Research Article

Phytochemical and antihyperglycemic characterization of aqueous extract of *Gossypium hirsutum* L. (Malvaceae) and *Terminalia catappa* L. (Combretaceae) mixing

Trebissou Aïssé Florence Judith[1], Okogni Okpo Jean-Noël[2], Yapo Adou Francis[2]

[1]*Biology Laboratory and Medical Research, National Institute of Public Health, Côte d'Ivoire. Box 47, Abidjan*

[2]*Laboratory of Natural Substances Pharmacology, UFR Bioscences, Félix Houphouët Boigny University, Abidjan, Côte d'Ivoire. Box 34, Abidjan*

Received: 11 September 2024 Revised: 23 October 2024 Accepted: 29 October 2024

Abstract

Background: Diabetes is a metabolic disease which is characterized by chronic hyperglycemia, so be it a glycemia to have eaten and drunk nothing higher than 1.6 grams/litre (7 mmole/litre) at least at two resumptions**.** The aim of this work is to explore the phytochemical composition and antihyperglycemic activity of mixing of *Gossypium hirsutum* L. and *Terminalia catappa* L., under form of decoction. **Material and Methods:** Both species selected for this study are *Gossypium hirsutum* L. and *Terminalia catappa* L.. Phytochemical characterization was carried out aid of specific colorimetric tests. Animals used for the in vivo study of antihyperglycemic activity are some rats of founder Wistar of both sexs, weighting between 100 and 225 grams and to be two to five months old. Six groups of rats were formed. Glycemia of rats was measured aid of Accu-Chek® glucometer (Roche Diagnostics). **Results:** The results revealed the presence of bioactive secondary metabolites such as alkaloids, polyphenols, sterols, polyterpenes, gallic tannins and quinone compounds, suggesting interesting pharmacological properties (anti-inflammatory, antioxidants, antihyperglicemic). The fall of the glycemia is stayed significantly strong (P < 0,001) for the dose of AEGhTc at 1000 mg/kg of T90 to T180, all as for the glibenclamide. **Conclusion:** This study puts in front the therapeutic potentials of AEGhTc. The dose of 1000 mg/kg of AEGhTc had an important antihyperglycemic activity.

Keywords: Phytochemistry, antihyperglycemia, *Gossypium hirsutum* L., *Terminalia catappa* L., diabetes, Côte d'Ivoire

Introduction

Diabetes is a metabolic disease which is characterized by chronic hyperglycemia, so be it a glycemia to have eaten and drunk nothing higher than 1.6 g/l (7 mmole/litre) at least at two resumptions (DeFronzo et al., 2015; Kouakou et al., 2016). It carries many complications such as cardiovascular diseases, renal failure (Cole et al., 2020). In accordance with statistical data world, thereabouts 537 million people have diabetes, and this increasing prevalence could reach 643 millions by 2030 (IFD, 2021). In Africa, diabetes touches thereabouts 24 million people, with a prevalence rate of 4.5 % (IFD, 2021). Among these cases, 54% are not diagnosed, which further complicates the management of the disease (IFD, 2021). In Côte d'Ivoire, the prevalence of diabetes is passed of 5.7% in 1997 to 6.2 % en 2017 (NPFMD / PNCT, 2017). These alarming data underline the importance of better understanding the effects of hyperglycemia on the health. In the context of increasing prevalence of diabetes, the use of medicinal plants offer a promising therapeutic alternative.

Medicinal plants constitute a precious resource in the research of new therapeutic solutions, particularly in the regions where access in convential medicines is limited. In Côte d'Ivoire, traditional pharmacopoeia rests on great diversity vegetable, whose certain species, as *Gossypium hirsutum* L. (Malvaceae) and *Terminalia catappa* L. (Combretaceae) are used so as empiric to treat chronic affections as diabetes. These plants are recognized for their health benefits. *Gossypium hirsutum* L. is known for itself antimicrobial and antiviral activities (Lima et al., 2021). Some ethnobotanics studies showed that the leafs and roots of this plant are used under form of decoction in the Northwest of Nigeria to treat diabetes (Udoamaka and Prieto, 2014). As for *Terminalia catappa* L. whose the fruit is called

Address for Corresponding Author:
Trebissou Aïssé Florence Judith
National Institute of Public Health, Côte d'Ivoire, Box 47, Abidjan
Email: aisse.judith@gmail.com

DOI: ttps://doi.org/10.31024/ajpp.2024.10.5.3

« badame » or « little cocoman », it improves blood circulation, prevents heart disease, lowers blood pressure, reduces cholesterol level and strengthens immunity (Alka et al., 2016). The combined decoction of these two plants is often cooked for themselves effects presenting some synergies, but themselves bioactive compounds and itself innocuousness have not been yet rigorously evaluated. A phytochemical characterization is essential to identify the secondary metabolites responsible of these effects.

The aim of this study is to explore phytochemical composition and anti-hyperglycemic activity of mixing of *Gossypium hirsutum* L. and *Terminalia catappa* L., under the decoction.

Material and methods

Plant material

The two species selected for this study are *Gossypium hirsutum* L. and *Terminalia catappa* L. *Terminalia catappa* L. was collected in the courtyard of the National Institute of Public Health of Côte d'Ivoire, while *Gossypium hirsutum* L. was obtained from a traditional practitioner in the commune of Yopougon.

Animal protocol

The animals used for the in vivo study of antihyperglycemic activity were Wistar rats of both sexes, weighing between 100 and 225 grams and aged 2 to 5 months. These animals were obtained the animal house of National Superior School.

The rats were housed in groups of three in plastic cages with stainless steel lids, measuring (36cm × 25cm). They had free access to water and food. Before the start of the experiments, the rats underwent a two-week adaptation period during which they were kept at an ambient temperature of 20 to 24°C, under a 12-hour light/dark cycle, in order to respect the biological clock.

The litter used consisted of wood shavings, renewed three times a week to ensure optimal hygiene conditions. Individual identification of the rats was carried out by numbering on the tail using a permanent marker.

Technical material

The technical equipment used in this study included several elements essential for the preparation and experimental manipulations. A saucepan was used for the decoction of the plants. Then, a spoon was used to take the necessary plant powder. Cotton wool and a white cloth were used to filter the solutions obtained after decoction. For the drying process, plates were used to place the decoctions in the oven, and a blade was used to scrape the solid extracts after drying.

For the preservation of the extracts, a urine box was used. In order to ensure safety during handling, protective gloves were worn to avoid any infection. Note-taking was carried out with a notebook and pen. A syringe was used to withdraw solutions and administer substances, and a gastric cannula was used for gavage of the rats.

Ethical consent

This study was validated by the Ethics Committee of the UPR Pharmacodynamics Biochemistry, Laboratory of Biology and Health, UFR Biosciences, Felix Houphouët-Boigny University of Abidjan, Côte d'Ivoire. Box 34 Abidjan 01 of May 22, 2024.

Preparation of aqueous extract of mixing of *Gossypium hirsutum* L. and *Terminalia catappa* L.

Fruit of *Terminalia catappa* L. and *Gossypium hirsutum* L. were washed, dried in the shade, then crushed separately to obtain some homogeneous powders. Fruit of *Terminalia cattapa* L. were beforehand shelled to conserve the pericarp. Powders obtained were stored to put under cover light and heat.

An aqueous extract was cooked by mixing forty-two grams of powder of *G hirsutum* L. and twenty-four grams of powder of *T catappa* L. in 4.5 Litres of distilled water. The mixing was brought to the boil for thirty minutes, filtered several times (strainer, white fabric, hydrophilic cotton) then dried at 55°C during forty-eight hours to get a powder, written down AEGhTc.

This powder was preserved in some sterile bowls at ambient temperature (27°C) for the later expérimentations.

Phytochemical screening

To show secondary metabolites consist in some characterization testings of great groups of chemical compounds contained in the aqueous extract (Wagner and Bladt, 2001; Abo, 2013; Mea et al., 2017).

Characterization of sterols and polyterpenes

The test of Liebermann-Burchard, is based on the oxidation some sterols and triterpenes by the sulfuric acid concentrated, in presence of anhydride acetic. This reaction carries a series of changing of colors, from purple or crimson to blue, next to green, indicated the presence of researched compounds.

Polyphenols characterization

Polyphenolic derivatives react with the ferric chloride to form colored complexs. In presence of polyphenols, blue-blackish colouring or dark green appears, indicating them presence in the sample.

Flavonoids characterization

Shinoda reaction is based on the flavonoids reduction by the magnesium in presence of hydrochloric alcohol. This reaction produces a pink orange-coloured or purple, indicating a positive reaction. Colouring is compared to that of a standard quercerol to confirm the presence of flavonoids.

Catechin tannins characterization

Catechin tannins, of non-hydrolyzable nature, precipitate under form of flocks in presence of Stiasny reagent (formalin 30% and ClH concentrated). This test permits to identify the presence of these tannins into an extract by formation of a characteristic.

Gallic tannins characterization

The gallic tannins, derived of gallic acid, react with the ferric chloride (Cl_3Fe) in saturated medium of sodium acetate, provoking appearance of blue-black intensive colouring, revealing their presence in the extract.

Quinone compounds characterization

Borntraeger reaction rests on the extraction of quinones in organic phase (chloroform), followed of a reaction with diluted ammonia. In presence of quinone compounds, the solution develops a characteristic colouring going red to purple.

Alkaloids characterization

Alkaloids form colored complexs with Dragendorff and Bouchardât reagents. In presence of alkaloids, a precipitate brown-reddish appears, confirming their presence in the extract.

Saponosides characterization

Saponosides, when they are dissolve in the water, form the stable moss after agitation because of surfactant properties. The formation of the moss, of the height greater than one centimeter after rest, indicate their presence.

Assessment of antihyperglycemic activity

The assessment of antihyperglycemic activity in rats was carried out according to the method of N'doua et al. (2015). For this experiment, 18 rats divided into 6 groups of 3 rats each were used. All animals had been fasting since the previous day (24 hours). The glucose level is determined immediately before treatment, which constitutes the starting glucose level (t0). The different groups of rats received orally using a gastric cannula a single dose of 1 ml of test doses of AEGhTc (300, 1000 and 2000 mg/kg of Body Weight (BW)) or of glibenclamide (10 mg/kg of BW) or of anhydrous glucose (4 g/kg of BW) per 100 g of rat BW. Each treated rat received 30 minutes after administration of 4 g/kg of BW of glucose, a dose of AEGhTc or of glibenclamide. Glycemia is measured every 30 minutes for 2 hours 30 minutes after treatment.

So,

Group 1 : Negative control rats given only 10 ml/kg BW of distilled water.

Group 2 : Positive control rats given only 4 g/kg anhydrous glucose

Group 3 : Rats given 4 g/kg anhydrous glucose BW then 10 mg/kg glibenclamide BW 30 minutes later.

Group 4 : Rats given 4 g/kg BW of glucose, then 300 mg/kg BW of AEGhTc 30 minutes later.

Group 5 : Rats given 4 g/kg BW of glucose, then 1000 mg/kg BW of AEGhTc 30 minutes later.

Group 6 : Rats given 4 g/kg BW of glucose, then 2000 mg/kg BW of AEGhTc 30 minutes later.

Glucose levels were measured at 60 min (T60), 90 min (T90), 120 min (T120), 150 min (T150) and 180 min (T180) to assess the effect of the different treatments on hyperglycemia using an Accu-check® glucometer (Roche Diagnostics) (Figure 1). The extent of hyperglycemia is assessed by determining the rate of change in glycemia (RCG) of each post-treated or non-treated group (Begbin et al., 2021).

$$\mathbf{RCG}\ (\%) = \frac{(\textbf{Final glycemia} - \textbf{Initial glycemia})}{(\textbf{Initial glycemia})} \boldsymbol{X100}$$

Principle of the Accu-chek® glucometer (Roche Diagnostics)

The principle of the Accu-Chek® glucometer (Roche Diagnostics) is based on an electrochemical method. First, the test strips contain a capillary that draws up the amount of blood required for the measurement (0.6 µl). Then, the glucose in the blood reacts with an enzymatic electrode that contains glucose oxidase. The enzyme is then re-oxidized with an intermediate reagent such as the ferricyanide ion (Fe(CN)6 3-). This ion is re-oxidized by a reaction at the electrode, which will generate an electric current. The electric current passing through this electrode is proportional to the level of glucose in the blood

Figure 1 : Photograph of glycemia measurement in Wistar rats

that has reacted with the enzyme. We can then know the blood sugar level (Accu-Check® Guide).

Statistical Analysis

Data analysis was performed using GraphPad Prism software (San Diego, CA, USA, version 8). Statistical analysis was performed using the Student t test. Dunnett's multiple comparison test was used for comparison of the variance of controls with those of other groups. Differences were considered significant according to the following criteria: Significant: $p < 0.05$, very significant: $p < 0.01$, highly significant: $p < 0.001$, extremely significant: $p < 0.0001$.

Results

Yield of aqueous extract of EAGhTc

From the mixing of forty-two grams of powder of fruit of *Gossypium hirsutum* L. and twenty-four grams of powder of pericarp of *Terminalia catappa* L., driving at a total of sisty-six, aqueous extraction has given an extract of seven grams, so be it an yield of 10.60%.

Phytochemical composition of AEGhTc

Phytochemical analyses of AEGhTc has revealed the presence of alkaloids, polyphenols, sterols, polyterpenes and quinones compounds. Catechin tannins and saponosides were absent (Table 1).

Assessment of antiglycemic activity

The evolution of the glycemia values of the rats during this study is recorded in Table II and illustrated in Figure 2. Before treatment (T0), the fasting glycemia was 1 ± 0.08 g/l for all animals in the six experimental groups. 30 minutes

Table 1: Phytochemical composition of AEGhTc

Phytochemical compounds		Test or reagents	Observation
Sterols and polyterpenes		Liebermann	+
Polyphenols		Ferric Chloride	+
Flavonoids		Cyanidin	+
Saponosids		Vigorouse Agitation	-
Quinone compounds		Borntraeger	+
Alkaloids		Dragendorff	+
		Bouchardat	+
Tannins	Catechin	Stiasny	-
	Gallic	hydrochloric Acid	+

Table 2: Evolution of blood glucose in rats made hyperglycemic by glibenclamide and different doses of AEGhTc, in comparison with glucose over time

Groups	Time											
	T0	T30		T60		T90		T120		T150		T180	
	Glycemia (g/l)	Glycemia (g/l)	RCG (%)	Glycemia (g/l)	RCG (%)	Glycemia (g/l)	RCG (%)	Glycemia (g/l)	RCG (%)	Glycemia (g/l)	RCG (%)	Glycemia (g/l)	RCG (%)
Group 1 (distilled water)	1±0.08	0.99± 0.08	-	0.90±0.11	-	0.98±0.09	-	0.88± 0.02	-	0.96± 0.11	-	1.06 ±0.03	-
Group 2 (Glucose only)	1 ±0.08	1.25 ± 0.1	00	1.15 ± 0.1	00	1.06±0.04	00	0.98±0.07	00	1.08±0.05	00	0.96±0.04	00
Group 3 (Glibenclamide)	1 ±0.08	1.25±0.1	00	0.84±0.04	-22.62±2.09	0.66±0.05	-37.73±6.77	0.69±0.08	-29.59±9.07	0.43±0.16	-60.18±14.21	0.57±0.06***	-40.62 ±11.86
Group 4 (Extract 300 mg/kg)	1 ±0.08	1.25 ±0.1	00	1.01 ± 0.15	-12.17± 3.34	1.02± 0.07	-03.77 ± 1.23	0.99± 0.16	+01.02 ±0.61	0.95±0.04	-12.03±6.71	0.94±0.1	-02.08 ±1.43
Group 5 (Extract 1000 mg/kg)	1 ±0.08	1.25 ±0.1	00	0.95±0.11	-17.39±0.45	0.74±0.15	-30,19 ± 8,41	0.65±0.10	-33.67 ± 9.05	0.81 ±0.05	-25.00 ± 5.22	0.72 ±0.08**	-25.00 ±4.44
Group 6 (Extract 2000 mg/kg)	1 ±0.08	1.25±0.1	00	0.87±0.02	-24.39± 5.21	1.03±0.09	-02,83 ±1,89	0.93±0.02	-05.10 ±3.15	0.95±0.16	-12.03 ±7.08	0.94± 0.21	-02.08 ±1.02

T0: Initial time at the beginning of the experiments; T30: Time after induction of hyperglycemia; T 60, 90, 120,150 and 180: Time after treatment of rats with Glibenclamide and AEGhTc extract at doses of 300, 1000 and 2000 mg/kg BW; RCG: the Rate of change in glycemia. (-): decrease; (+): increase. *=p<0.05; **= p<0.01; ***p<0.001.

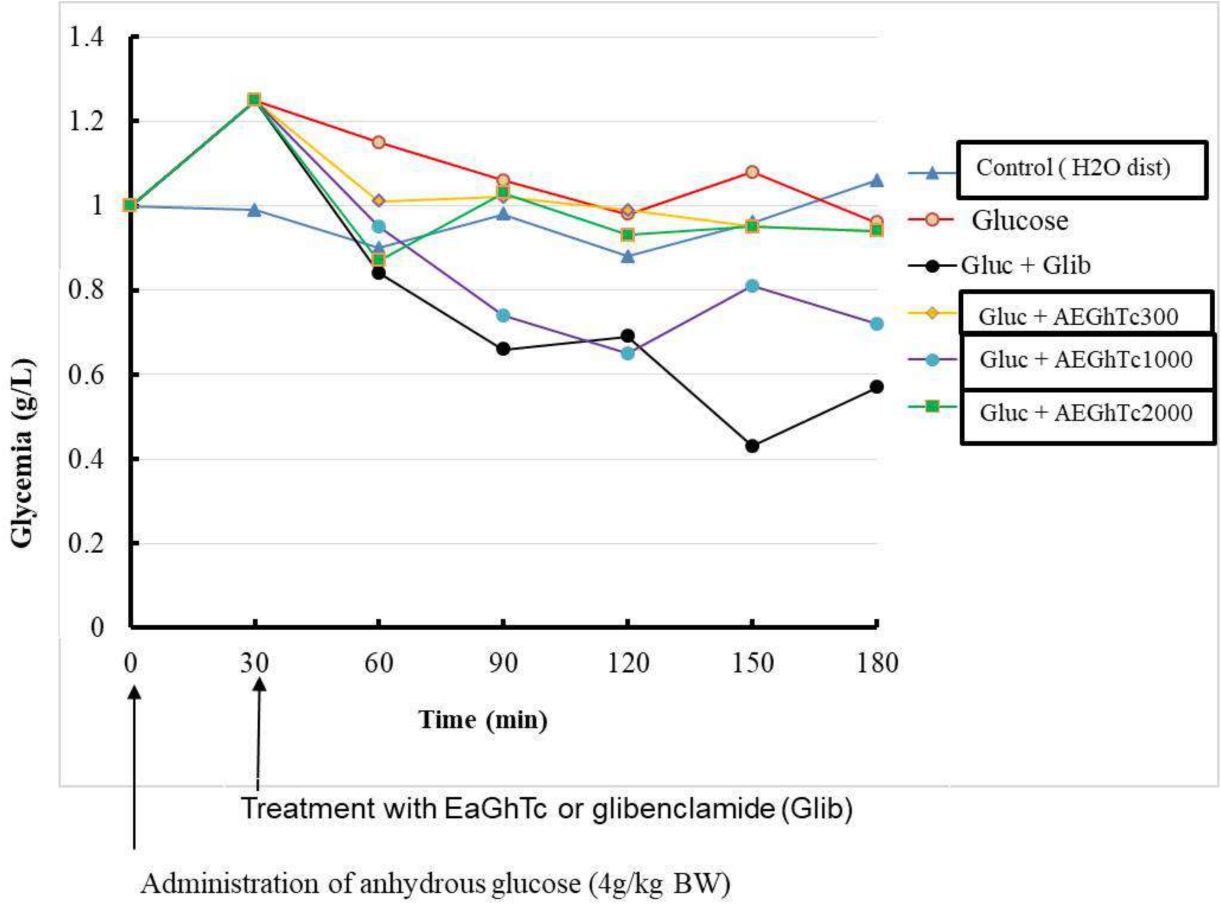

Figure 2 : Variation of glycemia in rats made hyperglycemic after treatment with EaGhTc or glibenclamide over time

after treatment with anhydrous glucose (T30), the glycemia increased to 1.25 ± 1.00 g/l, an increase of 25.00 ± 8.34%, except for the negative control group (distilled water).

Furthermore, after treatment with AEGhTc and glibenclamide, a decrease in glycemia was observed in all animals compared with those receiving glucose. This decrease was significant at T60 for all doses of AEGhTc, as well as for glibenclamide. The rates of decrease induced by AEGhTc at 300, 1000, and 2000 mg/kg and by glibenclamide were 12.17 ± 3.34% ; 17.39 ± 0.45% ; 24.39 ± 5.21% ; and 22.62 ± 2.09%, respectively (Table 2).

The decrease in glycemia remained significantly high ($P < 0.001$) for the 1000 mg/kg AEGhTc dose from T90 to T180, as for glibenclamide. The rates of change in glycemia relative to glucose at these time points were 30.19 ± 8.41% and 37.73 ± 6.77% at T90, 33.67 ± 9.05% and 29.59 ± 9.07% at T120, 25.00 ± 5.22% and 60.18 ± 14.21% at T150, and 25.00 ± 4.44% and 40.62 ± 11.86% at T180. In contrast, other doses of AEGhTc (300 and 2000 mg/kg) did not result in a significant decrease ($P > 0.05$) in glycemia relative to glucose between T90 and T180 (Figure 2).

Discussion

The present study aimed to determine, through a phytochemical screening, the presence of secondary metabolites in the cure AEGhTc. Results are revealed many bioactives molecules such as the alkaloids, polyphenols, sterols, polyterpenes, quinones compounds and gallic tannins. These results are comparable to those of Dembele (2021), who showed that pericarp of *Terminalia catappa* L. contained also sterols, polyterpenes, flavonoids, alkaloids and tannins. The presence of phytocomponuds into AEGhTc suggests pharmacological properties potentially interesting against diabetes. Flavonoids identify into the cure AEGhTc are known for their anti-inflammatory properties. hepatoprotectives (González et al., 2011), as their antioxidant effects, vasculoprotectives (antiedeumatoids), antimutagenes, antiallergic, anticarcinogenic (Panche et al., 2016).

The results of the effect of EaGhTc aqueous extract on orally induced hyperglycemia in rats showed a significant increase ($P<0.05$) at T30 in all groups that received anhydrous glucose load at 4g/kg BW. This confirms the hyperglycemic effect of anhydrous glucose, showing how blood glucose naturally increases after a glucose load.

At a dose of 300 mg/kg BW, EaGhTc had no significant effect ($P>0.05$) on hyperglycemia, with a return to initial glycemia after 180 minutes. At 1000 mg/kg, the extract revealed a very significant antihyperglycemic activity ($P<0.001$) with a return to initial glycemia after 60 minutes, similar to the effect observed with glibenclamide, a reference antidiabetic However, at 2000 mg/kg of PC, the initial glycemia level is recovered after 60 minutes, but it increases again before returning to its initial level, the dose of 2000 mg/kg did not reveal a good long-term antihyperglycemic activity compared to the dose of 1000 mg/kg. These results reveal that the AEGhTc extract, at a dose of 1000 mg/kg, could act on the regulation of insulin in the pancreas (Magnan et al., 2005). AEGhTc could stimulate glycogenolysis which is the production of glucose from the phosphorolysis of glycogen. Glycogen makes it possible to obtain glucose-6-phosphate molecules which can either participate in glycolysis to provide energy in the form of ATP, or be dephosphorylated by a glucose-6-phosphatase present mainly in the liver and to a much lesser extent in the kidney. This free glucose then makes it possible to maintain blood sugar at a value close to 0.9 g/L. These results are comparable to those obtained by Yao (2022) who showed a significant decrease in glycemia at times T90, T150 and T210 respectively at doses of 100 and 500 mg/kg of PC in rats made hyperglycemic and treated with the aqueous extract of the mixture of the plants Nauclea lotifolia, Cnestis ferruginea, Zingiber officinale, Anogeissus leiocarpus called DD3.

Conclusion

This study showed that the decoction of the mixing of *Gossypium hirsutum* L. and *Terminalia catappa* L. (AEGhTc) presents bioactive secondary metabolites such as alkaloids, polyphenols, sterols, polyterpenes, tannins, quinonic compounds, suggesting interesting pharmacological properties.

Regarding the antihyperglycemic effect, the 1000 mg/kg dose of AEGhTc demonstrated a very significant activity, comparable to that of glibenclamide, a reference antidiabetic, with a normalization of glycemia within 90 minutes after a glucose load. These results are very promising for the development of an improved traditional drug against diabetes.

Conflicts of interest

There is no conflict of interest.

References

Abo KJC. 2013. From the plant to the molecule: toxicity, pharmacological effects and mechanism of action of Justicia Secunda (Acanthaceae), an antihypertensive plant, on the cardiovascular system of mammals, State doctoral thesis in Natural Sciences, Félix Houphouët-Boigny University (Abidjan, Ivory Coast), n° 752 : 351 p.

Accu-check® guide. (https://www.accu-chek.fr/20/01/2025).

Alka D, Raman D, Yogesh K. 2016. Exploration of phytochemicals found in Terminalia sp. And their antiretroviral Activities. Pharmacognosy Review 10(20):73-83.

Cole JB, Florez JC. 2020. Genetics of diabetes mellitus and diabetic complications. Nature *Reviews* Nephrology 16 : 377-390.

DeFronzo RA, Ferrannini E, Alberti KGMM, Zimmet P, Alberti G. 2015. International Textbook of Diabetes Mellitus, 4eme ed, Vol 2, pp 1240, New Jersey (USA), John Wiley & Sons.

Dembélé F, Samaké S, Togola I, Karembé M. 2021. Études ethnobotanique et phytochimique d'espèces ornementales utilisées au Mali : cas de *Terminalia catappa* (L.) dans le district de Bamako. International Journal of Applied Research **7**(6): 01-07, p 5.

González R, Ballester I, López-Posadas R, Suárez MD, Zarzuelo A, Martínez-Augustin O, Medina FSD. 2011. Effets des flavonoïdes et autres polyphénols sur l'inflammation. Revue Critique Des Sciences Alimentaires et de la Nutrition 51 (4): 331–362.

IFD (International Federation of diabetes) 2021. IDF Diabetes Atlas, 10th ed. Brussels, Belgium.

Kouakou AYF, Kamagate A, Yapo AP. 2016. Complications of Diabetes in Ivory Coast in Patients Diagnosed Late. European Scientific Journal, 12(27): 250-262.

Lima LF, Oliveira JO, Carneiro JNP, Lima CNF, Coutinho HDM, Morais Braga MFB. 2021. Ethnobotanical and antimicrobial activities of the genus Gossypium (Cotton): a review. Journal of Ethnopharmacology 279: 114-363.

Magnan C, Ktorza A. 2005. Production et sécrétion de l'insuline par la cellule β pancréatique. Médecine des Maladies Métaboliques, 10 (362): Article E-10.

Mea A, Ekissi Y H R, Abo K J C, Kahou B G P. 2017. Hypoglycaemiant and anti-hyperglycaemiant effect of *juscticia secunda* m. vahl (acanthaceae) on glycaemia in the wistar rat. International Journal of Development Research 07(06) (2017), 13178-1.

National Program for the Fight against Metabolic Diseases and Prevention of Non-Communicable Diseases (NPFMD / PNCT). 2017. Prevalence and characteristics of diabetes in Côte D'Ivoire – PREVADIA-CI 2017. 55p.

N'doua LAR, Abo KJC, Aoussi S, Gbogbo M, Yapo AP, Ehile EE. 2015. Effets hypoglycémique et antihyperglycémique de l'extrait éthanolique 70 % de racines de Rauvolfia vomitoria Afzel (Apocynaceae). European Scientific Journal, 11(6): 176-187.

Panche AN, Diwan A D, Chandra S R. 2016. Flavonoids: An overview, Journal of Nutritional Science, 5: e47.

Udoamaka F E, Prieto J M. 2014. The use of plants in the traditional management of diabetes in Niageria : Pharmacological and toxicological considerations. Journal of Ethnopharmacology 155: 857-924.

YAO AN. 2022. Potential effects of a herbal remedy "DD3" on free radical inhibition and glucose tolerance in orally hyperglycemic Wistar rats. Master's thesis in Biology, Health and Natural Substances of Interest, UFR Agroforestry, Jean Lorougnon Guédé University, Daloa, Ivory Coast, 33p.

Wagner H, Bladt S. 2001. Plant drug analysis. A thin layer chromatography atlas, *2ème* édition, Springer, 384 p, Berlin, Allemagne.