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Quantification of Total Phenols, Total Flavonoids, Total Anthocyanins and Evaluation of Antioxidant and Antiradical Activities of Detarium Senegalense Extracts from Chad

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Abstract

The aim of the present work is to assess the value of Detarium Senegalense by determining the content of total phenols, total flavonoids and total anthocyanins, and by evaluating the free radical scavenging activity of Detarium Senegalense extracts. For this purpose, sequential extraction using solvents of increasing polarity was essential. The various extracts obtained underwent phytochemical and biochemical analyses. Phytochemical screening revealed the presence of flavonoids, alkaloids, tannins, polyphenols, anthocyanins and steroids/terpenes. Quantitative analysis of total polyphenols, total flavonoids and total anthocyanins yielded the following results: total flavonoids (0.803 ± 0029 mg EQ/100g P for acetone extract of roots and 0.871 ± 0.401 mg EQ/100g P for methanol extract of leaves); total polyphenols (23.298 ± 12.68 mg EAG/100g P for acetone extract of roots and 24.69 ± 0.49 401 mg EAG/100g P for methanol extract of leaves); total monomeric anthocyanins (44.697 ± 0.939 mg EC3G/100g P and 16.699 ± 0.193 mg EC3G/100g P respectively for acetone and methanol extracts of stem bark). DPPH free radical scavenging activity was 1.674 ± 0.023 mg/mL for the acetone extract and 0.934 ± 0.24 mg/mL for the methanol extract of roots.

Keywords

Total Phenols, Total Flavonoids, Total Anthocyanins, Antioxidant and Anti-Radical Activities, Detarium Senegalense, Chad

1. Introduction

Native to tropical Africa, Detarium senegalense belongs to the Detarium genus known as "Detar" from Senegal, and was first mentioned by De Jussieu in the gênera Plantarum [1]. A number of authors subsequently became interested in the Detarium genus because of the identification of two varieties with morphotypes that were difficult to differentiate, one of which produced poisonous fruit. This rare fact, also observed in the species Amygdalus communis L., two varieties of which contain cyanogenic heterosides in different doses, is at the root of the confusion in the identification of Detarium species [2].

The majority of the population turns to medicinal plants for treatment, due to lack of access to conventional medicines, cultural attachment, but also because these plants are often genuinely effective [3]. With this in mind, we focused our study on Detarium senegalense, a plant easily found in southern Chad.

In pharmacology, the seed coats of Detarium senegalense are used in Nigeria to treat arrow poisoning, while in Senegal, the burnt seeds are used as a mosquito repellent [4]. Fractions of the hydroethanol extract of Detarium senegalense bark have antibacterial activity against a wide range of pathogenic bacteria [5]. In trials, flour prepared from seeds reduced postprandial glycemia and insulin concentrations in humans [6]. The aqueous extract of stem bark has been shown to have anti-diarrhoeal activity [7], to treat venereal diseases, urogenital infections, haemorrhoids, rheumatism, stomach ache and intestinal worms, and to relieve pains such as headaches, backache, sore throat and painful menstruation [8] [9]. In northern Nigeria, Detarium senegalense is used in cosmetics [10].

In phytochemistry, alkaloids, sterols, triterpenes, flavonoids, saponins, coumarins, tannins, anthraquinones and cyanogens were identified in Detarium senegalense. Quantification of secondary metabolites from seeds and stem bark of Detarium senegalense Gmelin in southeastern Nigeria revealed alkaloid content of 0.37% - 0.72%; flavonoids 2.28% - 5.68%; tannins 0.47% - 0.79%; phenols 0.35% - 0.67% and saponins 1.85% - 4.60% [11]. Some flavonoids, saponosides, alkaloids and anthocyanins have been isolated from Detarium senegalense [5].

The main objective of this study is to valorize Detarium senegalense for its anti-free radical and antioxidant potential. To achieve this, it is necessary to qualitatively and quantitatively analyze and evaluate certain secondary metabolites with anti-free radical properties.

2. Materials and Methods

2.1. Plant Material

The plant material for our study consists of leaves, trunk bark, stems and roots of Detarium senegalense. It was collected on October 10, 2020, between Canton Kiagor and Canton Goré-Bôh in the sub-prefecture of Bébalem in the Ngour-kosso Department of the Logone Occidentale Province, and then identified by a botanist and teacher-researcher in the Biology Department of the Faculty of Exact and Applied Sciences (FSEA) at the University of N'Djaména and at the Institut

de Recherche pour l'Elevage et le Développement. All samples were dried separately, protected from light and humidity. They are ground and pulverized. The resulting powders are stored in glass bottles for later analysis.

2.2. Sequential Extraction

The powders of different parts of Detarium senegalense preserved for analysis underwent sequential extraction with solvents of increasing polarity (hexane, acetone and methanol). 50 g of powder from the various plant parts were placed in 150 mL of solvent. After 60 min of magnetic stirring at room temperature, the extract is filtered under vacuum to concentrate and dry it, then the solvent is recovered. This operation is performed in triplicate. Each time, the residue is dried and extracted with a low-polarity solvent. After drying, the yield of each extract is calculated, and the extracts are subjected to phytochemical and pharmacological analysis.

2.3. Qualitative Analysis

The various extracts obtained after sequential extraction underwent phytochemical screening using the protocol described by N'Guessan *et al.* [12] which Betoloum *et al.* [13] adapted.

2.4. Quantitative Analysis

2.4.1. Determination of Total Polyphenols

To 1.05 mL of sample, 2.5 mL of Folin's reagent was added and the resulting solution diluted 10-fold. After 8 min, 4 mL of 7.5% (w/v) sodium carbonate was added. The mixture was incubated for 30 min and absorbance measured at 765 nm. Gallic acid was used as the standard. Results are expressed as mg Gallic Acid Equivalent (GAE)/100g powder. All experiments were performed in triplicate.

2.4.2. Determination of Total Flavonoids

To 1 mL of $AlCl_3$ solution (2% dissolved in methanol), 1 mL of each sample and standard (prepared in methanol) was added. Absorbance was read after 10 minutes of incubation against the prepared reagent blank [13].

Flavonoid concentrations were deduced from the calibration curve range established with quercetin (0 - 35 µg/mL) [14]. Results are expressed in milligrams Quercetin Equivalent per 100 g powder: mg EQ/100g P.

2.4.3. Determination of Total Anthocyanins

The total anthocyanin content of extracts is estimated by the pH-differential method using two buffer systems: potassium chloride solution (KCl), pH 1.0 (0.025 M) and sodium acetate solution (CH_3COONa), pH 4.5 (0.4 M).

To 1.2 ml of extract, 10.8 ml of the corresponding buffers were added and the absorbance was read against the blank at 510 nm and at 700 nm 15 minutes later. Absorbance A was calculated as follows: A = (A510 - A700) pH 1.0 - (A510 - A700) pH 4.5. The monomeric concentration of anthocyanin dyes in the extract was calculated as cyanidin-3-glucoside [15] where A: absorbance; MW: molecu-

lar weight; (449.2); DF: dilution factor; ε: molar absorptivity (26,900). Total anthocyanin contents are expressed in micrograms of cyanidin-3-glucoside per gram of dry material.

2.5. Evaluation of Antioxidant Activity: DPPH Test

Numerous methods are used to assess the antioxidant activity of extracts. Most of these methods are based on the coloration or decoloration of a reagent in the reaction medium. The DPPH test is used to assess the antioxidant activity of Detarium senegalense extracts.

This method is based on the reduction of the stable radical species DPPH—in the presence of a hydrogen-donating antioxidant (AH), resulting in the formation of a non-radical form. In the presence of free-radical scavengers, the violet DPPH—is reduced to yellow DPPHH. The reduction of the DPPH free radical can be monitored by UV visible spectrometry, measuring the decrease in absorbance at 517 nm [16].

The reaction medium was made by mixing 0.16 mL of DPPH solution with a concentration of 0.04 mg/mL (10 mg/250mL methanol) with 8 mL of extracts at concentrations ranging from 0, 312 mg/mL to 10 mg/mL. Absorbance was read at 517 nm after 30 min incubation in the dark. The percentage of DPPH radical inhibition was calculated according to the following equation:

$$\text{DPPH inhibution}(\%) = \left[\left(\text{Absorbance Essay}\right)/\left(\text{Absorbance Blank}\right) - 1\right] \times 100 \quad (1)$$

Each point represents the mean of 3 replicates. IC50 values, which are the concentrations of plant or quercetin extracts producing 50% DPPH radical inhibition were determined according to the protocol described by Bétoloum *et al.* [13].

2.6. Evaluation of Antioxidant Power by Ferric Ion Reduction FRAP (Ferric Reducing Antioxidant Power)

The reducing power of an extract is associated with its antioxidant power. The iron-reducing activity of extracts is determined according to the method described by Oyaizu [17] and taken up by Zhao *et al.* [18] with slight modification. It is based on the chemical reaction of reduction of Fe^{3+} to Fe^{2+} present in the $K_3Fe(CN)_6$ complex. This reducing capacity can serve as a significant indicator of a compound's potential antioxidant activity. The absorbance of the reaction medium is determined at a wavelength of 700 nm using a UV-Visible spectrophotometer. Ascorbic acid is used as the standard.

2.7. Procedure

One milliliter of extracts of different concentrations (from 0.018 to 2.5 mg/mL) is mixed with 2.5 mL of 0.2 M phosphate buffer (pH = 7) and 2.5 mL of 1% potassium ferricyanide $K_3Fe(CN)_6$. The whole set is heated in a water bath at 50˚C for 20 min. Next, 2.5 mL of 10% trichloroacetic acid is added to stop the reaction. The tubes are centrifuged at 3000 rom for 10 min.

An aliquot (2.5 mL) of supernatant is diluted with 2.5 mL distilled water and 0.5 mL 0.1% $FeCl_3$ aqueous solution. The absorbance of the reaction medium is read at 700 nm against a blank having undergone the same preparation, replacing the extract with distilled water. The activity of the extracts is compared with that of two standard antioxidants, ascorbic acid and gallic acid, whose absorbance was measured under the same conditions as the extracts, but at lower concentrations. An increase in absorbance corresponds to an increase in the reducing power of the extracts tested [19].

2.8. Determination of Antioxidant Activity by Thin-Layer Chromatography

Thin-layer chromatography is performed on a glass plate coated with a thin layer of stationary phase. The extracts to be separated are deposited on a line drawn 5 cm from the base of the plate. This is done manually by filling a calibrated glass capillary tube after the sample has been taken by capillary action. The end of the plate is then immersed in a tank containing the eluent. The stationary phase is silica, which is responsible for adsorption and partitioning. The compounds to be separated from the extract are dissolved in the eluent vapour, which carries them away, separating them into small-diameter spots. The result is diffuse round spots [20].

Chemical detection is carried out directly after revelation by spraying with a reagent capable of reacting with the separated molecules to give colored or fluorescent substances. This physical detection is carried out under visible light and then under UV at two (2) wavelengths, preferably 254 nm and 366 nm.

Each component migrates at a speed that depends on its partition coefficient. At the end of the operation and after revelation, each substance appears in the form of a spot, in principle circular and symmetrical; the notion of reference Rf (Rate of flow) is introduced, by the relation:

$$\mathrm{Rf} = \left(\text{Distance travelled by the substance}\right) / \left(\text{Distance travelled by the solvent front}\right) \quad (2)$$

3. Results

3.1. Extraction Yields

Yields of extracts from different plant parts are shown in **Table 1**. Values vary according to plant material and extraction solvent.

3.2. Phytochemical Screening

The results of the qualitative analysis are shown in **Table 2**. These results reveal the presence of alkaloids, flavonoids, saponins, tannins, anthocyanins and coumarins, and the absence of sterols and terpenoids in the acetone and methanol extracts of all plant parts. For hexane extracts, however, the analysis revealed only sterols and terpenoids, but not other secondary metabolites.

Table 1. Extraction yields.

Samples	Solvent		
	Hexane	Acetone	Methanol
Leaves	17.01%	11.43%	23.67%
Stem bark	4.03%	21.43%	3.87%
Roots	12.21%	20.73%	25.48%

Table 2. Phytochemical screening results.

Samples	Chemical *groups*	Solvent		
		Hexane	Acetone	Methanol
Leaves	Alkaloids	−	+	+
	Flavonoids	−	+	+
	Saponosides	−	+	+
	Tannins	−	+	+
	Anthocyanins	−	+	+
	Stérols/terpenes	+	−	−
	Coumarins	−	+	+
	Alkaloids	−	+	+
Stembark	Flavonoids	−	+	+
	Saponosides	−	+	+
	Tannins	−	+	+
	Anthocyanins	−	+	+
	Stérols/terpenes	+	+	+
	Coumarins	−	+	+
Roots	Alkaloids	−	+	+
	Flavonoids	−	+	+
	Saponosides	−	+	+
	Tannins	−	+	+
	Anthocyanins	−	+	+
	Stérols/terpenes	+	+	+
	Coumarins	−	+	+

(−): Absence; (+): Presence.

3.3. Quantitative Analysis

3.3.1. Determination of Polyphenols

The standard used for this analysis is gallic acid. A range of concentrations of gallic acid solutions was used, from 0 to 0.6 mg/mL in 0.1 mg/mL steps. The calibration curve obtained is shown in **Figure 1** below.

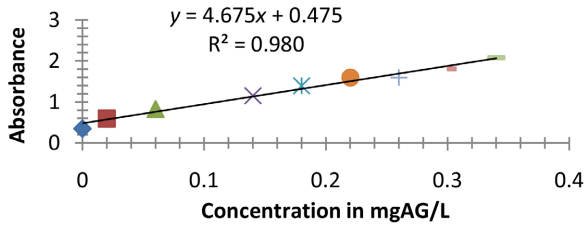


Figure 1. Gallic acid calibration curve.

After calculations based on the calibration curve, the results of spectrophotometric analysis of total polyphenol content are shown in **Table 3**. These results are expressed in milligrams of gallic acid equivalent (mg GAE) per 100 grams of powder, and the values represent the averages of three measurements ± standard deviation.

3.3.2. Flavonoid Assay

The standard used for this analysis is quercetin. The calibration curve is obtained by a range of concentrations of quercetin solutions from 0 to 0.6 mg/mL in steps of 0.1 mg/mL. This calibration curve is shown in **Figure 2** below.

The results of spectrophotometric analysis of total flavonoids are obtained on the basis of calculations made from the calibration curve. These results are reported in **Table 4**, where the total flavonoid content is expressed in milligram quercetin equivalent per 100 grams of powder (mg EQ/100g P). Values represent averages of three replicates ± standard deviation.

3.3.3. Anthocyanin Quantification

Antioxidant quantification is based on free radical scavenging at DDPH. It was deduced from the Quercetin-DPPH calibration absorbance (**Table 5**).

Table 5 shows total anthocyanin content.

3.4. Pharmacological Analyses

3.4.1. Anti-Free Radical Activity

The results of anti-free radical tests carried out by thin-layer chromatography are shown in **Figures 3-5** below.

For the DCM/MeOH/H_2O system (9.5/0.5/0.5).

Anti-radical activity: AcOEt/AAG/EAU system.

3.4.2. Antioxidant Quantification

Antioxidant quantification is based on free radical scavenging at DDPH. It was deduced from the calibration absorbance of Quercetin-DPPH in **Table 6**.

The calibration curve is shown in **Figure 6** below.

The results of this analysis are shown in **Table 7**.

3.5. Statistical Analysis

The statistical study was carried out using Excel software with a probability threshold of 5%, according to the protocol of Hougard J. M. *et al.*, 2003 [21]. All

Table 3. Total polyphenol content.

Plant material	Solvent	Total polyphenol content (mg GAE/100g P)
Leaves	Acetone	19.275 ± 0.3217b
	Methanol	24.690 ± 0.4913a
Stem barks	Acetone	4.299 ± 5.777c
	Methanol	22.55 ± 0.235b
Roots	Acetone	23.298 ± 12.680a
	Methanol	21.558 ± 2.599c

Values with the same superscript letters in the columns are not significantly different ($p < 0.05$) according to Duncan's multiple comparison test.

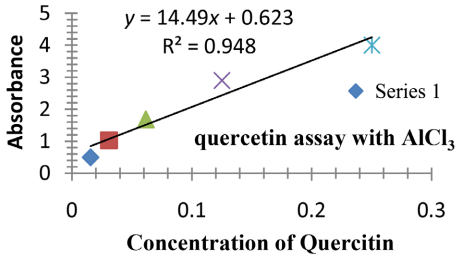


Figure 2. Calibration curve for quercetin.

Table 4. Total flavonoid content.

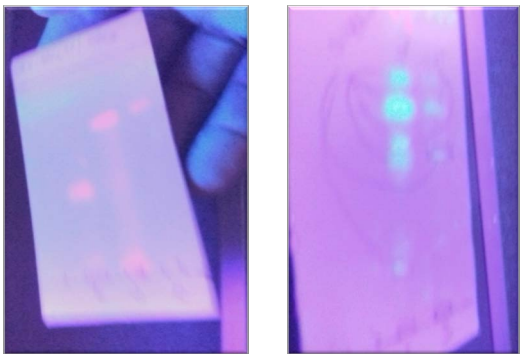
Plant material	Solvent	Total flavonoid content (mg QE/100g P)
Leaves	Acetone	0.831 ± 0.136b
	Methanol	0.871 ± 0.401a
Stem barks	Acetone	0.286 ± 5.777a
	Methanol	0.291 ± 0.012c
Roots	Acetone	0.803 ± 0.029c
	Methanol	0.296 ± 0.04b

Values with the same superscript letters in the columns are not significantly different ($p < 0.05$) according to Duncan's multiple comparison test.

Table 5. Total monomeric anthocyanin content.

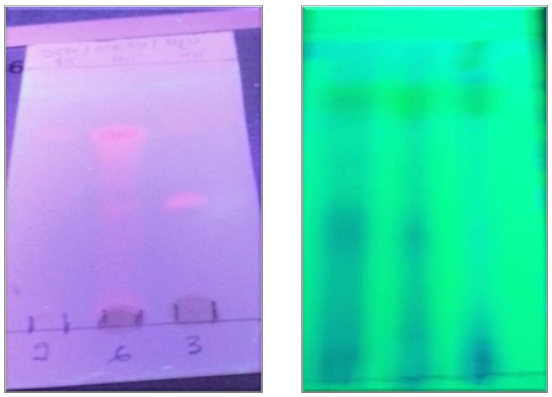
Plant material	Solvent	Total anthocyanin content (mg/100g P)
Leaves	Acetone	8.450 ± 0.021b
	Methanol	10.520 ± 0.221b
Stem barks	Acetone	44.697 ± 0.939a
	Methanol	16.699 ± 0.193a
Roots	Acetone	6.457 ± 0.578c
	Methanol	9.129 ± 0.171c

Values with the same superscript letters in the columns are not significantly different ($p < 0.05$) according to Duncan's multiple comparison test.



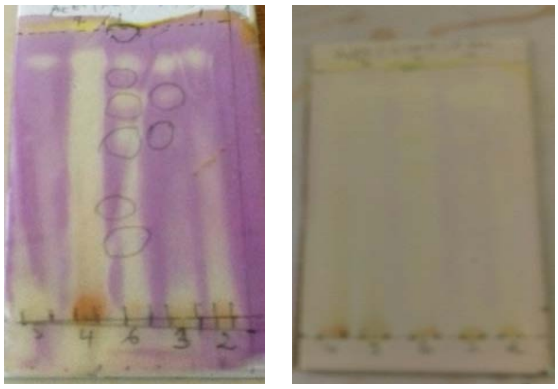
(a) (b)

Figure 3. Chromatogram of flavonoids. (a) Before revelation; (b) After revelation. 3: Methanol extract of leaves; 6: Acetone extract of bark; 9: Acetone extract of leaves.



(a) (b)

Figure 4. Flavonoid chromatogram revealed with NEU. (a) Before revelation; (b) After revelation. 3: Methanol extract of leaves; 6: Acetone extract of bark; 9: Acetone extract of leaves.



(a) (b)

Figure 5. Anti-radical test. (a) Before revelation; (b) After revelation.

Table 6. Quercetin-DPPH calibration absorbance.

Quercetin concentration (mg/mL)	0	0.005	0.01	0.015	0.02	0.025
Absorbance (256 nm)	0.6865	0.5365	0.4125	0.2775	0.1435	0.0575

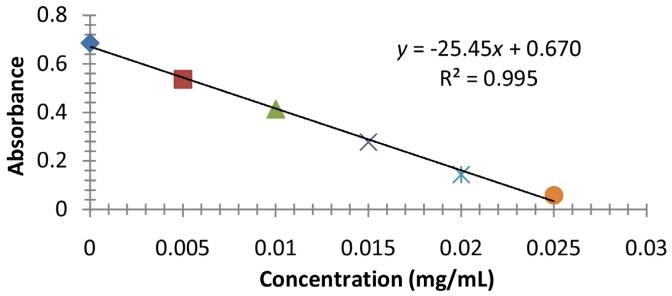


Figure 6. DPPH quercetin calibration curve.

Table 7. Antioxidant content.

Plant material	Solvent	Antioxidant content (mg QE/100g P)
Leaves	Acetone	2.438 ± 0.03a
	Methanol	2.152 ± 0.07a
Stem barks	Acetone	1.256 ± 0.15c
	Methanol	1.634 ± 0.05b
Roots	Acetone	1.674 ± 0.023b
	Methanol	0.934 ± 0.024c

Values with the same superscript letters in the columns are not significantly different ($p < 0.05$) according to Duncan's multiple comparison test.

experiments were performed in triplicate. Results are expressed as mean ± standard deviation. Values of $p < 0.05$ are considered statistically significant.

4. Discussion

4.1. Extraction Yields

Extraction yields vary according to the affinity of the secondary metabolites with the extraction solvents. Table 1 shows that the yields of methanol extracts are 25.48% for roots, 23.67% for leaves and 3.87% for stem barks. This explains why polar compounds are more prevalent in roots and leaves, but less so in stem barks. Concerning acetone extracts, yields are respectively 21.43% for stem barks, 20.73% for roots, and 11.43% high. Explanations could be that stem barks contain more semi-polar compounds, followed by roots and leaves. As for the yields of hexane extracts, the values obtained are very low compared with the other values. They are 17.01% for leaves, 12.21% for roots and 4.03% for stem bark. This can be explained by the lack of apolar compounds in stem bark, and their minimal presence in the plant.

4.2. Phytochemical Screening

The results of the phytochemical assays designed in Table 2 corroborate with those given by Mme Khadiadiatou Dia, Dia [10]. While the results of qualitative analyses of the exhausted organic solvent fractions of the aqueous extract of D.

senegalense indicated the presence of carbohydrates, tannins, saponins, glycosides, flavonoids, alkaloids and terpenes/steroids in the various organic solvent fractions. The results of Sanni *et al.* [7] which show the presence of alkaloids, tannins and flavonoids, among others. The results of Elhadji *et al.* [5] also reveal the presence of tannins, flavonoids, terpenes and steroids. These results are also similar to our own, despite some analyses that we did not carry out.

4.3. Quantitative Analysis

4.3.1. Determination of Polyphenols

Total polyphenol content values ranged from 4.291 to 24.690 mg EAG/100g P (**Table 3**). The methanol extracts of leaves and stems and the acetone extract of roots showed the highest polyphenol contents, with 24.690, 22.55 and 23.298 mg EAG/100g P respectively. These results are better than those of Sulaiman *et al.* [22] in India and Boulanouar *et al.* [20] in Nigeria. These results reflect the plant's richness in phenolic compounds such as polyphenols.

4.3.2. Flavonoid Assay

Values for total flavonoid content ranged from 0.291 to 0.871 mg EQ/100g P (**Table 4**). The methanol extracts of leaves and the acetone extracts of leaves and roots showed the highest flavonoid contents, with 0.871, 0.831 and 0.80 mg EQ/100g P respectively. These results are better than those of Sulaiman *et al.* [22] in India and Boulanouar *et al.* [20] in Nigeria. These results reflect the plant's richness in phenolic compounds such as flavonoids.

4.3.3. Anthocyanin Assay

According to **Table 5** above, the acetone and methanol extracts of bark, followed by the methanol extract of leaves, showed higher levels of total anthocyanins. Total monomeric anthocyanins (TMA) are then expressed in milligram C3G equivalent per 100g powder (mg EC3G/100g P) or mg/100g P.

It's important to note that there is total synergy between the values found for total polyphenols, total flavonoids and total monomeric anthocyanins. These compounds have almost the same biological activities.

4.4. Pharmacological Analysis

4.4.1. Anti-Free Radical Activity

For anti-free radical activity (**Figures 3-5**), we used thin-layer chromatography in the search for flavonoids, which are good anti-free radical agents, and also DPPH trapping.

The systems and developers used to detect flavonoids are as follows:

- System 1 (ACOET/HCOOH/H_2O; 8/1/1);
- System 2 (n-BuOH/AAG/H_2O;
- The developers are aluminum chloride ($AlCl_3$) and Neu's reagents.
- For the system: AcOEt/HCOOH/H_2O (8/1/1), chromatogram B shows five spots after spraying the plate with aluminum chloride. Four are blue and one yellow at UV 366 nm, with respective Rf values of 0.19 (blue); 0.5 (blue); 0.54

(blue); 0.73 (blue) and 0.66 (yellow) in the visible range.

Chromatogram A 9 shows three spots: two blue and one yellow, whose spots are shown in **Figure 3**. These chromatograms reveal the presence of flavonoids.

For the plates in **Figure 4**, revealed with Neu's reagent, we observe yellow and blue spots. These colors show that these spots reveal the presence of flavonoids.

For the ethyl acetate/glacial acetic acid/water (8/1/1) system (**Figure 4**), after spraying the plate with DDPH, we observe a violet color change to yellow. The more the plate is exposed to sunlight, the more yellow it becomes. All methanol and acetone extracts show significant anti-radical activity.

4.4.2. Antioxidant Quantification

Antioxidant content is presented in **Table 7** above and is expressed as milligram quercetin equivalent per 100 grams of powder (mg EQ/100g P). We note that the acetone extract of the leaves has a higher antioxidant content than the other extracts. The acetone and methanol extracts of leaves have antioxidant contents of 2.438 and 2.152 mg EQ/100g powder respectively. The acetone and methanol extracts of bark have antioxidant contents of 1.256 and 1.634 g EQ/100g P respectively. The methanol extract of roots has a lower oxidant content.

5. Conclusions

At the end of this work, sequential extractions of the different parts of Detarium senegalense, enabled us to obtain the highest yields with methanol extracts respectively 35.48% in the roots and 29.67% in the leaves.

Phytochemical studies revealed the presence of alkaloids, flavonoids, saponosides, tannins, anthocyanins, coumarins and polyphenols in the methanol and ethyl acetate extracts. Quantification of total flavonoids, total polyphenols and total monomeric anthocyanins, extracted with methanol and ethyl acetate, gives us respectively, total polyphenols: 21.558 ± 2.599 mg EAG/100g P and 23.298 ± 12.680 mg EAG/100g P for roots; 22.55 ± 0.235 mg EAG/100g P and 4.299 ± 5.777 mg EAG/100g P for stem barks, then 24.690 ± 0.4913 mg EAG/100g P and 19.275 ± 0.3217 mg EAG/100g P for leaves; Total flavonoids: 0.296 ± 0.04 mg EQ/100g P and 0.803 ± 0.029 mg EQ/100g P for roots, 0.291 ± 0.012 mg EQ/100g P and 0.2856 ± 5.777 mg EQ/100g P for stem barks then 0.871 ± 0.401 mg EQ/100g P and 0.831 ± 0.136 mg EQ/100g P for leaves; Total monomeric anthocyanins: 9.129 ± 0.171 mg/100g P and 6.457 ± 0.578 mg/100g P for roots, 16.699 ± 0.193 mg/100g P and 44.697 ± 0.939 mg/100g P for stem barks then 10.520 ± 0.221 mg/100g P and 8.450 ± 0.021 mg/100g P for leaves.

The antioxidant activities of the various extracts tested were corroborated by the activities of flavonoids and phenolic compounds, suggesting a synergy of compounds in the extracts. All methanol and ethyl acetate extracts of the three plant organs were found to be active against DPPH. Values for methanol and ethyl acetate were: 0.934 ± 024c mg EQ/100g P and 1.674 ± 0.023b mg EQ/100g P for roots; 1.634 ± 0.05b mg EQ/100g P and 1.256 ± 0.15c mg EQ/100g P for

stem bark; and 2.152 ± 0.07a mg EQ/100g P and 2.438 ± 0.03a mg EQ/100g P for leaves.

These results confirm the use of methanol and ethyl acetate extracts of Detarium senegalense roots, stem bark and leaves in traditional medicine as a plant with antioxidant properties.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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