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HYPOGLYCAEMIANT AND ANTI-HYPERGLYCAEMIANT EFFECT OF JUSCTICIA SECUNDA M. VAHL (ACANTHACEAE) ON GLYCAEMIA IN THE WISTAR RAT

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ABSTRACT

In animal experiments, it is possible to induce hyperglycaemia in healthy animals. Subsequently, the administration of drugs makes it possible to measure the evolution of this hyperglycaemia induced. It is this pharmacological method that we used in this work to evaluate the effect of *Justicia secunda* on healthy animals and made hyperglycaemic. The basal glucose levels ranged from 0.59 ± 0.02 g / l to 1.2 ± 0.05 g / l in fasted rats used in these different experiments. From 2 to 3 g / kg BW, AEJs induces dose-dependent hypoglycemia in normoglycaemic rats. The glucose administration of 4 g / kg BW (by force-feeding) of anhydrous glucose induced hyperglycaemia (glucose > 1.2 ± 0.05 g / l) which was measurable. Thus, a peak increase in blood glucose occurs 30 minutes after treatment. The hyperglycemia thus induced by glucose is progressively reduced and canceled in the animals treated with EAJs and glibenclamide. When the rats were pretreated (treated before force-feeding with glucose) with AEJs at doses of 2.5 g / kg BW and 3 g / kg BW on the one hand and glibenclamide at 10^{-2} g / kg BW, on the other hand, the glucose-induced hyperglycemia peak is lower than that of the non-pretreated hyperglycaemic control. The reduction in hyperglycaemia is more pronounced. The cancellation of this hyperglycaemia occurs more rapidly. Similarly, in post-treated animals, the return of blood glucose to normal is faster compared to hyperglycemic control rats. After return to basal glucose, hypoglycemia was observed at high doses of AEJs and glibenclamide. The dose reduction of glucose-induced hyperglycemia was dose-dependent and the dose of 3 g / kg BW was substantially identical (P> 0.05) to that of glibenclamide at 10^{-2} g / kg BW. Examination of the liver-released glucose level of control normoglycemic rats and normoglycemic rats treated with AEJs and glibenclamide shows that AEJs and glibenclamide decrease the glucose released by the liver.

INTRODUCTION

Africa has an important diversity of medicinal plants (Dibong *et al*., 2011). These medicinal plants are valuable resources for the majority of rural populations who use them to meet their health needs (Jiofack *et al*., 2009 and 2010). According to Pousset (2006), medicinal plants play an important role in the treatment of chronic pathologies such as high blood pressure and diabetes mellitus in Africa. Diabetes is the fourth leading cause of hospitalization and death per year (Witting, 2011) and is considered by WHO to be a public health problem. According to the International Diabetes Federation (IDF) and WHO (2013), diabetes care is very expensive in hospitals (IDF, 2013).

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In addition, regular intake of synthetic drugs, including insulin and oral hypoglycaemic agents, often leads to undesirable side effects (Nissen and Wolski, 2007). Diabetologists have come to the conclusion that a therapeutic supplement consisting of plant extracts is necessary to optimize the treatment of diabetes (Jin *et al*., 2008; WHO, 2013). Nowadays more than 1200 plant species including *Justicia secunda* M. Vahl (Acanthaceae) are used in traditional medicine to treat diabetes (Marles and Farnsworth, 1995). *Justicia secunda* M. Vahl (Acanthaceae) occurs in the tropical and subtropical zones of Africa, Madagascar, the West Indians and Asia. It is cultivated, like the majority of species in this family, as a garden ornamental plant (Heywood *et al*., 2007). Leaves and leafy stems give a red tisane, which would have a clarifying action for the Creoles. This herbal tea is taken in case of amenorrhea. It is also considered abortive (Grenand *et al*., 1987). The leaf decoction of this plant is used to control anemia in Congo (Chifundera, 2001), Madagascar (Moswa *et al*., 2008) and Benin (Tossou *et al*., 2008).

For this, in Benin, the plant is commonly called in the fonbge language "hounsiman", that is to say, a plant that gives blood. The decoction of leaves of *Justicia secunda* is also used in traditional medicine in Côte d'Ivoire and the West Indies (Etifier-Chalono, 2005) for the treatment of hypertension (Abo *et al*., 2016). *Justicia secunda* M. Vahl (Acanthaceae) is considered antidiabetic in the African Pharmacopoeia. This work therefore consists in evaluating the pharmacological effects of an aqueous extract of *Justicia secunda* (AEJs) on normal glucose-induced hyperglycaemic rats and on the glucose released from the liver of rats.

MATERIALS AND METHODS

Biological material

Plant material

The plant material used for this study consists of fresh leaves of *Justicia secunda* (Acanthaceae) purchased from the Yopougon-Nouveau-quartier market in Abidjan (Côte d'Ivoire). It was identified and authenticated in comparison with herbarium number 21160 of the National Center of Floristics (CNF) of University Félix Houphouët-Boigny.

Animal equipment

Male and female albino white rats, *Rattus norvegicus* (Muridae), of the Wistar strain, are used for the experiments. They come from the laboratory of Animal Physiology of the Training and Research Unit (RUF) of Biosciences of the Felix Houphouët-Boigny University. They are fed, ad libitum, pellets and tap water through feeding bottles. They benefit from daylight and night darkness at a temperature of 25 ± 3 ° c. They have an average weight of 200 and 250 g. All handling procedures are in accordance with the guide for the health and use of laboratory animals published by the National Institute of Public Health of Côte d'Ivoire.

Methods of study

Preparation of the aqueous extract of Justicia secunda (Acanthaceae)

Fifty grams (50 g) of fresh leaves of *Justicia secunda* are placed in one liter (1 l) of distilled water. The mixture is boiled for ten minutes (10 min). The decoction obtained is filtered three times on hydrophilic cotton and on Wattman filter paper. The filtrate is dried in an oven at 50 ° C. according to the method described by Irie Bi *et al*. (2016). The powder obtained, of brown color, constitutes the aqueous extract of *Justicia secunda* (AEJs). It is weighed and diluted to form the different test doses.

Search for some secondary metabolites contained in the aqueous extract of Justicia secunda (Acanthaceae)

This study makes it possible to demonstrate the large chemical groups of pharmacological interest, namely sterols, polyterpenes, flavonoids, tannins, quinone compounds, saponosides and alkaloids. This study is carried out by a qualitative method described by Mea *et al*. (2016) in test tubes in the presence of specific reagents (Wagner and Bladt, 2001).

Measuring Blood Glucose in the Rat with the Accu-Chek Glucose Meter

The Accu-Check Aviva Glucometer (Roche, Germany) used contains an orifice into which a test strip for blood glucose measurement is inserted. This strip has an absorbent layer on which a drop of blood taken from the caudal vein is deposited according to the method described by Kahou Bi *et al*. (2016). The resulting color is measured by reflectometry in the meter and the blood glucose value is displayed on the glucose monitor. This value is given in mg / dl (Mansar-Benehamza *et al*., 2013).

Preparation of normoglycaemic rats

The evaluation of the effects of aqueous extract of *Justicia secunda* (AEJs) on blood glucose in normoglycaemic rats is monitored for 3 hours (180 min) after force-feeding of the animals with different doses of this extract. This experiment is carried out on a total of 20 Wistar rats weighing between 200 and 250 g. These animals were divided into 4 batches of 5 rats and fasted for 18 hours. The average weight of each batch is determined. Prior to the administration of the test substances, blood glucose is measured in all animals at a time T0. The rats of batch 1 (control batch) receive 2 ml of distilled water. The rats of batches 2, 3 and 4 (batches tests) receive 2 ml of AEJs in doses of 2; 2.5 and 3 g / kg BW (body weight) respectively. Blood glucose levels in these rats were measured at regular intervals of 30, 60, 90, 120, 150 and 180 minutes after administration of the test substances.

Preparation of Pretreated Hyperglycaemic Rats

Normoglycaemic rats weighing between 200 g and 250 g were fasted 18 hours before the start of the experiment. Six (6) batches of 5 rats are formed and the average weight of each batch is determined. These batches of rats are distributed as follows:

Batch 1 (R-T) is the control batch in which the rats receive 2 ml of distilled water; - Lot 2 (R-T +) constitutes the positive control: It is the batch composed of hyperglycaemic control rats. The rats of this batch received distilled water and, after 30 min, 4 g / kg Pc of anhydrous glucose; Batch 3 (R-Glib) consisted of rats which received glibenclamide at a dose of 10-2 g / kg BW and, after 30 min, 4 g / kg BW of anhydrous glucose; - Lots 4, 5 and 6 (R-AEJs) consist of rats which receive 2 respectively; 2.5 and 3 g / kg BW of AEJs and, after 30 minutes, 4 g / kg BW of anhydrous glucose. This series of experience lasts 210 minutes.

Preparation of Post-Treated Hyperglycaemic Rats

In this series of experiments, the batches of rats are constituted identical to those of the study on pretreated rats. On the other hand, the rats receive the anhydrous glucose before receiving the test substances, 30 min afterwards. Thus, the rats are distributed as follows:

Batch 1 (R-T) is the control batch in which the rats receive 2 ml of distilled water; Batch 2 (R-T +) constitutes the positive control. It is the batch composed of hyperglycemic control rats. The rats of this batch are given 4 g / kg BW of anhydrous glucose;

Batch 3 (R-Glib) consists of rats which receive 4 g / kg BW of anhydrous glucose and then, after 30 min, glibenclamide (sulphonamide oral hypoglycaemic agent) at a dose of 10^{-2} g / kg BW. Lots 4, 5 and 6 (R-AEJs) consist of rats which receive 4 g / kg BW of anhydrous glucose and then, 30 min after, respectively, 2; 2.5 and 3 g / kg BW of AEJs.
This series of experience lasts 210 minutes.

Measurement of glucose released from the liver of rats

Principle

In the presence of glucose oxidase (GOD), glucose is oxidized to gluconic acid and of hydrogen peroxide. The hydrogen peroxide released during the reaction reacts under the action of peroxidase (POD) with phenol and amino-4-phenazole to form a pink complex. The intensity of the staining is proportional to the concentration of glucose in the sample.

Experimental protocol

This study is carried out on 25 normoglycaemic Wistar rats, with a body weight between 200 and 250 g, distributed in 5 batches.

- The animals in lot 1 (control) receive by force-feeding 2 ml of distilled water for 28 days in addition to the daily quantity required and fed to the granules.
- The rats of batches 2, 3 and 4 are treated (force-feeding) with 2 ml of AEJs per day in the respective doses of 2; 2.5 and 3 g / kg BW fed pellets with the required amount of water.
- The rats in lot 5 are force-feeding with 10 mg / kg BW (10^{-2} g / kg) glibenclamide per day.

After 28 days of treatment, the animals are sacrificed and a liver fragment weighing 2 g is taken from each of the rats of each batch. The liver fragments collected in batches 1, 2, 3, 4 and 5 were immersed in S1, S2, S3, S4, S5 solutions containing 4 ml of glucosed Mac-Ewen respectively and incubated at 37 ° C for 60 minutes. The supernatant of each solution is taken to assay the amount of glucose in the presence of glucose oxidase (GOD) and peroxidase (POD) (reagents). This assay is carried out using a spectrophotometer (BIOLABO Diagnostics, France), at 500 nm, at times 0 min (before the solution in the organs), then 10, 20, 30, 40, 50 and 60 min after immersing the organs in the Mac Ewen glucose solution.

Physiological Solutions and Pharmacodynamic Substances 2-2-5-1- NaCl 9 ‰ and Mac Ewen Solutions

The saline solution of NaCl 9 ‰ is used for the dilution of the test substances and for the force-feeding of the rats. The Mac Ewen glucose is used for the study of glucose released by isolated rat liver. One liter of Mac Ewen's solution is 130 mM NaCl; 5.63 mM KCl; 12.16 mM CaCl2; 0.91 mM H2PO4Na; 11.90 mM HCO3Na and 0.25 mM MgCl2. Two (2) g glucose is added to this physiological solution prior to the experiments.

Pharmacological Substances

The pure anhydrous glucose (Cooper, France) is diluted and used to induce oral hyperglycaemia (force-feeding) in the rat.
Glibenclamide (Daonil® 5 mg, Sanofi-Aventis, France) is a sulphonylurea hypoglycemic agent used as a reference antihyperglycaemic agent in rats.

Statistical Processing and Analysis of Results

The computer program graphPad InStat (San Diego CA, USA) is used for statistical analysis of the results. Values are given as an average followed by the standard error on the mean (MEAN + SEM). The difference between two values is determined by the Student-Newman-Keuls comparison test. It is considered as non-significant (ns) for a probability greater than 5% (P> 0.05). It is significant: * for P <0.05; ** for P <0.01; *** for P <0.001.

RESULTS

Demonstration of some secondary metabolites in the aqueous extract of Justicia secunda (Acanthaceae)

The phytochemical screening made it possible to demonstrate the presence of polyphenols, alkaloids, saponosides and sterols and polyterpenes in the aqueous extract of *Justicia secunda* (AEJs). On the other hand, catechic and gallinic tannins, quinones and flavonoids were not found in the extract.

Table 1. Gives the results of the phytochemical test of the aqueous extract of *Justicia secunda*

Compounds sought		Result
Polyphenols		+
Alkaloids		+
Saponosides		+
Sterols and polyterpenes		+
Tannins	Gallic	–
	Catechics	–
Quinones		–
Flavonoids		–

+: Positive test (Presence of compound)
-: Negative test (Absence of compound)

Pharmacological effects of AEJs on the glycaemia of normoglycaemic rats and carbohydrate overloaded rats

Effects of AEJs on blood glucose in normoglycaemic rats

The effects of AEJs at the doses of 2, 2.5 and 3 g / kg BW on the glycaemia of normoglycaemic rats as a function of time are shown in figure 1. Basal values of fasting glucose in rats measured before the different treatments showed no significant differences between batches. They are of the order of 0.96 ± 0.09 g / l. Lower doses of AEJs at 2 g / kg BW do not alter blood glucose levels in rats. Rats given the dose 2 g / kg BW of AEJs showed a non-significant decrease (P> 0.05) in blood glucose, as 0.95 ± 0.01 g / l. In animals fed with AEJs at a dose of 2.5 g / kg BW, the decrease in blood glucose was significant (P <0.05). At this dose, the glycaemia which was initially 0.96 ± 0.07 g / l increased to 0.76 ± 0.05 g / l; A decrease of 26.31% at the end of the experiment. The dose of 3 g / kg BW of AEJs results in a more pronounced decrease in blood glucose. From 0.96 ± 0.07 g / l, the blood glucose increases to 0.70 ± 0.04 g / l, as 37.14% reduction at the end of the experiment.

Effects of the aqueous extract of Justicia secunda (AEJs) on the glycaemia of hyperglycaemic rats

Blood glucose variation in pretreated hyperglycaemic rats

In this series of experiments, the average blood glucose level of the animals at the beginning was 1.15 ± 0.014 g / l. Thus, 30 minutes after administration of AEJs to 2; 2.5 and 3 g / kg BW

and glibenclamide at 10^{-2} g / kg BW, the average blood glucose measured did not significantly change (P> 0.05) from 1.15 ± 0.014 to 1.11 ± 0.021 g / l. Glucose administration at 4 g / kg BW yields variable and significant (P <0.01) increases in blood glucose in animals in each batch. In the control rats, the glucose administered results in an increase in blood glucose, with a peak of hyperglycemia 30 min afterwards, which is of the order of 1.46 ± 0.18 g / l. Subsequently, hyperglycemia was gradually reduced to 1.16 ± 0.15 g / l at the end of the experiment. In the treated animals, blood glucose increases from the mean of 11.11 ± 0.21 to 1.32 ± 0.12 g / l, 30 min after force-feeding with glucose. This blood glucose decreases as a function of the dose of AEJs and of the time. The dose of 3 g / kg bw and glibenclamide at 10-2 g / kg bw have the same peak and the blood glucose reduction is approximately the same over time. This reduction is at the average of 0.93 ± 0.13 g / l at the end of the experiment. Table 2 shows the percent reduction in blood glucose in each batch of rats. In the control animals the blood glucose decreased by 13.79% after 30 min and by 103.44% at the end of the manipulation.

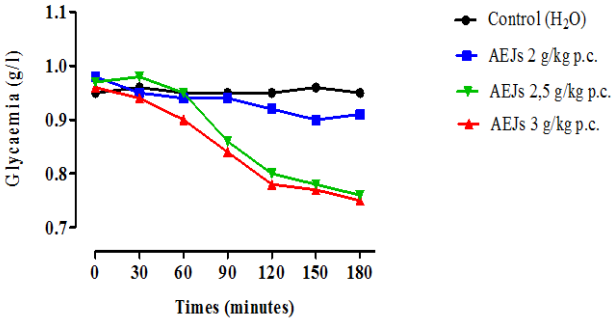

Figure 1. Dose-response effects of an aqueous extract of Justicia secunda (AEJs) on blood glucose in normoglycaemic rats

In animals treated with AEJs at 2; 2.5 and 3 g / l blood glucose respectively decreased by 7.69; 28.00 and 58.33% after 30 min and 98.30; 120 and 137.5% at the end of the experiment.

In glibenclamide-treated animals, blood glucose decreased by 67.85% after 30 min and by 157.14% at the end of the experiment. Figure 2 shows the variation in blood glucose in pre-treated hyperglycaemic rats with AEJs and glibenclamide as a function of the experimental time.

Variation of blood glucose in post-treated hyperglycaemic rats

During this experiment, the rats are rendered hyperglycemic after glucose anhydrous glucose and the mean measured blood glucose is 0.96 ± 0.17 g / l in the animals of different batches. This glucose level increases from 0.96 ± 0.17 to 1.47 ± 0.15 g / l 30 min after force-feeding of the animals in almost all the animals of the different batches (figure 3). Thereafter, this hyperglycaemia gradually decreases until the initial glycaemia returns. The reduction in hyperglycemia varies according to the dose of AEJs and time. In rats treated with AEJs at 2 g / kg bw, the reduction was not significant in comparison with the control. On the other hand, for animals treated with 2.5; 3 g / l AEJs and glibenclamide 10-2 g / l blood glucose is reduced to 0.90 ± 0.13; 082 ± 0.08 and 0.77 ± 0.10 g / l at the end of 180 min of experimentation. Table 3 shows the blood glucose reduction rates in treated animals as a function of time. In control rats, glycaemia decreased from 20.45 to 100% from the beginning to the end of the manipulation. In rats treated with AEJs, 2; 2.5 and 3 g / l, the blood glucose first drops to 11.90; 28.88 and 37.25% initially at 95.23; 117.77 and 127.45% at the end of the experiment. In rats treated with glibenclamide, the decrease is initially 40.90 at the beginning to 150% at the end.

Pharmacological effects of an aqueous extract of Justicia secunda (Acanthaceae) on the release of glucose by the liver of rats

The liver, even when removed from the body, produces glucose by glycogenolysis. In this manipulation, it is a question of assaying the glucose level produced by the isolated rat liver.

Table 2. Reduction of glucose-induced hyperglycemia in rats pretreated with AEJs and glibenclamide

		Time after administration of glucose				
		30 min	60 min	90 min	120 min	150 min
Percent reduction in hyperglycemia induced by 4 g / kg BW glucose Hyperglycemic control	Control Hyperglycemic	13,79	34,48	58,62	79,31	103,44
	AEJs (2 g/kg BW.)	7,69	23,07	42,30	65,38	98,30
	AEJs (2,5 g/kg BW.)	28	36	72	92	120
	AEJs (3 g/kg BW.)	58,33	75	95,83	116,66	137,5
	Glibenclamide (10^{-2} g/kg p.c.)	67,85	85,71	107,14	132,14	157,14

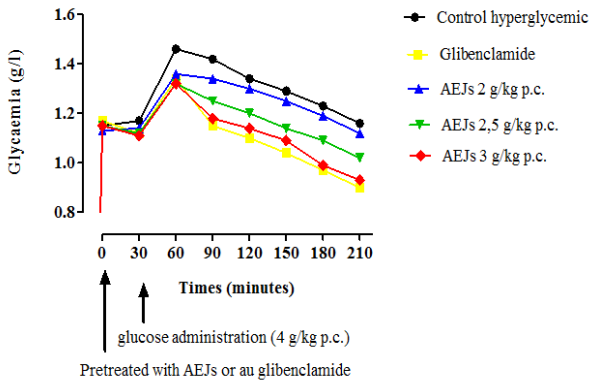

Figure 2. Time course of blood glucose in hyperglycaemic rats pretreated with aqueous extract of Justicia secunda (AEJs) and glibenclamide

Table 3: Reduction of glucose-induced hyperglycemia in rats post-treated with aqueous extract of Justicia secunda (AEJs) or glibenclamide

		Time after administration of glucose					
		30 min	60 min	90 min	120 min	150 min	180 min
Percent reduction in hyperglycemia induced by 4 g / kg BW glucose	Control Hyperglycaemic	20,45	36,36	54,54	68,18	84,09	100
	AEJs (2 g/kg BW.)	11,90	26,19	47,61	66,66	78,57	95,23
	AEJs (2,5 g/kg BW)	28,88	42,22	64,44	82,22	100	117,77
	AEJs (3 g/kg BW.)	37,25	52,94	74,50	101,96	115,68	127,45
	Glibenclamide (10^{-2} g/kg BW.)	40,90	59,09	84,09	109,54	134,09	150

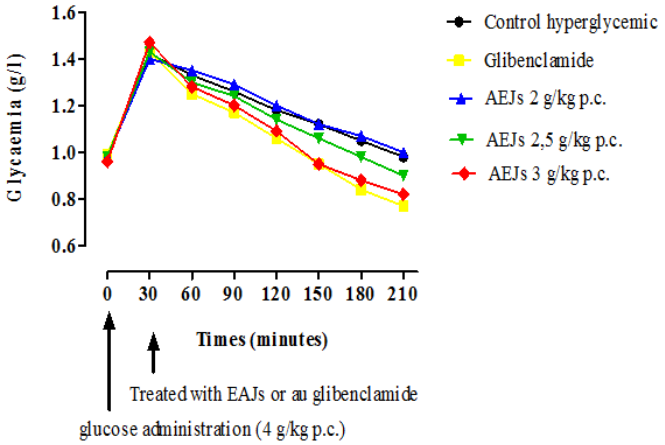

Figure 3. Time course of glycaemia in hyperglycemic rats post-treated with EAJs and glibenclamide

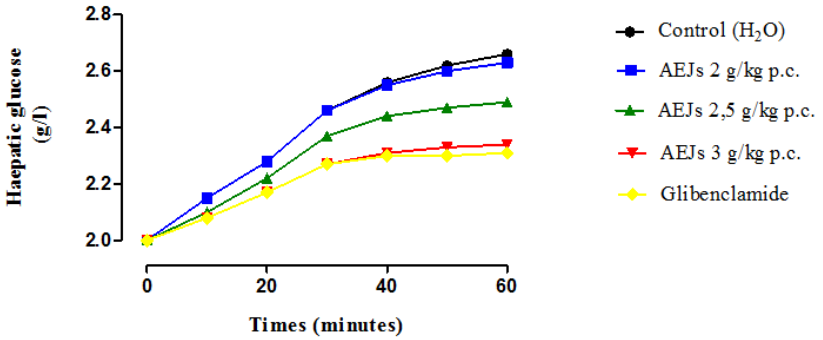

Figure 4. Evolution of the haepatic glucose of the control and treated animals as a function of time

The glucose concentration of each of the Mac Ewen glucose solutions before the experiment was 2 g / l. That of the control solution (S1) containing the liver of the control rats given distilled water increased from 2 g / l at the beginning of the experiment to 2,66 g / l at the end of the experiment; An increase of 24.81% in the glucose level. The glucose concentrations of the S2, S3 and S4 solutions, which received the liver from the rats treated with AEJs at the respective doses of 2 g / kg BW, 2,5 g / kg BW and 3 g / kg BW, were 2, 63 g / l, 2.49 g / l and 2,34 g / l respectively at the end of the experiment. In these solutions, the produced glucose level is 23.95% (S2), 19.67% (S3) and 14.52% (S4) relative to the initial glucose concentration. This is 0.05; 5.14 and 10.29% reduction of glucose produced by the liver compared to the control solution (S1). In solution S5 containing the liver of glibenclamide-treated rats at a dose of 10^{-2} g / kg BW, the glucose concentration at the end of the experiment was 2.31 g / l; as13.41% increase over the initial glucose concentration.

Figure 4 shows the time course of hepatic glucose concentration in control rats treated with AEJs and glibenclamide. The evolution of the hepatic glucose level in the S2 solution is equivalent to that of the glucose level in the solution S1 ($P > 0.05$). However, compared to the glucose level of the control solution (S1), glucose concentrations in rats treated with AEJs at 2.5 and 3 g / kg BW, as well as glibenclamide treated rats (S3, S4, S5) decreased significantly ($P < 0.05$).

DISCUSSION

The pharmacological study of the effects of the aqueous extract of *Justicia secunda* (AEJs) on blood glucose shows that the fasting glucose values (basal glucose) in Wistar rats used range from 0.59 ± 0.02 g / l to 1 , 2 ± 0.05 g / l. These values are consistent with normoglycaemic Wistar rats, as reported by Ojewole (2003), Giknis and Clifford (2008). AEJs, at doses greater than or equal to 2 g / kg BW, induce dose-dependent hypoglycemia.

These results show that the aqueous extract of *Justicia secunda* is a hypoglycemic substance. Force-feeding administration of 4 g / kg BW anhydrous glucose to control rats, pretreated or post-treated with AEJs and glibenclamide resulted in hyperglycemia (blood glucose > 1.2 ± 0.05 g / l), with a peak increase in blood glucose that occurs after 30 minutes. The glucose-induced hyperglycemia is subsequently progressively reduced and canceled. These results are in agreement with the work of Aziz (2012) and N'Doua *et al*. (2015) in Wistar rats. When rats were pretreated with AEJs at doses of 2.5 g / kg BW and 3 g / kg BW and with glibenclamide at 10^{-2} g / kg BW, the glucose-induced hyperglycemia peak was lower by Hyperglycaemic control. The reduction of the hyperglycaemia is more pronounced, with a cancellation of this hyperglycemia which occurs more quickly, causing hypoglycaemia to appear later. Similarly, in post-treated animals with AEJs (2.5 and 3 g / kg BW) and glibenclamide (10^{-2} g / kg BW), blood glucose return to normal is faster compared to rats Hyperglycaemic controls.

The reduction in glucose-induced hyperglycemia by EAJs is dose-dependent, and this extract, at a dose of 3 g / kg BW, has substantially identical (P> 0.05) effects to glibenclamide 10^{-2} g / kg BW Thus, like glibenclamide, the aqueous extract of *Justicia secunda* has anti-hyperglycemic effects. The effects of AEJs similar to those of glibenclamide, a hypoglycaemic, antihyperglycaemic agent of the sulphamide family, on blood glucose suggest that AEJs could act by the same mechanism as the reference substance used. Hypoglycaemia and reduction in hyperglycemia observed in rats treated with aqueous extract of *Justicia secunda* could be explained by stimulation of insulin secretion by the pancreas (Jackson and Bressler, 1981). This would make the aqueous extract of *Justicia secunda* an antidiabetic potential in patients with type 2 diabetes. The level of glucose released by the liver from control normoglycaemic rats and normoglycaemic rats treated with AEJs or with glibenclamide increases with time. It is known from the work of Bernard (1853) that the liver releases glucose. The production of hepatic glucose and its release into the bloodstream would be due to the hydrolysis of glycogen to glucose by the enzyme glycogen phosphorylase (Madsen, 1991). Compared to control normoglycaemic rats, the glucose level released from the liver of rats treated with AEJs and glibenclamide was much lower. These results are consistent with those of Kahou Bi *et al*. (2016) with the total aqueous extract of Pseudarthria hookeri (AEPh).

Thus, the reduction in hepatic glucose release in the presence of AEJs could be explained by inhibition of the enzyme glycogen phosphorylase. This inhibition is responsible for decreasing blood glucose levels (Hong *et al*., 2007). Furthermore, the reduction in hepatic glucose release by AEJs at 3 g / kg BW is similar to that of glibenclamide at 10^{-2} g / kg BW. It can therefore be suggested that, like glibenclamide, the mechanism of action of AEJs passes through its direct action on glut 2 receptors (glucose transporter in the cell) or stimulation of residual β cells of the pancreas to allow the storage of glucose (Hue, 1987). The presence in the aqueous extract of *Justicia secunda* of secondary metabolites showed the presence in this extract of polyphenols, alkaloids, saponosides, sterols and polyterpenes. These different chemical groups that contain AEJs are substances commonly used in therapeutics. Because of their properties, they are responsible for the hypoglycaemic, antihyperglycaemic and other known therapeutic effects of *Justicia secunda*.

Indeed, studies carried out by several authors have shown the hypoglycemic and antihyperglycaemic properties of phytosterols. Ladouari (2013) showed that the high content of flavonoids and phenolic compounds in the aqueous extract of *Zygophyllum album* (Zygophylaceae) would help to alleviate the symptoms of diabetes. The work of Kim (1999) showed the inhibition of α-glucisidase by the alkaloids. Hobou (2013) finds that the alkaloids contained in the aqueous extract of *Stachytarpheta indica* (Verbanaceae) inhibit glycogenolysis and stimulate glycogenogenesis, which is the cause of decreased blood glucose.

Conclusion

The secondary compounds present in the aqueous extract of *Justicia secunda* justify its use in the treatment of diabetes by African populations. The results obtained on the pretreated animals make it possible to say that this extract must be taken just before or during meals in order to keep low the blood sugar of the patients.

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