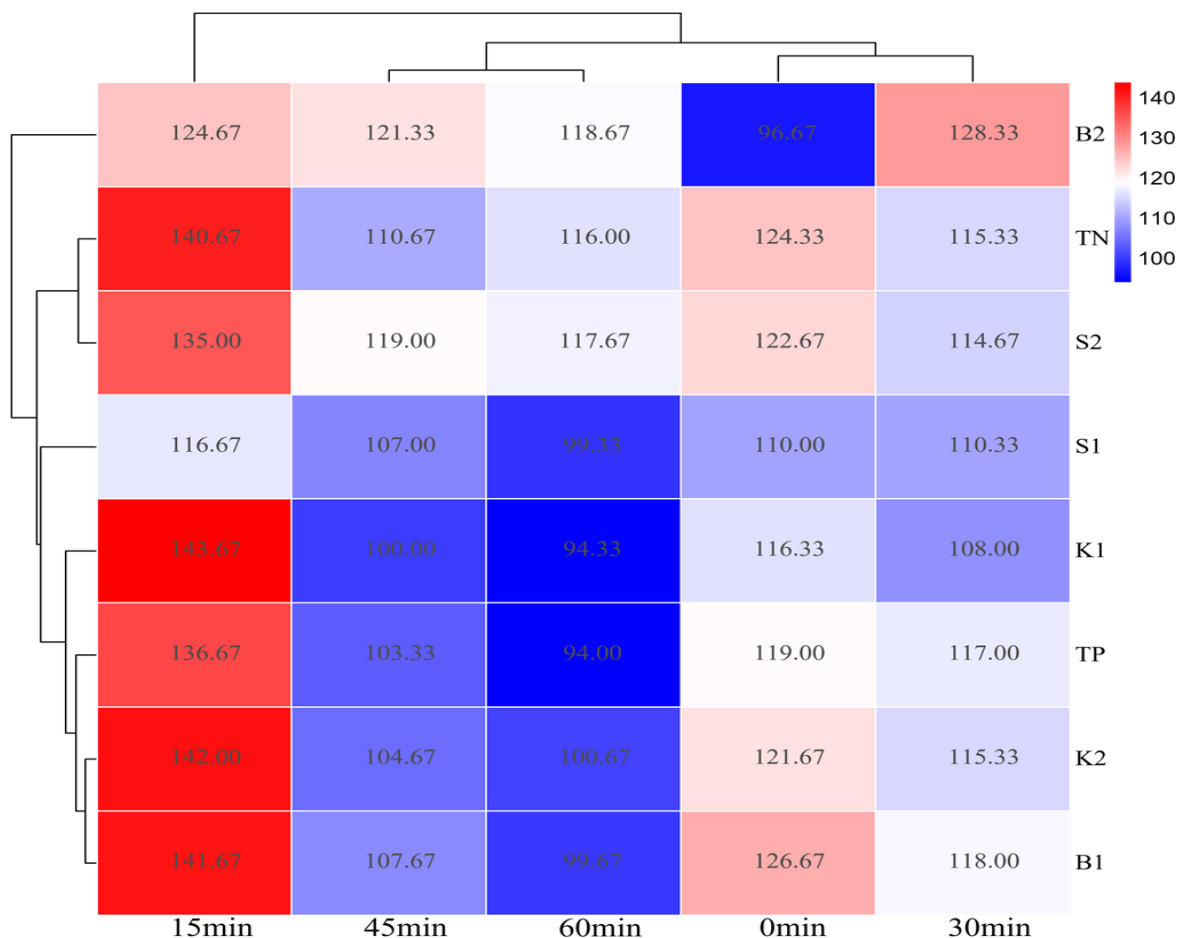


Figure 5: Correlation between blood glucose levels.

DISCUSSION

Sclerocarya birrea, a plant used in traditional medicine for its many virtues. Its various traditional uses are important and help to complete the file of the phytomedicine Diabétisane from the Department of Traditional Medicine (DMT). Hyperglycemia can be induced temporarily from a glucose solution or permanently with agents such as streptozotocin or alloxan (Hanhineva and al., 2010). Our results on the Oral Hyperglycemia Induced Test (OGTT) taking into account the different fasting blood glucose times (T0 minute) up to 60 minutes with a test every 15 minutes showed significant differences at ($p < 0.05$) as well as different associated correlations. This study is about temporarily

inducing a D glucose solution in normoglycemic rats and testing every 15 minutes the different blood glucose levels up to 60 minutes or 1 hour.

At the 15th minute, in all treatment batches, blood sugar levels increased very considerably. At the 30th minute, metformin caused a remarkable drop as did the aqueous extracts of the samples from the different cities. At 45 minutes, metformin and all the different aqueous extracts of 10 mL/Kg gave drops in blood sugar levels below those obtained at 45 minutes. At 60 minutes, the reference product, metformin gave a drop of 94.00 mg/dL as well as some extracts caused an increase in blood sugar levels.

The results obtained show that rats ingesting *Sclerocarya birrea* extracts from Sarh1, Koumra1, Koumra2 and Bongor1 showed glycemic reduction values of 99.33 mg/dL, 94.33 mg/dL; 100.67 mg/dL, 99.67mg/dL respectively, compared with the negative control 116.00 mg/dL, one hour after taking the extracts. The aqueous extract of Koumra1 showed the strongest reduction in blood glucose of 94.33 mg/dL, comparable to the positive control (metformin) of 94.00 mg/dL. In fact, the water-soluble compounds other than tannins (flavonoids, saponins, alkaloids, etc.) present in the extracts would provide additional antihyperglycemic activity. The present results differ from those obtained by Niang et al. (2022) on the Hypoglycemic effect of acetonic and methanolic extracts from leaves and bark of *Sclerocarya birrea* (A.Rich.) Hochst in guinea pigs with blood glucose levels 60 minutes after use of the reference product glibenclamide and the aqueous fruit extract. Furthermore, the present results are even lower than those obtained by Maiga et al. (2010) on the study of phytochemistry, antiradical activity and subchronic dependence of leaves of *Sclerocarya birrea*, (A.Rich) Hoscht (Anacardiaceae), used in the traditional treatment of diabetes in Mali 60 minutes after ingestion. In vitro studies have shown the inhibitory effect of aqueous globular leaf extract on pancreatic and intestinal α -amylases (6.03 ± 0.33 mg/mL) and a 13% reduction in blood glucose levels in rats in the study by Stéphan (2020).

In the regulation of blood glucose, previous work suggests that minerals such as calcium, magnesium and copper potentiate the action of secondary metabolites. These are essential elements involved in molecular structures and in many metabolic reactions (Victor et al., 2020). In addition, it has been shown that polyphenolic compounds, including flavonoids, are capable of activating the Phosphoinositide 3-kinase (PI3K) signaling

pathway. This activation would result in an insulinomimetic action that would stimulate glucose absorption, glycogen synthesis and inhibit gluconeogenesis in target tissues. All these synergistic reactions would have the effect of reducing established hyperglycemia, giving the extracts under study an antidiabetic property (Muniyappa et al., 2007). Indeed, water-soluble compounds other than tannins (flavonoids, saponins, alkaloids, etc.) present in the extracts would provide additional antihyperglycemic activity.

Conclusion

Sclerocarya birrea is a plant used in most countries for its medicinal properties. Several studies have demonstrated the use of bark, leaf and root extracts for *Sclerocarya birrea*'s anti-diabetic, hypoglycemic activities. This was the subject of our current study aimed at evaluating the hypoglycemic activities of *S. birrea* fruits produced in three localities in Chad; Sarh (Moyen Chari), Koumra (Mandoul) and Bongor (Mayo-Kebbi). The hypoglycemic activities showed a decrease in the proportion of blood sugar after 45 min. A reduction in blood glucose after 60 minutes in some samples, and in others 45 minutes. Ultimately, the Koumra extract has significant hypoglycemic activity compared to Sarh and Bongor. However, scientific limitations, practical modalities and field reality led to the analysis of certain parameters that are also important for this work.

COMPETING INTERESTS

The authors declare that they have no competing interests.

AUTHORS' CONTRIBUTIONS

TT collected the field samples and wrote the first draft. TT and LK performed the laboratory analyses. TT, LK, and AK wrote the manuscript. SID and MM supervised all activities.

ACKNOWLEDGEMENTS

The authors thank the Doctoral School of Sciences, Technology and Environment (ED-STE) of the University of N'Djamena for the authorization of the research, as well as the local administrative authorities of the different cities which participated in the data collection, the Physicochemistry Laboratory of the Food Quality Control Center (CECOQDA) for the analysis of the samples of this study.

REFERENCES

- Abdelaziz AB. 2021. Evaluation of Primary Health Care policy in the Maghreb. Feedback from Expert-Leaders* in Tunisia. *La Tunisie Médicale*, **99**(1) : 59.
- Adiza A. 2007. Etude d'une recette traditionnelle, des écorces de tronc de *Sclerocarya birrea* Hosch et de *Uapaca togoensis* Pax utilisées dans le traitement du diabète. Thèse de Doctorat en Pharmacie, Université Bamako, Mali, 141p.
- Al-Achi A. 2005. Herbs that affect blood glucose levels. *Women's Health in Primary Care*, **8**(7) : 325-330.
- Calop J, Limat S, Fernandez B. 2008. *Prescription Validation Algorithm. Clinical and Therapeutic Pharmacy* (3rd edn). Elsevier Masson: Paris.
- Ekoumou C. 2003. Etude phytochimique et pharmacologique de 5 recettes traditionnelles utilisées dans le traitement des infections urinaires et de la cystite. Bamako: Thèse de Doctorat en Pharmacie de l'Université de Bamako.
- Faye MD, Weber JC, Abasse TA, Boureima M, Larwanou M, Bationo AB, Diaite, DS. 2011. Farmers preferences for tree functions and species in the west african sahel. *Forests, Trees and Livelihoods*, **20**(2-3) :113-136.
- Ghedira K. 2005. Flavonoids: structure, biological properties, prophylactic role and therapeutic uses. *Pharmacognosie*, **3**: 162-169.
- Hanhineva K, Tunoner R, Bon Pon I, Pekkinen J, Kokhannina H, Poutanen K. 2010. Impact of dietary polyphenol on carbohydrate metabolism. *J. Mol. Sci.*, **11**: 1365-1402.
- Hameg T, Taleb D. 2018. Evaluation de l'activité antimicrobienne, et antioxydante des composés phénoliques du Marrube blanc «*Marrubium vulgare*» (Doctoral dissertation, Université Mouloud Mammeri).
- Haoues M, Zedini C, Chadli-Chaieb M. 2023. Factors predictive of the level of knowledge, attitudes and quality of life in Tunisian diabetics-A propos de 1007 cas . *Journal of Epidemiology and Public Health*, **71**(1) : 101413.
- Kando PB, Hilou A, Traore ER, Nanema RK, Zongo JD. 2009. Variability of some biochemical characters of *Sclerocarya birrea* (A. Rich.) Hochst. fruits in Burkina Faso. *Fruits*, **64**(6) :351-360.
- Karou D, Aly S, Antonella C, Saydou Y, Carla M, Jacques S, Vittorio C, Alfred ST. 2005. Antibacterial activity of alkaloids from *Sida acuta*. *African Journal of Biotechnology*, **4** (12) :1452-1457.
- Kebieche M, Meraihi Z. 2009. Activité biochimique des extraits flavonoïdiques de la plante *Ranunculus repens* L (Doctoral dissertation, Université Frères Mentouri-Constantine 1).
- Maiga B. 2010. Etude de la phytochimie, de l'activité antiradicalaire et de la toxicité sub-chronique des feuilles de *Sclerocarya birrea* (A. Rich) Hoscht (Anacardiaceae), utilisées dans le traitement traditionnel du diabète au Mali (Doctoral dissertation, Université de Bamako).
- Muniyappa R, Montagnani K, Koh K, Quon MJ. 2007. Cardiovascular actions of insulin. *Endocrine Reviews*, **28** (5): 463 – 491.
- Niang L, Gueye FK, Thioye A, Don OR, Diallo EHC, Soumare M, Diop CM. 2022. Effet hypoglycémiant des extraits

- méthanoliques et acétoniques de feuilles et d'écorces de tronc de *Sclerocarya birrea* (A. Rich.) Hochst chez les souris [Hypoglycemic effect of acetonc and methanolic extracts from leaves and bark of *Sclerocarya birrea* (A. Rich.) Hochst in guinea pigs]. *International Journal of Innovation and Scientific Research*, **61**(1): 34–42.
- Normand É. 2023. Le métabolisme énergétique et l'implication du microbiote intestinal dans la scoliose idiopathique chez les adolescentes. Thèse de Doctorat, Université de Montréal. <http://hdl.handle.net/1866/34001>
- Ojewole JA. 2004. Evaluation of the analgesic, anti-inflammatory and antidiabetic properties of *Sclerocarya birrea* (A. Rich.) Hochst. stem bark aqueous extract in mice and rats. *Phytotherapy Research: An International Journal Devoted to Pharmacological and Toxicological Evaluation of Natural Product Derivatives*, **18**(8) : 601-608.
- Racah D. 2004. Epidemiology and pathophysiology of degenerative complications of radicals from alcohols: deposite formation. Doctoral thesis, University of Limoges, pp. 24-42.
- Shackleton SE. 2002. The informal marula beer traders of Bushbuckridge, Limpopo Province, South Africa. Rhodes University, South Africa.
- Stéphan JM. 2020. À propos d'un cas clinique de diabète de type 2: effets immédiats de l'acupuncture et de l'électroacupuncture. Quels effets à long terme? *Acupuncture & Moxibustion* (1633-3454), **19**(2).
- Sylla SI. 2023. Evaluation of the management of type 2 diabetes in the era of new non-insulin antidiabetic molecules in a sub-Saharan African country (Mali) (Doctoral dissertation, USTTB).
- Traoré M. 2020. Dossiers of AMM of four new MTAs of the Department of Traditional Medicine (Doctoral dissertation, University of Sciences, Techniques and Technologies of Bamako).
- Victor P, Embeya O, Mavungu GN, Celestin P, Shongo P. 2020. Effet Antihyperglycémiant des Extraits Aqueux et Méthanoliques des Feuilles de *Vinca rosea* Chez les Cobayes. *East African Journal of Forestry*, **2** (2): 40 – 44. DOI: <https://doi.org/10.37284/eajfa.2.2.232>
- Vitor RF, Mota-Filipe H, Teixeira G, Borges C, Rodrigues AI, Teixeira A, Paulo A. 2004. Flavonoids from a *Pterospartum tridentatum* extract showing endothelial protection against oxidative damage. *Journal of Ethnopharmacology*, **93**(2-3): 363-370.
- Zourdani S. 2017. Microfinance et pauvreté : quantification de la relation sur la population de Tizi-Ouzou [texte imprimé] (Doctoral dissertation, Université Mouloud MAMMERI Tizi-Ouzou).