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Phytochemical screening, antioxidant and antidiabetic activities of *Maerua crassifolia* (Forsk) leaves, a medicinal plant used in the treatment of diabetes in Niger

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ABSTRACT: Diabetes is a pathology frequently encountered throughout the world. This disease is currently a public health problem in Africa. Medicinal plants are a source of molecules that can be used as antidiabetic agents. The present study aimed to study the phytochemistry and evaluation of antioxidant and inhibitory activities of α-amylase and α-glucosidase *in vitro* from crude extracts of aqueous decocted and hydroacetonic, ethanolic and methanolic macerated leaves of *Maerua crassifolia*. Phytochemical screening was carried out using colorimetric standards methods. The phenolics content was determined used spectrophotometric methods. The antioxidant and antidiabetic activities were evaluated. The screening revealed the presence of several secondary metabolites, such as alkaloids, tannins, flavonoids, coumarins, saponins, sterols and triterpenes. The antioxidant activity results show that the hydroacetonic extract is most active by the ABTS (2,2'-azinobis-(3-ethylbenzothiazoline-6-sulphonic acid)) method with an IC_{50} (inhibitory concentration 50) equal to 0.68±1.13 mg/mL and 0.80±0.41 mg/mL with the methanolic extract by the DPPH method (2,2-Diphenyl-1-picrylhydrazyl). The evaluation of the enzymatic inhibitory activity of the crude extracts showed inhibition percentages ranging from 61.59% to 90.07% for α-amylase and from 61.42% to 77.66% for α-glucosidase. The presence of certain secondary metabolites (flavonoids, saponosides and tannins) could justify the traditional use of *Maerua crassifolia* in diabetes management in Niger.

Keywords: *Maerua crassifolia*; Medicinal plants; Diabetes; Antioxidant; Antidiabetic.

1. INTRODUCTION

The use of medicinal plants by man is confused with the very history of humanity, both for food purposes, protection, energy and fight against disease [1]. Traditional medicine appears as a means of combating the inexorable rise in chronic non-communicable diseases [2]. Diabetes is an important public health issue and is one of the non-communicable diseases targeted by world leaders in recent years [3]. Globally, according to the

World Health Organization (WHO), in 2014, 8.5% of adults aged 18 and over had diabetes [3]. In 2019, diabetes was the direct cause of 1.5 million deaths and 48% of all these deaths occurred before age 70 [4]. The International Diabetes Federation (FID) estimated the number of diabetics at 463 million in 2019, a number that should exceed 578 million in 2030 [5]. In Africa, currently 24 million adults live with diabetes. This number is expected to increase, to 55 million people by 2045 [6]. In Niger, it is estimated that 382,000 people would be affected by 2050 [7]. Conventional drugs available are capable of delaying the fatal outcome, accessibility to these drugs remains nowadays very limited given their very high cost. This situation largely justifies the increased use of medicinal plants by poor populations. Worldwide, according to the WHO, up to about 80% of the world's population still relies on herbal medicines for their primary health care. This shows the important role of medicinal plants in maintaining health and in treating diseases as an alternative therapeutic [4,8]. Thus, the use of traditional medicine is still very widespread in developing countries and has become increasingly common in recent years in developed countries [3]. It is within the framework of the valorization of medicinal plants in Niger that this work must be situated.

The aim of the present study was to evaluate the antioxidant and antidiabetic activities of aqueous decocted and hydroacetonic, ethanolic and methanolic macerated extracts of *Maerua crassifolia* leaves by inhibition of the enzymatic activity of α-amylase and α-glucosidase methods. To find out why this plant is used in the treatment of diabetes and to highlight its various chemical characteristics in a scientific application.

2. MATERIAL AND METHODS

2.1. Plant material

The plant material was made of the fresh leaves of *M. crassifolia*. They were harvested in the botanical garden of the Faculty of Science and Technology (FAST) of the Abdou Moumouni University of Niamey, on October 10, 2022 (13°30'05.4"N 2°05'28.6"E). The Botanical identification of plants was made by the Garba Mounkaila Laboratory of the Department of Biology at the Abdou Moumouni University in Niamey. An herbarium specimen (Tandou makani/N°104) has been deposited as reference. The collected sample (leaves) was washed, then dried at room temperature and powdered.

2.2. Preparations of crude extracts

The leaves of *M. crassifolia* were washed and spread on a table to accelerate drying for 48 hours in the laboratory at room temperature and away from the sun. They were then ground into a fine powder using a grinder. From the obtained powder, the different raw extracts were obtained by decoction and maceration with ethanol (EtOH), methanol (MeOH) and a hydroacetonic mixture (HA).

2.2.1. Method of obtaining crude extract by decoction

30 g of leaf powder were placed in a one-liter flask, 300 mL of distilled water were added to it. The contents of the flask were homogenized and then brought to a boil for 30 minutes. After cooling, the obtained homogenate was successively filtered three (3) times on hydrophilic cotton and once on Whatman N°1 paper. The decocted was poured into a previously darned cup and then the water was evaporated using a sand bath. After, evaporation the raw extract was obtained.

2.2.2. Method of obtaining crude extracts by maceration

In three (3) Erlenmeyer flasks of 1L, 30 g of leaf powder were added in 300 mL of ethanol, methanol and a water–acetone mixture (20:80) respectively for 24h at room temperature. The operation was repeated three

times, each maceration was followed by 3 filtrations on hydrophilic cotton and once on Whatman N°1 paper, in order to retain the residues. In each case, the filtrates obtained were pooled and then evaporated the solvents using a rotary evaporator, then air-dried and the crude extracts were obtained.

2.3. Phytochemical screening

Phytochemical screening is a set of methods and techniques for the preparation and analysis of natural organic substances in plants. The detection tests for secondary metabolites focused on raw extracts of *M. crassifolia* leaves. These tests used are based on staining and precipitation reactions to highlight these chemical groups.

2.3.1. Characterization of polyphenols

To 1 mL of each extract was added a drop of an alcoholic solution of ferric chloride at 2%. The appearance of a more or less dark blue-blackish coloration indicates the presence of polyphenols [9].

2.3.2. Characterization of flavonoids

Flavonoids were characterized by the Shibata reaction: 2 mL of each extract were reincorporated into 2.5 mL of half-diluted hydrochloric acid with ethanol. The solution obtained was transferred into a test tube. The addition of 3 pieces of magnesium shavings results in a release of heat, then the appearance of an orange-pink or violaceous coloration indicates the presence of flavonoids [10].

2.3.3. Characterization of sterols and triterpenes

Sterols and triterpenes have been characterized by the Lieberman-Buchard reaction. It was made from 5 mL of each dry extract evaporated in a porcelain capsule with a sand bath. The residue was dissolved hot in 1 mL of acetic anhydride. The solution was thus transferred into a test tube in which 0.5 mL of concentrated sulfuric acid was carefully added along the tube wall. The appearance at the interphase of a purple or violet ring turning blue then green indicates the presence of sterols and triterpenes [9].

2.3.4. Characterization of tannins

In a test tube, to 1 mL of each extract are added 3 mL of the reagent of Stiasny: reaction with hydrochloric formalin in order to highlight the catechial tannins. The obtained solution was heated in a water bath at 80°C for 30 minutes. The appearance of large flakes after cooling indicates a positive reaction. This previously obtained solution was filtered and saturated with sodium acetate, then 3 drops of 2% $FeCl_3$ were added to it. The appearance of a blackish blue coloration indicates the presence of gallic tannins [11].

2.3.5. Characterization of quinones

The quinones were highlighted by the Borntaëger reaction. In a porcelain capsule, 2 mL of each extract were added, then triturated in 5 mL of hydrochloric acid diluted to 1/5. Afterwards, each solution was boiled in a water bath for 30 minutes. After cooling, the obtained solutions contained in test tubes, 20 mL of chloroform were added. Finally, the chloroformic phase was separated, then saturated with 0.5 mL of ammonia diluted to half, the appearance of a cherry red coloration indicates the presence of quinones [11].

2.3.6. Characterization of saponosides

The saponosides were highlighted by the foam test, as described: 2 mL of each extract was added to 20 mL of boiling water, after cooling the solutions were filtered. 10 mL of the filtrate were introduced into a test

tube. The tube was then shaken for about 15 seconds and left to stand for 15 minutes. A height of 1 cm of formed foam persistent for a few minutes indicates the presence of saponosides [9].

2.3.7. Characterization of alkaloids

The alkaloids were characterized using Dragendorff and Wagner reagents. 6 mL of each extract were added in 6 mL of 60% ethanol. Each solution thus obtained was divided into two test tubes A and B to which two drops of reagents from Dragendorff and Wagner were added respectively. The appearance of a brownish precipitate or an orange coloration with Dragendorff reagent and a dark brick red precipitate with Wagner reagent indicates the presence of alkaloids [10].

2.3.8. Characterization of coumarins

The search for coumarins was carried out by adding 1 mL of each extract into 1 mL of hot water. After cooling, each solution was divided into two test tubes: Tube 1 (control) and Tube 2 (addition of 0.5 mL of NH_4OH at 25%). The appearance of intense fluorescence (greenish-blue or violet) under a UV lamp at 366 nm indicates the presence of coumarins [9].

2.3.9. Quantification phenolic compounds

Determination of total polyphenol content

0.5 mL of each extract (1 mg/mL), 2.5 mL Folin Ciocalteu reagent diluted 10 times with distilled water and 2 mL sodium carbonate solution (75 g/L) were added. After homogenization, the mixture was incubated in darkness at room temperature for 30 minutes. Absorbance was read at 760 nm using a spectrophotometer (Thermoscientific Helios α) against distilled water as white. A linear calibration curve was drawn at concentrations: 0, 20, 40, 60, 80 and 100 mg/L with gallic acid as standard [12]. The results of the total polyphenols contents were expressed in mg gallic acid equivalent (mg GAE/g dry extract).

Determination of total flavonoids content

1 mL of each extract (1 mg/mL) was mixed with 1 mL of sodium nitrite $NaNO_2$ (5%), 1 mL of aluminum trichloride solution (20 g/L) and 2 mL of NaOH (4%). After incubation in the dark for 30 minutes at room temperature, the absorbance of the solution was read at 415 nm against distilled water as white. Flavonoid contents were determined from a linear calibration curve, established with concentrations 5; 10; 15; 20; 25 and 30 mg/L of quercetin as standard (10 mg/10mL) [13].

The results of the total flavonoids contents were expressed in mg quercetin equivalent (mg EQ/g dry extract).

$$C = \frac{ci \times D}{m} \times 100$$

C (Content expressed in mg equivalent to gallic acid 10 mg/10mL of extract), ci (concentration of the sample read (mg/L), D (dilution factor) and m (mass of the sample in mg).

Method for assessing tannin content

The assay is based on the property of proanthocyanidins to transform, by cleavage of the interflavane bond in an acid medium and at 100°C., into colored anthocyanidins (yellow-green) absorbing mainly at 550 nm. This reaction is commonly called the Bate-Smith reaction. To 2 mL of each crude extract (1 mg/mL) were placed in each hydrolysis tube and then 3 mL of hydrochloric acid (37%) was added to it. The test tubes were closed with a cap and placed in a water bath at 100°C for 30 minutes. The control tubes were left at room temperature. After cooling, the optical density of the solution in each test tube was measured using a type spectrophotometer (Thermoscientific Helios α) at 550 nm [14]. The tannin contents of the extracts were calculated according to the following formula:

C= 19.33(Doh - Dot)

C (the tannin content expressed in g/L), Doh (the optical density of the hydrolyzed tube) and Dot (the optical density of the control tube).

2.4. Evaluation of the antioxidant activity of crude extracts

2.4.1. DPPH scavenging

The antioxidant activity of crude extracts from *M. crassifolia* leaves was evaluated according to the method described by Blois. The extracts were diluted to 3 mL in order to obtain final concentrations in 2000; 1000; 500; 250; 125 and 62.5 µg/mL extracts, for a total of 6 tubes. 750 µL of each diluted solution were introduced into each tube and 2250 µL of the DPPH• solution (0.02%) was added to it. The reading of optical densities at 517 nm of the tube solutions was carried out after 30 min of incubation at room temperature and protected from light. The negative control consisted of DPPH without extract and the positive control of gallic acid treated as the samples but with final concentrations of 100 50; 25; 12,25; 6,25 and 3,12 µg/mL [15].

2.4.2. Scavenging of ABTS

The antiradical activity of crude extracts from *M. crassifolia* leaves was evaluated by the $ABTS^{\bullet+}$ radical cation discoloration test. The extracts were diluted to final concentrations in 2000; 1000; 500; 250; 125 and 62.5 µg/mL extracts. 750 µL of each diluted solution were introduced into a hemolysis tube and 2250 µL of $ABTS^{\bullet+}$ solution (0.175 mM) was added to it. The optical density reading of each solution at 734 nm was carried out after 30 minutes of incubation at room temperature and protected from light. The negative control consisted of ABTS reagent without extract and the positive control of ascorbic acid treated as extracts but with final concentrations of 100; 50; 25; 12,25; 6,25 and 3,12 µg/mL [16].

2.5. Evaluation of the antidiabetic activity *in vitro* of crude extracts

2.5.1. Inhibition of α-amylase

At 500 µL of each test extract (1 mg/mL), 500 µL of sodium phosphate buffer (0.02 M), 6 mM sodium chloride and 0.04 units of α-amylase solution were mixed in a test tube. The reaction mixture was then incubated for 10 min at 37°C. After that, 500 µL of 1% maltose solution dissolved in sodium phosphate buffer (0.02 M) were added. The test tube was then incubated in a boiling water bath for 5 min to stop the reaction and allowed to cool to room temperature. The absorbance of the solution was read at 540 nm using a type spectrophotometer (Evolution 300) after dilution of the reaction mixture by adding 10 mL of distilled water. Control samples (without raw extract) were prepared and their absorbances read as that of each test sample [17].

2.5.2. Inhibition of α-glucosidase

At 1000 µL of 0,1 M phosphate buffer (pH 7,0), 250 µL of each test extract (1 mg/mL), 250 µL of maltose (1%), 250 µL of p-NPG (0.5 mM), 250 µL of α-glucosidase solution (a stock solution of (1 mg/mL) in 0,01 M phosphate buffer, pH 7,0, was diluted to 0,1 unit/mL with the same buffer, pH 7.0). This reaction mixture was then incubated at 37°C for 30 min at room temperature. The reaction was then stopped by adding 100 µL of a sodium carbonate solution (0.2 M). Finally, the absorbance of the solution was read at 400 nm using a type spectrophotometer (Evolution 300) [18]. Control samples (without raw extract) were prepared and their absorbances read as that of each test sample. The results were expressed as a percentage of inhibition (%) using the equation (A_B: White absorbance; A_E: Sample absorbance):

Inhibition (%) = $[(A_B - A_E) / A_B] * 100$

3. RESULTS AND DISCUSSION

3.1. Yields of extractions from raw extracts

The yields of crude extracts obtained by decoction and maceration of *M. crassifolia* leaves are recorded in Table 1.

Table 1. Yields from the extraction of *Maerua crassifolia* leaves.

	Leaves of *Maerua crassifolia*			
Extraction method	Decoction	Maceration		
Nature of the extract	Aq	HA	EtOH	MeOH
Mass of the extract in (g)	2,1	2	1,5	1,2
Yield in (%)	7,00	6,67	5,00	4,00
Colors of the dry extract	Yellowish	Blackish green	Dark green	Dark green

Aq: aqueous, HA: hydroacetonic, EtOH: ethanolic and MeOH: methanolic.

The results of the extraction of *M. crassifolia* leaves by different decoction and maceration, show that the highest yields were obtained with decocted and hydroacetonic macerated respectively 7,00% and 6.67% and the lowest with ethanolic and methanolic macerates respectively 5.00% and 4.00%. Diallo study performed extractions of different organs of *M. crassifolia* (leaves, root and trunk bark) by decoction and maceration (with methanol, ethanol and water) [19]. The highest yields were obtained with ethanolic macerate of root bark (66.98%), followed by ethanolic, aqueous and methanolic macerates of leaves, respectively 30.56%, 20.4% and 10.86% [19]. Regarding the ethanolic and methanolic macerates of the leaves, his results are much higher than those obtained in this study. This difference could be explained by environmental or genetic factors that could impact certain biological characteristics of plants.

3.2. Test of phytochemical screening

The phytochemical screening highlighted the presence of eight (8) secondary metabolites in the crude extracts of *M. crassifolia* leaves. The results obtained are presented in Table 2.

Table 2. Results of the phytochemical screening of *Maerua crassifolia* leaves.

Crude extracts	**The groups chemicals**									
	Poly	**Flav**	**St & tri**	**Tannins**		**Qui**	**Sap**	**Alkaloids**		**Cou**
				Cat	**Gal**			**Dra**	**Wag**	
Decocted	+	+	-	+	+	-	+	-	-	+
Macerated/HA	+	+	-	+	+	-	+	-	-	-
Macerated/EtOH	+	+	-	+	+	-	+	-	-	+
Macerated /MeOH	+	+	+	+	+	-	+	-	-	+

Poly = polyphenols, Flav = flavonoids, St/tri = Sterols & triterpenes, Cat = catechial, Gal = gallic, Qui = quinones, Sap = saponosids, Dra = Dragendorff, Wag = Wagner, Cou = coumarines, Presence (+) et absence (-).

According to these results, the crude extracts of the leaves of *M. crassifolia* contain polyphenols, flavonoids, tannins, saponosides, coumarins, sterols and triterpenes. However, we detected neither quinones nor alkaloids in the studied extracts. This fact is partly in agreement with the results obtained by Diallo (2005), who did not detect any trace of alkaloid either in the crude extracts of the leaves or in those of the root and trunk

bark of *M. crassifolia*, but the quinones were present [19]. On the other hand, Akuodor *et al.* and Chaibou *et al.* reported that the aqueous extract of the leaves contains alkaloids [20,21]. This difference in chemical composition could also be explained by certain environmental and/or genetic factors of the plants or by the extraction methods.

3.3. Determination of total polyphenols, total flavonoids and tannins

The contents of total polyphenols, total flavonoids and tannins, expressed respectively in milligrams gallic acid equivalent per gram of extract (mg GAE/g), in milligrams quercetin equivalent per gram of extract (mg QE/g) and in grams per liter (g/L) are given in Table 3.

Table 3. Contents of phenolic compounds of raw extracts of *Maerua crassifolia* leaves.

Crude extracts	Phenolic compound content		
	Total polyphenols (mg GAE/g)	Total flavonoids (mg QE/g)	Tannins g/L
Decocted	49.13±0.027	9.93±0.085	1.024±0.04
Macerated/HA	76.31±3.363	19.95±0.005	0.406±0.01
Macerated /EtOH	24.06±0.344	17.24±0.016	5.277±2.57
Macerated /MeOH	44.51±0.354	15.90±0.001	0.006±0.35

Aq: aqueous, EtOH: ethanolic, HA: hydroacetonic and MeOH: methanolic, GAE: gallic acid equivalent, QE: quercetin equivalent.

The assay of phenolic compounds from crude extracts of *M. crassifolia* leaves, revealed that the macerated HA has the best content in polyphenols (76.31±3.363 mg GAE/g) and flavonoids (19.95±0.005 mg QE/g). However. the latter contains a small amount of tannins (0.406±0.01 g/L). The best tannin content was obtained with the ethanolic extract (5.277±2.57 g/L).

From the decocted leaves of *M. crassifolia*, Chaib found highest content of total flavonoids (15.720 1.046 mg QE/g) and tannins (10.2±0.34 g/L) than in this study [21]. On the other hand, we found the high content of total polyphenols (49.13±0.027 mg GAE/g) than in his study (35.129±2.291 mg QE/g).

It is noticed that in this study, the HA and aqueous extracts are richer in total polyphenols respectively 76.31±3.363 and 49.13±0.027 mg GAE/g compared to organic extracts (MeOH and EtOH) respectively 44.51± 0.354 and 24.06±0.344 mg GAE/g. Regarding the flavonoid content, the largest values were found with HA and ethanol extracts respectively 19.95±0.005 and 17.24±0.016 mg QE/g. According to scientific literature, phenolic compounds are sources of various biological activities and constitute the main group that contributes to the antioxidant activity of plants, fruits, and cereals [22,23].

3.4. Antioxidant activities

The values of inhibitory concentrations (IC_{50}) of gallic acid (reference antioxidant) for DPPH and ascorbic acid (reference antioxidant) for ABTS and different crude extracts from *M. crassifolia* leaves are presented in Figure 1.

The evaluation of the antioxidant activity of the different raw extracts of *M. crassifolia* leaves by the DPPH method revealed the following inhibition percentages: 60.19%, 61.35% and 53.27%, respectively for decocted, macerated MeOH and HA. It is less than 50% or 41.15% for the macerated EtOH.

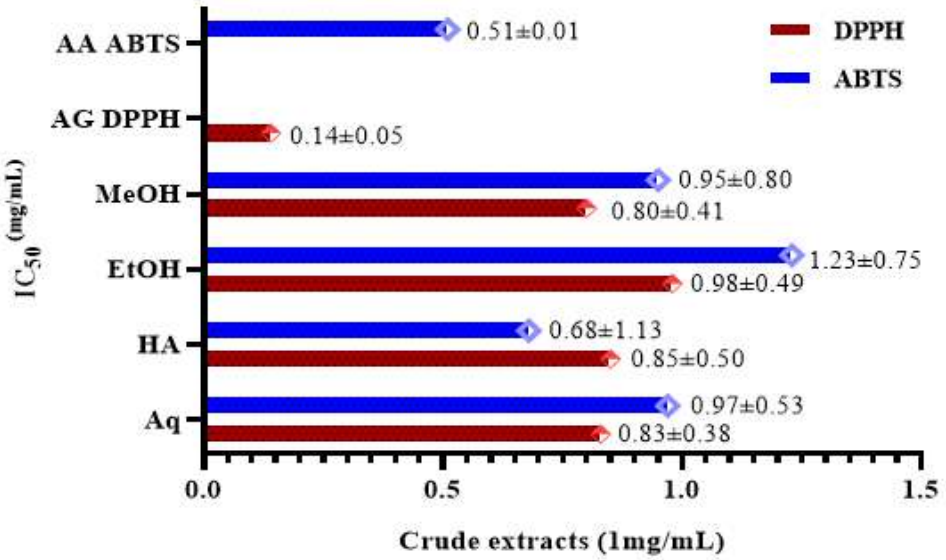

Figure 1. Values of inhibitory concentrations (IC_{50}) of the various crude extracts of *Maerua crassifolia* leaves by methods using the radical DPPH· and $ABTS^{-+}$. Aq: aqueous, EtOH: ethanolic, HA: hydroacetonic and MeOH: methanolic, AA: ascorbic acid, AG: gallic acid.

By the ABTS method, the inhibition percentages found are 53.90%, 57.51% and 61.85%, respectively for the decocted and macerated MeOH and HA. That of the macerated EtOH is found to be less than 50% or 39.00%. We note that the highest inhibition percentages were obtained with HA and MeOH macerated by the DPPH method and ABTS with 61.85% and 61.35% respectively. Indeed, the macerated EtOH has the lowest percentages lower by the two (2) methods. The greater the percentage of inhibition of an extract, the more significant the antioxidant activity [24]. It appears from the analysis of these results that the macerated HA is the extract with the highest antioxidant activity [24].

The inhibitory concentration values (IC_{50}) of the DPPH radical scavenging test by the different crude extracts from the leaves of *M. crassifolia* showed that these have significant antioxidant activity, but remain low compared to that of gallic acid (reference antioxidant). The MeOH extract (IC_{50} 0.80±0.41 mg/mL), followed by decocted (IC_{50} 0.83±0.38 mg/mL), HA extract (IC_{50} 0.85±0.50 mg/mL) and then EtOH extract (IC_{50} 0.98±049 mg/mL); the IC_{50} value of gallic acid being equal to 0.14±0.05 mg/mL. Ckilaka et al. obtained by the DPPH method an IC_{50} of 58.9 µg/mL for the MeOH extract from the leaves of *M. crassifolia* [25]. The extract from the leaves of *Maerua crassifolia* that is the subject of this study is significantly less active with an IC_{50} of 0.80±041 mg/mL (800 µg/mL) than the extract from the leaves of *M. crassifolia* on which this author has worked.

In a study, Chaib et al. found with the MeOH extract an IC_{50} of 122.89 µg/mL for the leaf extract of M. *crassifolia* [26]. It also appears from this study that the MeOH extract is significantly less active for an IC_{50} of 800 µg/mL. IC_{50}, is the antioxidant value necessary to decrease the initial concentration of free radicals from DPPH• or ABTS•+ by 50%. The lower the concentration inhibiting 50% of free radicals, the more the extract has a very good antioxidant activity [27].

By the ABTS method, the IC_{50} values are 0.68±1.13, 0.95±0.80, 0.97±0.53 and 1.23±0.75 mg/mL respectively for the HA, MeOH, Aq and EtOH extracts of *M. crassifolia* leaves compared to ascorbic acid (IC_{50}=0.51±0.01 mg/mL) as a reference antioxidant. From the IC_{50} obtained for the different extracts of *Maerua*

crassifolia leaves, it appears that the HA extract with an IC_{50} of 0.68±1.13 mg/mL has the highest antioxidant activity compared to other raw extracts tested.

The results of the ABTS test, based on the proton trapping capacity by the cationic radical ABTS•+, corroborate those already obtained with the DPPH test on the antioxidant ability of different extracts from the leaves of *M. crassifolia*. Indeed, by analyzing the values of IC_{50} obtained, it appears that by the two methods DPPH and ABTS, it is respectively the MeOH extracts (IC_{50} = 0.80±0.41 mg/mL) and HA (IC_{50} = 0.68±1.13 mg/mL) which have the best antioxidant powers. On the other hand, the EtOH extract is the least active in both cases with IC_{50} = 0.98±0.49 mg/mL and IC_{50} = 1.23±0.75 mg/mL respectively by the DPPH method and by the ABTS method. The two methods show that all the different crude extracts of *M. crassifolia* leaves inhibit the radicals DPPH and ABTS•+, their inhibitory powers are however lower than those of gallic acid and ascorbic acid (reference antioxidants).

According to literature, the presence of polyphenols, flavonoids and tannins in plants could be responsible for antioxidant activity [27]. This activity could be due to their redox properties, which play an important role in the adsorption and neutralization of free radicals, the quenching of singlet oxygen or the decomposition of peroxides. Sterols/triterpenes and flavonoids are often presented as antiinflammatories and hepatoprotectors [28]. They also possess antioxidant activities, the property of decreasing the permeability of blood capillaries and strengthening their resistance [29].

3.5. Inhibition of α-amylase and α-glucosidase activity

The results regarding the inhibition of α-amylase and α-glucosidase activities by the different crude extracts of *M. crassifolia* leaves are shown in Figure 2.

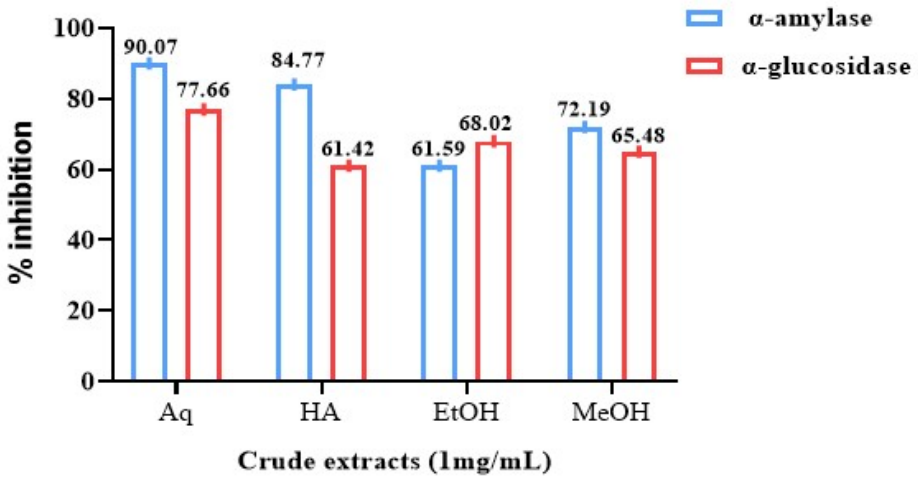

Figure 2. Percentages of inhibition of α-amylase and α-glucosidase activity on crude extracts of *Maerua crassifolia* leaves. Aq: aqueous, EtOH: ethanolic, HA: hydroacetonic and MeOH: methanolic.

The evaluation of the percentages of inhibition of α-amylase and α-glucosidase by crude extracts of the leaves of *M. crassifolia* revealed that all the extracts have inhibition percentages higher than 50%. The best percentage of inhibition were obtained with decocted and the HA extract on the α-amylase are respectively 90.07% and 84.77% and with decocted and the EtOH extract on α-glucosidase are respectively 77.66% and 68.02%. Indeed, the higher the rate of inhibition, the greater the enzyme inhibition. α-amylase and α-glucosidase are the two enzymes that play an important role in regulating postprandial blood sugar. Their respective inhibitions could decrease the blood glucose level in diabetic patients [30].

It has been reported that tannins have hypoglycemic properties [29], flavonoids, sterols and triterpenes could help prevent diabetes complications such as arteriosclerosis [31] and inflammations in diabetic [29]. The presence of these groups of chemical compounds in the different extracts from the leaves of *M. crassifolia* could explain the use of this medicinal plant in the treatment of diabetes in Niger.

4. CONCLUSION

Finally, the study of the phytochemical screening of aqueous crude extracts, hydroacetonic, ethanolic and methanolic of *M. crassifolia* leaves revealed the presence of important classes of secondary metabolites such as, polyphenols, flavonoids, tannins, saponosides, coumarins, sterols and triterpenes. The quantitative assay showed that the hydroacetonic extract contains the highest levels of total polyphenols and total flavonoids, and the ethanolic extract the highest in tannins.

The evaluation of antioxidant activity by chemical methods using DPPH• free radical and $ABTS^{\bullet+}$ cation radical trapping showed that all extracts tested have significant antioxidant activity except for the ethanolic extract.

The study of the inhibitory activity of α-amylase and α-glucosidase showed a significant inhibitory activity of all raw extracts of *M. crassifolia* leaves tested on these targeted enzymes.

The results obtained during phytochemical studies and antioxidant and antidiabetic activities could justify the traditional use of *M. crassifolia* in the treatment of type 2 diabetes.

Author Contributions: BSA: conceptualization, research, methodology, analysis, writing– original version. AKD: methodology, writing–original version, validation, supervisor. MML: conceptualization, writing – revision and editing, co-supervisor. MIIA: methodology, analysis, software. TJ-M: Theme, validation, revision and editing, original version. BS: Conceptualization, examiner. All authors have read and agreed to the published version of the manuscript.

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REFERENCES

1. Macheix JJ, Fleuriet A, Jay-Allemand C. Phenolic compounds in plants: an example of economically important secondary metabolites. Lausanne: PPUR Polytechnic Press; 2005. Available from: https://books.google.ne/books.
2. WHO. WHO cooperation strategy in the country 2009-2015: Niger. Geneva: WHO; 2014. p. 81. Available from: https://iris.who.int/handle/10665/250676.
3. WHO. Global report on diabetes. Geneva: World Health Organization; 2016 [cited 20 July 2022]. 86 p. Available from: https://apps.who.int/iris/handle/10665/254648.
4. Steinmetz JD, Bourne RRA, Briant PS, Flaxman SR, Taylor HRB, Jonas JB, et al. Causes of blindness and vision impairment in 2020 and trends over 30 years, and prevalence of avoidable blindness in relation to VISION 2020: the Right to Sight: an analysis for the Global Burden of Disease Study. Lancet Global Health. 2021; 9(2): e144-160.

5. Habak N, Rouibah N, Chikouche A. Prevalence of hyperuricemia in type 2 diabetics. Algerian J Biochem Med Gen. 2022; 1(2): 18-27.
6. WHO. Guidance on monitoring non-communicable diseases in health facilities: framework, indicators and application. Geneva: WHO; 2022. 68 p. Available from: https://www.who.int/fr/news-room/fact-sheets/detail/diabetes.
7. OOAS. Pharmacopoeia of West Africa. OOAS. 2013. p. 1-268. Available from: https://www.wahooas.org/web-ooas-prod/sites/default/files/publications/2192/manuel-de-formation-des-tradipraticiensok.pdf.
8. WHO. Strategy for Traditional Medicine 2002-2005. Geneva: WHO; 2002. p. 78.
9. Bonga GM, Guede-Guina FR, Vanga-Mandah M. Demonstration of antifungal phytosteroids against Cryptococcus neoformans. Rev Afr Med Pharmacopoeia. 1995; 9: 21-30.
10. Wagner H, Bladt S. Plant Drug Analysis. 2nd ed. Berlin: Springer. 1996. Available from: http://dx.doi.org/10.1007/978-3-642-00574-9.
11. Evans WC, Evans D, Trease GE. Trease and Evans pharmacognosy. 16th ed. Edinburgh; New York: Saunders/Elsevier; 2009. 603 p.
12. Singleton VL, Orthofer R, Lamuela-Raventós RM. Analysis of total phenols and other oxidation substrates and antioxidants using the folin-ciocalteu reagent. In: Methods in enzymology. Vol. 299. Elsevier; 1999. p. 152-78.
13. Arvouet-Grand A, Vennat B, Pourrat A, Legret P. Standardization of propolis extract and identification of the main constituents. Pharm J Belg. 1994; 49(6): 462-468.
14. Bate-Smith EC. Investigation of the chemistry and taxonomy of sub-tribe Quillajeae of the Rosaceae using comparisons of fresh and herbarium material. Phytochemistry. 1965; 4(4): 535-539.
15. Blois MS. Antioxidant determinations by the use of a stable free radical. Nature. 1958; 181(4617): 1199-1200.
16. Re R, Pellegrini N, Proteggente A, Pannala A, Yang M, Rice-Evans C. Antioxidant activity applying an improved ABTS radical cation decolorization assay. Free Radical Biol Med. 1999; 26(9-10): 1231-1237.
17. Miller GL. Use of the reagent dinitrosalicylic acid for the determination of reducing sugar. Anal Chem. 1959;31(3): 426-428.
18. Nurcholis W, Artika IM, Seno DSH, Andrianto D, Aprianti A, Febrianti F, et al. Phytochemical analysis, in vitro α-glucosidase inhibition activity and kinetic enzyme of ethyl acetate and hexane extracted from Graptophylum pictum (L.) Griff. Current Biochem. 2014; 1(2): 58-65.
19. Diallo AM. Study of medicinal plants from Niafunke (Timbuktu region). Phytochemistry and pharmacology of Maerua crassifolia Forsk (Capparidaceae). Doctoral thesis. University of Bamako. 2005; 140 p.
20. Akuodor GC, Ibrahim JA, Akpan JL, Okorie AU, Ezeokpo BC Phytochemical and anti-diarrhoeal properties of the methanolic leaf extract of Maerua crassifolia Forssk. Eur Rev Med Plants. 2014; 4(10): 1223.
21. Chaib F. Study of some Saharan plants from Tamanrasset «El-Hoggar»: Extraction, Identification and Biological Activities of Essential Oils [Doctoral Thesis]. University of Tlemcen, Algeria; 2018. 165 p.
22. Tachakittirungrod S, Ikegami F, Okonogi S. Antioxidant active principles isolated from Psidium guajava grown in Thailand. Scientia Pharmac. 2007; 75(4): 179-193.
23. Rubió L, Motilva MJ, Romero MP. Recent advances in biologically active compounds in herbs and spices: a review of the most effective antioxidant and anti-inflammatory active principles. Crit Rev Food Sci Nutr. 2013; 53(9): 943-953.
24. Fofie NBY, Odoh EA, Kiendrebeogo M, Sanogo R, Kone-Bamba D. Antioxidant and anti-hyperglycemic activity of Sorghum. Sci Nat. 2016; 2: 11.
25. Ckilaka KC, Akuodor GC, Akpan JL, Ogiji ED, Eze CO, Ezeokpo BC. Antibacterial and antioxidant activities of the methanolic leaf extract of Maerua crassifolia. Rev Appl Pharmac Sci. 2015; 5(10): 147-150.

26. Chaib F, Sahki R, Sabaou N, Rached W, Bennaceur M. Phytochemical study and biological activities of certain Saharan plants of the Hoggar. J Agricult Sci. 2015; 7(7): 163.
27. Choho MF, Kporou KE, Ouattara S, Gbogbo M, Kroa E, Kouakou GS, et al. Phytochemical characterization and antioxidant activity of an herbal drug "Datras Epigastro" used in the traditional therapy of gastritis in Côte d'Ivoire. Pharmacopeia Tradit Afr Med. 2022; 21(1): 40-49.
28. Bruneton J. Pharmacognosy, phytochemistry, medicinal plants. 4th ed. Lavoisier; 2009. 1289 p.
29. Bruneton J. Pharmacognosy: phytochemistry medicinal plants. Lavoisier. 1993. p. 316.
30. Bhat M, Zinjarde SS, Bhargava SY, Kumar AR, Joshi BN. Indian antidiabetic plants: a good source of potent amylase inhibitors. Evid-Based Complem Altern Med. 2011; 2011: 10.
31. Perez GRM, Zavala SMA, Perez GS, Perez GC. Antidiabetic effect of compounds isolated from plants. Phytomedicine. 1998; 5(1): 55-75.