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Comparative Study of the Chemical Composition and Antioxidant Capacity of Leaves, Stems and Roots of *Alchornea cordifolia (Schumach. & Thonn.) Müll. Arg.*

Emmanuel N'Dri Koffi[1,2*], Olivier Hugues Alain N'Guessan[3], Philippe Kessé N'Da[2], Ismael Sanga Ouattara[4], Séraphin Kouakou Konan[4] and Augustin Amissa Adima[2]

[1]Department of Sciences and Technologies, Advanced Teachers' Training College of Abidjan (ENS), 08 BP 10 Abidjan 08, Cote d'Ivoire.
[2]Laboratory of Industrial Processes, Synthesis, Environment and New Energies (LAPISEN), INPHB, BP 1093 Yamoussoukro, Cote d'Ivoire.
[3]Laboratory of Bioorganic Chemistry and Natural Substances (LCBOSN), Nangui Abrogoua University, 02 BP 801 Abidjan 02, Cote d'Ivoire.
[4]Laboratory of Environmental Science and Technology, Jean Lorougnon Guede University, BP 150 Daloa, Cote d'Ivoire.

Authors' contributions

This work was carried out in collaboration among all authors. Author ENK designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors OHAN, PKN, ISO, SKK and AAA managed the analyses of the study. All authors read and approved the final manuscript.

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ABSTRACT

Aims: This work aims to compare the chemical composition and the antioxidant capacity of the leaves, stems and roots of *Alchornea cordifolia*.
Study design: The leaves, stems and roots of *Alchornea cordifolia* were harvested during the month of August 2020 in the botanical garden of the University Jean Lorougnon Guede in Daloa.

**Corresponding author: E-mail: emmanuelnkoffi@gmail.com;*

After that, they were dried in the shade for 17 days. Subsequently, they were crushed and kept in jars in order to be sent to the Laboratory of Industrial Processes, Synthesis, Environment and New Energies (LAPISEN) of Yamoussoukro (Côte d'Ivoire), for analyzes.
Place and duration of study: This study was carried out during september to december 2020 in Laboratory of Industrial Processes, Synthesis, Environment and New Energies (LAPISEN) of Yamoussoukro (Côte d'Ivoire)
Methodology: Physicochemical parameters (pH, ° Brix and dry matter percentage) and the mineral contents of leave, stem and root aqueous extracts were determined by classic methods. Then, the phytochemical screening are carried out by TLC analysis followed by spectrophotometric assay of total polyphenols, total flavonoids and antioxidant activity.
Results: The results showed that the aqueous extract from *A. cordifolia* leaves, stems and roots are all acidic (pH ≤ 5.33). However, these extracts contain a low level of dry matter. The measured minerals (Na, Ca, Mg, Mn, K, Fe; Cu and Zn) are present in these extracts at varying concentrations. The leaf extract is richer in Fe (8.28 ppm), Ca (1.71 ppm), Mn (1.17 ppm) and K (0.55 ppm). In contrast, the root extract contains more Na (18.38 ppm), Cu (0.75 ppm) and Mg (0.34 ppm). As for the phytochemical screening revealed the presence of coumarins, flavonoids, sterols and terpenes, in the aqueous extract of all organs, except tannins, absent in the roots. However, the leaves have the highest content of polyphenols (256.67 $mg.g^{-1}$ GAE) and flavonoids (92.75 $mg.g^{-1}$ QE), as well as the best antioxidant capacity (204.23 $\mu mol.L^{-1}$ TE).
Conclusion: The leaves, stems and roots of *A. cordifolia* contain practically the same chemical compounds with a few exceptions. However, the difference lies in the concentration of these compounds in the different extracts.

Keywords: Alchornea cordifolia; physicochemical characteristics; mineral composition; phytochemical composition; antioxidant activity.

1. INTRODUCTION

Alchornea cordifolia is a medicinal plant widely distributed throughout tropical Africa; it belongs to the Euphorbiaceae family [1]. It is one of the most widely used herbs in traditional medicine across Africa, mainly for inflammatory, antimicrobial and parasitic diseases [2]. In Côte d'Ivoire, this plant has got different names: *djéka* in the Baoule, *glouméï* in the Bete, *diéca* in the Agni, *lofègué* in the Senoufo, *poho* in the Guere, *n'dzè* the Attie, *kodjiran* the Aboure, *gbadalefrè* in the Avikam, *flennê* in the Gouro, *fonnê* in the Yacouba and *vidjovê* in the Abbey [3]. Different organs of this plant (leaves, fruits, leafy stems, bark and roots) are used alone or in combination with other plant organs for the treatment of the aforementioned conditions. Among the organs cited above, the leaves are frequently the most used [3,4].

The therapeutic virtues attributed to these plant extracts are generally due to secondary metabolites (polyphenols, terpenes and alkaloids) which exert significant pharmacological effects on human body [5]. These secondary metabolites are often unevenly distributed within the organs of the same plant; which gives them various uses [6]. Therefore, there is a need to question the scientific basis of the preferential use of the leaves of this plant compared to the stems and roots. The current research was carried out in order to compare the chemical composition (minerals and phytonutrients) and the antioxidant capacity of the leaves, stems and roots of *Alchornea cordifolia*.

2. MATERIALS AND METHODS

2.1 Plant Material

The plant material consists of leaves, stems and roots of *Alchornea cordifolia* (Fig. 1). These organs were harvested during the month of August 2020 in the botanical garden of the University Jean Lorougnon Guéde in Daloa. After that, they were dried in the shade for 17 days. Subsequently, they were crushed and kept in jars in order to be sent to the Laboratory of Industrial Processes, Synthesis, Environment and New Energies (LAPISEN) of Yamoussoukro (Cote d'Ivoire), for analyzes.

Alchornea cordifolia plant

Dried leaves

Dried stems

Dried roots

Fig. 1. Plant material

2.2 Methods

2.2.1 Preparation of extracts

The extracts of leaves, stems and roots of *Alchornea cordifolia* were prepared by decoction during 30 minutes with 4 g of sample dissolved in 100 mL of distilled water. The extract are obtained after filtering the mixture.

2.2.2 pH determination

The pH was measured by directly immersing the electrode of the HANNA type pH meter (France), previously calibrated with two buffer solutions: pH = 4.0 and pH = 7.0, in 50 mL of extract from each organ of *A cordifolia*. The pH value is read on the display of the pH meter.

2.2.3 Determination of ° Brix

The Brix degree was measured using an Atago-type infrared refractometer (France) by putting 3 drops of extract on the prism. The Brix value is read on the screen by pressing the "start" button on the refractometer. Calibration was done using distilled water. Readings were performed in triplicate.

2.2.4 Determination of the dry matter content

The dry matter content was determined according to the AOAC method [7]. To do this, 5 mL of plant extract, placed in a crucible, was dried in an oven at 105 ± 2 ° C for 24 hours. After that, the crucible was cooled in a desiccator and then weighed. The tests were carried out in triplicate.

2.2.5 Determination of mineral content

Minerals such as potassium, calcium, magnesium; sodium, iron, manganese, copper and zinc from extracts from *A. cordifolia* leaves, stems and roots, were quantified with a flame atomic absorption spectrophotometer (Varian AA 20 Spectrometer, Australia). Mineral contents of the different extracts were determined according to AOAC method by the calibration line of each mineral.

2.2.6 Phytochemical screening

2.2.6.1 Selective extraction of secondary metabolites

The aqueous extracts from *A. cordifolia* leaves, stems and roots were respectively treated with 3 x 20 mL of hexane, chloroform and ethyl acetate. The different organic fractions were concentrated under reduced pressure on a rotary evaporator and then stored in the refrigerator. Thus, for each extract, we obtained 3 selective extracts for a total of 9 extracts distributed as follows:

- Hexane extracts: Fh (leaves), Rh (roots) and Th (stems)
- Chloroform extracts: Fc (leaves), Rc (roots) and Tc (stems)
- Ethyl acetate extracts: Fa (leaves), Ra (roots) and Ta (stems)

2.2.6.2 Phytochemical screening of selective extracts

The phytochemical screening was carried out on chromatographic plates, with an aluminum support (60 F254, 20 × 20, Fluka-Silica gel/DC), according to the analytical procedures described by N'guessan [8]. The eluents used for the migration of secondary metabolites contained in the selective extracts are:

- Hexane / Ethyl acetate (8: 1.5, V/V) for the hexane fractions
- Chloroform / Ethyl acetate / Formic acid (6: 7: 2, V/V) for the ethyl acetate and chloroform fractions.

The developers that have been used for the identification of secondary metabolites are:

- The $AlCl_3$ reagent (1%, w/v) in EtOH for flavonoids (fluorescence varying from blue to brown),
- The KOH reagent (5%, w/v) in MeOH for coumarins (yellow spots in the visible which intensify or diversify into blue and green),
- The aqueous $FeCl_3$ solution (2%, w/v) for tannins (gray spots in the visible) and other polyphenols (red, green, blue spots in the visible).
- The Liebermann-Bürchard reagent for sterols and terpenes (various staining under UV visualization at 366 nm): red for triterpenes of the oleanane and ursane type; yellow-orange for lupane-type triterpenes; yellow or yellow-green for steroids.

2.2.7 Determination of total polyphenols content

The determination of the total polyphenols was carried out according to the method described by Wood et al. [9]. To do this, 30 µL of plant extract are added to 2.5 mL of Folin-Ciocalteu reagent diluted to 1/10. The mixture was kept for 2 min in the dark at room temperature (30 ± 2 ° C). After that, 2 mL of Na_2CO_3 (75 $g.L^{-1}$) was added. The solution thus obtained was incubated at 50 ° C in a water bath for 15 min to allow the complete development of the blue color of the reaction mixture. The absorbance of the resulting solution was read with a UV-visible spectrophotometer at a wavelength of λ = 760 nm, with distilled water as a blank. The total polyphenol content was expressed in milligram gallic acid equivalent per gram of dry plant material ($mg.g^{-1}$ GAE). The assays were carried out in triplicate.

2.2.8 Determination of the total flavonoid content

The determination of the total flavonoids was carried out according to the method described by Marinova et al. [10]. To 0.75 mL of 5% (w/v) $NaNO_2$ were added 0.75 mL of 10% (w/v) $AlCl_3$ and 2.5 mL of plant extract. After 6 min of reaction in the dark and at room temperature (30 ± 2 ° C), 5 mL of NaOH (1 M) was added to the mixture. After that, the volume of the mixture was adjusted to 25 mL with distilled water. The whole was subjected to vigorous stirring. Subsequently, the absorbance of the obtained solution was measured with a spectrophotometer at λ = 510 nm. The total flavonoid content was expressed in milligram quercetin equivalent per gram of dry

plant material (mg.g^{-1} QE). All assays were performed in triplicate.

2.2.9 Evaluation of the antioxidant activity of the different extracts

The evaluation of the antioxidant activity of different extracts of *A. cordifolia* was made according to the method described by Teow et al. [11], with some modifications. This method is based on the ability of compounds to reduce the $ABTS^{\bullet+}$ radical-cation (2,2'-azinobis-3-ethylbenzothiazoline-6-sulfonic acid). To do this, the $ABTS^{\bullet+}$ radical-cation was produced following an equivolumic mixture of 8 mM ABTS (87.7 mg in 20 mL of distilled water) and 3 mM of potassium persulfate (0.0162 g in 20 mL distilled water). The resulting mixture was then incubated in the dark at room temperature for 16 hours. A daughter solution was prepared extemporaneously before each series of assays, by diluting the stock solution of ABTS with methanol until an absorbance of 0.7 ± 0.02 was obtained at the wavelength of 734 nm. Then 3.9 mL of this test concentration was added to 100 µL of the extract to be tested. After stirring, the mixture was incubated for 6 minutes in the dark at room temperature (30 ± 2 ° C). The residual absorbance of the ABTS•+ radical was then measured at 734 nm with a UV-visible spectrophotometer. The tests were carried out in triplicate and the results were expressed in micromole trolox equivalent per liter of plant extract (µmol.L^{-1}TE) by comparing the percentage of inhibition of the $ABTS^{\bullet+}$ radical by the trolox to that of the sample. The percentage inhibition of the $ABTS^{\bullet+}$ radical (A) was expressed as follows:

$$\% I = [(A_0 – Ae) / A_0] \times 100$$

A_0 : absorbance of the diluted solution of ABTS

Ae: absorbance of the reaction medium containing the extract, after the incubation time

2.2.10 Statistical analysis of data

Statistical analysis was performed by performing one-way analysis of variance (one-way ANOVA) for all data (mean of each parameter assayed). This analysis was performed using Statistica 7.1 software (StatSoft, Inc, USA). Comparisons of means were made by Newman-Keuls test at the 5% significance level.

3. RESULTS AND DISCUSSION

3.1 Results

3.1.1 Physicochemical characteristics of aqueous extracts from *Alchornea cordifolia* leaves, stems and roots

The physicochemical characteristics of aqueous extracts from *Alchornea cordifolia* leaves, stems and roots are mentionned in (Table 1).

The pH of the different extracts varies from 3.90 to 5.33. Among the organ extracts studied, that of the leaves is the most acidic (pH = 3.90), followed by that of the stems (pH = 5.01) then that of the roots (pH = 5.33). As far as the percentage of dry matter and the ° Brix of the different extracts are concerned, the same trends are noticed. In ascending order of percentage of dry matter and ° Brix, we have: extract of stems < extract of roots < extract of leaves. So the leaf extract is richer in soluble solids compared to the root and stem extracts.

3.1.2 Mineral composition of aqueous extracts from *A. cordifolia* leaves, stems and roots

The mineral composition of aqueous extracts from *A. cordifolia* leaves, stems and roots is listed in (Table 2). The extracts from the different organs of this plant contain minerals such as Na, Ca, Mg, Mn, K, Fe, Cu and Zn in varying proportions. Sodium followed by iron are identified as being the most abundant of the mineral salts dosed. It is also noted that leaf extracts are richer in Ca, Mn, K and Fe compared to stem and root extracts. On the other hand, extracts from the roots contain more Na, Mg and Cu compared to extracts from leaves and stems. Furthermore, Zn is present at the same concentration in the leaves and stems.

3.1.3 Phytochemical composition of selective extracts from *A. cordifolia* organs

3.1.3.1 Case of ethyl acetate extracts

Identification of phenolic compounds by TLC of ethyl acetate extracts from *A. cordifolia* leaves, stems and roots revealed the presence of coumarins and flavonoids in these different extracts. With the exception of the root extract, the presence of tannins in the leaf and stem extracts; with a strong dominance in the leaf extract (Table 3).

3.1.3.2 Case of chloroform extracts

The KOH and $AlCl_3$ reagents enabled the respective identification of coumarins and flavonoids in chloroform extracts from the leaves, roots and stems of *A. cordifolia* (Table 4). In view of the number of spots identified, the chloroform extract from the roots appears to be richer in flavonoids and coumarins than the leaves and stems of *A. cordifolia*.

3.1.3.3 Case of hexane extracts

Hexane extracts sterols, terpenes and coumarins. However, only sterols and terpenes have been identified. Thus, the Liebermann-Buchard reagent was used to identify the sterols and terpenes contained in the hexane extracts. On analyzing the results reported in (Table 4), it emerges that the compounds identified are all steroids, with a strong predominance in the hexane extracts of the leaves and stems compared to the roots (Table 5).

In view of the results, it should be noted that the aqueous extracts from *A. cordifolia* leaves, stems and roots contain coumarins, flavonoids, sterols, terpenes except the tannins mainly present in the leaves and trace in the stems. The difference is in certain compounds whose spots do not appear for all extracts.

Table 1. Physicochemical characteristics of extracts from *A. cordifolia* leaves, stems and roots

Parameters investigated	Organs		
	Leaves	Stems	Roots
pH	$3,90 \pm 0,05^{a}$	$5,01 \pm 0,03^{b}$	$5,33 \pm 0,03^{c}$
Dry matter (%)	$1,39 \pm 0,03^{c}$	$0,29 \pm 0,03^{a}$	$0,59 \pm 0,03^{b}$
°Brix	$2,20 \pm 0,10^{c}$	$0,50 \pm 0,10^{a}$	$0,80 \pm 0,10^{b}$

These values are mean value ± standard error of means of 3 experiments. Values with the same letters in the same line are not significantly different at p = 0.05

Table 2. Mineral composition of aqueous extracts from *A. cordifolia* leaves, stems and roots

Mineral content (ppm)	Organs		
	Leaves	Stems	Roots
Na	$17,72 \pm 0,02^{a}$	$17,88 \pm 0,02^{b}$	$18,38 \pm 0,02^{c}$
Ca	$1,71 \pm 0,01^{b}$	$1,70 \pm 0,01^{a,b}$	$1,68 \pm 0,01^{a}$
Mg	$0,21 \pm 0,01^{a}$	$0,26 \pm 0,02^{b}$	$0,34 \pm 0,01^{c}$
Mn	$1,17 \pm 0,01^{c}$	$0,85 \pm 0,01^{b}$	$0,82 \pm 0,01^{a}$
K	$0,55 \pm 0,01^{b}$	$0,53 \pm 0,01^{b}$	$0,48 \pm 0,01^{a}$
Fe	$8,28 \pm 0,02^{b}$	$7,99 \pm 0,02^{a}$	$7,98 \pm 0,01^{a}$
Cu	$0,29 \pm 0,01^{a}$	$0,53 \pm 0,01^{b}$	$0,75 \pm 0,01^{c}$
Zn	$2,08 \pm 0,02^{b}$	$2,09 \pm 0,02^{b}$	$1,94 \pm 0,01^{a}$

These values are mean value ± standard error of means of 3 experiments. Values with the same letters in the same line are not significantly different at p = 0.05

Table 3. Retention factor value of compounds identified in ethyl acetate extracts

Reagents	Groups of coumpound	Identified colors	Retention factor value of compounds identified in the different organs
1% Ethanolic $AlCl_3$	Flavonoids	Blue, brown, yellow-green under UV 365 nm	**Leaves** : $0,05^{Y}$; $0,1^{Y}$; $0,18^{Y}$; $0,23^{Y}$; $0,7^{Y\text{-}Gn}$; $0,81^{B}$; **Roots** : $0,05^{Y}$; $0,1^{Y}$; $0,23^{B}$; $0,35^{B}$; $0,81^{B}$; **Stems:** $0,05^{Y}$; $0,1^{Y}$; $0,18^{B}$; $0,23^{Y}$; $0,35^{B}$; $0,81^{B}$.
5% Methanolic KOH	Coumarins	Blue, green under UV 365 nm	**Leaves** : 0^{B}; $0,05^{B}$; $0,1^{B}$; $0,18^{B}$; $0,35^{Gn}$; $0,56^{B}$; $0,81^{Fb}$,

Reagents	Groups of coumpound	Identified colors	Retention factor value of compounds identified in the different organs
			Roots: $0,18^{B}$; $0,81^{Fb}$; **Stems:** $0,81^{Fb}$
2% $FeCl_3$	Tanins	Grey, visible brown	**Leaves**: 0^{Gy}; $0,23^{Gy}$; $0,35^{Gy}$; $0,56^{Gy}$; **Roots** : no compounds; **Stems** ($0,05^{Gy}$)
	Other polyphenols	red, blue, visible green	**Leaves**: $0,05^{Gn}$; $0,1^{Gn}$; $0,18^{Gn}$, **Roots:** no compounds; **Stems**: no compounds.

Y: Yellow; Gn: Green; Y-Gn: Yellow-Green; B: Blue; Fb= Fluorescent blue; Gy: Grey

Table 4. Retention factor value of compound identified in the chloroform extracts

Reagents	Groups of compounds identified	Identified colors	Retention factor value of compounds identified in the different organs
1% Ethanolic $AlCl_3$	Flavonoids	Blue, brown, yellow-green under UV 365 nm	**Leaves**: $0,38^{B}$; $0,81^{Fb}$; $0,87^{Y}$; **Roots**: $0,38^{Y}$; $0,46^{Y}$; $0,81^{Gn}$; $0,87^{Y}$; **Stems** : $0,81^{Gn}$; $0,87^{Y}$..
5% Methanolic KOH	Coumarins	Bleu, vert sous UV 365 nm	**Leaves**: $0,81^{Fb}$; **Roots:** $0,81^{Fb}$; $0,87^{B}$; **Stems** : $0,81^{Fb}$; $0,87^{B}$

Y: Yellow; Gn: Green; Y-Gn: Yellow-Green; B: Blue; Fb= Fluorescent blue

Table 5. Retention factor value of compounds identified in the hexane extract

Reagents	Groups of compounds identified	Identified colours	Retention factor value of compounds identified in the different organs
Liebermann -Bürchard	Steroids	yellow, yellow-green	**Leaves**: $0^{Y\text{-}Gn}$; $0,03^{Y\text{-}Gn}$; $0,09^{Y\text{-}Gn}$; $0,17^{Y\text{-}Gn}$; $0,23^{Y\text{-}Gn}$; $0,32^{Y\text{-}Gn}$; $0,75^{Y\text{-}Gn}$; $0,92^{Y\text{-}Gn}$; **Roots**:$0,03^{Y\text{-}Gn}$; $0,09^{Y\text{-}Gn}$; $0,23Y^{\text{-}Gn}$; $0,32^{Y\text{-}Gn}$; $0,75^{Y\text{-}Gn}$; **Stems** ($0^{Y\text{-}Gn}$; $0,03^{Y\text{-}Gn}$; $0,09^{Y\text{-}Gn}$; $0,17^{Y\text{-}Gn}$; $0,23^{Y\text{-}Gn}$; $0,32^{Y\text{-}Gn}$; $0,37^{Y\text{-}Gn}$; $0,75^{Y\text{-}Gn}$; $0,92^{Y\text{-}Gn}$.

Y-Gn: Yellow-Green

3.1.4 Phytonutrient content of aqueous extracts from *A. cordifolia* leaves, stems and roots

Among the phytonutrients present in the various organs, polyphenols, in particular total flavonoids, being compounds with antioxidant capacity, were quantified (Fig. 2). Regarding the content of total polyphenols and total flavonoids in aqueous extracts from *A. cordifolia* leaves, stems and roots, we have the same tendencies. In increasing order of these contents, we have: extract of stems < extract of roots < extract of leaves. So the leaf extract is the richest in these phytonutrients (256.67 ± 1.33 $mg.g^{-1}$ GAE for total polyphenols and 92.75 ± 0.33 $mg.g^{-1}$ QE for total flavonoids).

3.1.5 Antioxidant capacity of aqueous extracts from *A. cordifolia* leaves, stems and roots

Fig. 3 shows the antioxidant capacity of extracts from *A. cordifolia* leaves, stems and roots. The extract with the best antioxidant capacity is that of the leaves (204.23 ± 1.67 µmol.L-1 TE) followed by that of the roots (118.58 ± 1.17 µmol.L-1 TE) and finally that of the stems (87.74 ± 1.33 $µmol.^{L-1}$ TE).

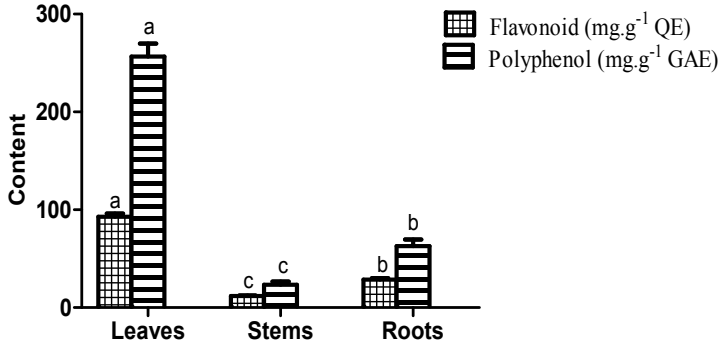

Fig. 2. Content of total polyphenols and total flavonoids in aqueous extracts from *A. cordifolia* organs

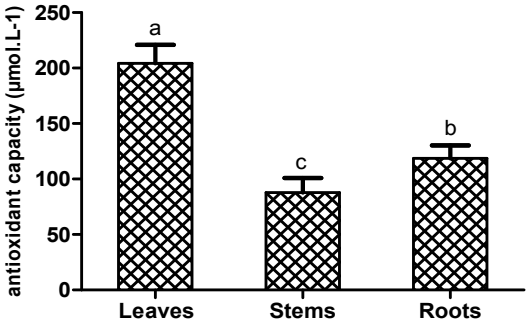

Fig. 3. Antioxidant capacity of aqueous extracts from *A. cordifolia* organs

3.2 Discussion

The aqueous extracts from *A. cordifolia* leaves, stems and roots are all acidic (pH ≤ 5.33), with the leaf extract having the most acidic pH. These extracts would thus be unfavorable for the growth of most pathogenic bacteria, because at this value acidophilic bacteria can develop [12]. Among these extracts, that of the leaves is the richest in soluble dry matter (° Brix ≤ 2.20 and % of dry matter ≤.1.39%). This suggests that the different extracts are poor in nutrients.

The determination of the mineral composition revealed that the aqueous extracts from *A; cordifolia* organs studied contain, in varying proportions, minerals such as sodium, calcium, magnesium, manganese, potassium, iron, copper and zinc. The presence of the minerals raised in the various extracts could be beneficial for humans. Indeed, according to Flood et al. [13], calcium has anti-carcinogenic activity, allowing it to reduce the risk of colorectal cancer. It is also a major factor in ossification and the nervous system as well as in blood clotting. In combination with phosphorus, calcium helps fight osteoporosis [13]. As for potassium, associated with sodium, it plays a key role in maintaining the electrical potential within membrane cells and in the conduction of nerve impulses [14]. It also regulates the heartbeat and muscle contraction. Manganese participates in the activation of enzyme systems. While copper helps in the formation of hemoglobin and red blood cells. On the other hand, magnesium is found in the bones and in the intracellular fluid, it acts as a cofactor of the enzyme in the chemical neurotransmission. As for iron, it is essential for replacement of hemoglobin. Deficiency of iron in the body causes anemia. Zinc is a powerful antioxidant [15].

Phytochemical screening of aqueous extracts from *A cordifolia* leaves, stems, roots revealed the presence of coumarins, flavonoids, sterols and terpenes; except for the tannins mainly present in the leaves and in a trace state in the stems. The phytochemical composition of the

leaf extract is similar to that determined by Gasting et al. [16] and Adeleye et al. [17] who worked respectively on leaves from southern Cote d'Ivoire, Cameroon and Nigeria. In addition, the results of Koné's [18] work on *A. cordifolia* collected in the center of the Cote highlighted the presence of all these compounds with the exception of coumarins. Concerning the stems, the phytochemical screening carried out by Ajali [19] on the ethanolic extract of the stems also revealed the presence of flavonoids, sterols, terpenes and tannins. For roots, Mambé et al. [20] found results almost identical to those in our study except for the tannins, which were found to be present in the extract they prepared. The differences observed in the results of the phytochemical screening with those of the literature could also be explained by the difference in the harvest site but also by the difference in the extraction solvent used.

The presence of secondary metabolites such as coumarins, flavonoids, tannins, sterols and terpenes, in extracts from *A. cordifolia* leaves, stems and roots, could justify their therapeutic uses. Indeed, flavonoids in addition to their antioxidant capacity, are known for their anti-inflammatory and diuretic properties [21]. As for tannins, these are substances with antiseptic and antidiarrhoeal properties [22]. In addition, coumarins are antibacterial, antioxidant, anti-inflammatory, anticoagulant and anti-tumor [23]. Terpenes are immunomodulatory, trypanocidal [24], antiplasmodial [25]; while sterols with a structure similar to that of cholesterol make it possible to limit the level of the latter in the blood [26].

Quantification of total polyphenols and flavonoids showed that leaves are richer in these compounds compared to roots and stems. This result confirms the higher antioxidant activity of the leaf extract compared to the other two. Indeed, according to Ksouri [27], polyphenols, in particular flavonoids, are endowed with a powerful antioxidant power.

This high concentration of polyphenols and total flavonoids in the leaves has been observed in other studies including that realised by N'Guessan [28] on the leaves of *A. cordifolia*. It would be justified by the fact that plants synthesize flavonoids through solar radiation to protect themselves from oxidation; the more exposure to sunlight increases, the more the flavonoid contents increase, especially in the most exposed parts [6].

4. CONCLUSION

This study was permitted to compare the chemical composition and the antioxidant activity of aqueous extracts from *Alchornea cordifolia* leaves, stems, roots. Phytochemical screening of these aqueous extracts revealed the presence of coumarins, flavonoids, sterols and terpenes; except for the tannins mainly present in the leaves and in a trace state in the stems. Moreover, the quantification of polyphenols and total flavonoids showed that the leaves are richer in these compounds compared to the roots and stems. The leaf extract also has the best antioxidant capacity. These great potentials of the leaf extract could justify its use in preference to that of extracts from stems and roots. In addition, the analysis of mineral composition has shown that the extracts of the different organs of this plant contain, in varying proportions, minerals such as sodium, calcium, magnesium, manganese, potassium, iron, copper and zinc. The leaves, stems and roots of *A. cordifolia* contain practically the same chemical compounds with a few exceptions. However, the difference lies in the concentration of these compounds in the different extracts.

CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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