

Parkia biglobosa (Mimosaceae) Leaves, Fruits' Pulp, and Barks of Stem and Root Phytochemicals Contents and Their Antioxidant Activities

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Abstract

More and more *Parkia biglobosa* plants' stem barks, and roots are collected for traditional medicine uses. This work aimed to quantify *Parkia biglobosa* plant parts total polyphenols, total flavonoids contents and their antioxidant activities. The hypothesis was that the plant parts would have different phytochemical contents. So, leaves, stem barks, root barks and mature fruit pulp were collected. Alongside the leaves, the stem and root barks were sliced, air-dried at room temperature for 30 days. Thereafter, the samples were crushed and sieved. Following this, the powders were extracted with distilled water by maceration and decoction. As a result, the decoction was more efficient than the maceration. Leaves had the highest total polyphenol content (14.68), followed by stem barks (11.69), and root barks (9.09 ± 0.43 mg GAE/g) (0.0001 ≤ p ≤ 0.0002). However, for total flavonoid contents, the stem barks were better than the other parts. Indeed, stem barks delivered 0.74 and were followed by leaves for 0.6, and root bark for 0.49 ± 0.02 mg EQ/g (0.0001 ≤ p ≤ 0.0169). Finally, the antioxidant activities were 3.07 and 2.86 ± 0.1 μmol T.E/g, respectively for stem bark, and leaves (p = 0.0532). In conclusion, there is no need to debark the stems, because, in decoction, leaves and stem barks would have the same efficacy.

Keywords

Parkia biglobosa, Total Polyphenols, Total Flavonoids, Antioxidant Activity

1. Introduction

The world health organization (WHO) promotes traditional health systems all over the world [1]. In fact, by helping with the installation of 25 collaborating centers for traditional medicine in Asia, Europe, and Africa, WHO allows developed and undeveloped areas people to access an additional healthcare system [1]. For example, in Hong Kong, which is one of the most advanced states in China, many persons are still enjoying traditional Chinese medicine [2]. Since the year 1997, the traditional healthcare system has been adopted by the government and accepted as a way of healing legally people [2]. To put an emphasis on traditional Chinese medicine, the central government financed US \$770.5 million for research in 2010 [1]. Firstly, traditional medicine practitioners use plants' leaves, stem, and roots' barks [3] [4] [5]. Secondly, because traditional knowledge about plants and their phytotherapy possibilities are cultural, many plants are used from Asia to Africa [6]. Like Asia, in many African countries, mainly the developing ones, people are heavily relying on traditional healthcare systems [7]. Even though some people have enough resources for the western medicine system, Mbinile *et al.* [5] concluded that 89% of Tanzania patients are going for traditional medicine. Among these persons, 89.3% argued that this system is cheaper. Moreover, among these respondents, 83.4% were still thinking that traditional medicine is safer compared to the western healthcare system.

In West-African countries, many plants' importance is based on their capacity of delivering additional food sources during the lean periods between crops' sowing and harvesting, and their parts' medicinal potentials. Among many trees, *Parkia biglobosa* holds an important role. In fact, *Parkia biglobosa* tree is a very important tree, because the mature fruits contain an important pulp and grains [8]. This pure yellow flour pulp can either be used alone for making a paste or associated with millet [8]. Moreover, the grains can be fermented and used as food additives ingredients [9]. Interestingly, *Parkia biglobosa* fruits' pulp and grains are very rich in minerals [8] [9]. Despite, these nourishing utilities, some scratched stems, and dried wood can be observed everywhere, in the wild, and in gardens. Obviously, *Parkia biglobosa* is an important medicinal tree. Specifically, [10] reported an analgesic activity from *Parkia biglobosa* stem bark extract. For example, [11] observed that the administration of fermented *Parkia biglobosa* grain led to an important hypoglycemic activity, hence, an antidiabetic property. Again, in the aim to understand why rural people use *Parkia biglobosa* stem bark extract to treat snakebites, [12] worked with day-old chicks. It was observed that a stem bark extract of 10 mg/1.5mL concentration could stop *Naja nigricollis* venom effect and avoid the day-old chicks' death. They concluded that the use of the plant in ethnomedicine to treat snakebite had a pharmacological basis. Finally, in a mini-review, [13] reported on *Parkia biglobosa* tree parts' importance in traditional medicine in West Africa. Because we did not come across a quantitative evaluation of *Parkia biglobosa* parts' medicinal properties, this work aimed to assess its leaves, bark stem and roots, and fruits' pulp bioactive compounds

contents. The hypothesis assumed that *Parkia biglobosa* tree parts' bioactive content may differ greatly from part to part.

2. Material and Methods

2.1. Collection of Tree Parts

Parkia biglobosa plants leaves, stem and roots barks were collected around the graduate school of Agronomy at National Polytechnic Institute Felix Houphouët Boigny, Yamoussoukro, Cote d'Ivoire. Then, dead corks on the stem bark were carefully removed. Following, the stem and root barks were sliced into small pieces. Altogether, the plant parts were dried at room temperature for thirty days in a laboratory. Thereafter, the dried products were powdered in a mortar. Finally, through a laboratory sieve (Iso 3310-1BODY 36 LMESH-Steel/RF S/N 04003699, Body = 200 mm × 50 mm), the big particles were removed. Also, some mature fruits were gathered, and their pulp was removed, powdered, and sieved. The powders were bottled and kept in a dry place, out of the light until further analyses.

2.2. Samples Extraction

The powders were extracted through maceration and decoction, by using uniquely some distilled water (DW). In fact, [4] [14] [15] proved that using DW as solvent gives good results for medicinal plant parts extractions. Referring to [16] approach, in a 100 mL flask, 60 mL of solvent were added to 1 g of powder. Already, [16] demonstrated that when a dried sample is finely crashed, and well sieved, a 1/50, m (g)/v (mL) ratio is very good for extraction. Moreover, they concluded that 30 min of extraction time is enough. Herein, during the extractions, a magnetic agitator was immersed in each mixture made of the distilled water and the sample.

2.2.1. Maceration

The macerations were done on magnetic stirrers RSLAB 5C and RSLAB 5NC Multiplot 10, with step-less speed regulation from 1100 rotations per minute (r.p.m). The flasks were closed with some aluminium paper to avoid distilled water evaporations. The maceration lasted 60 min. Thereafter, the solution was filtered.

2.2.2. Decoction

Firstly, a closed-circuit system was made by joining a cooling system, and a heating one. It was used to perform the decoction extraction [17]. Hereafter, the mixture was heated on an electric agitator (furnace motor heater Agimatic-N, West Germany), set at 100°C. After the first boiling bubble observation, the solution boiled for 30 min, and the heater was turned off. Thereafter, the solution stayed on the heater for 15 additional minutes with the aim to collect the last drops. Secondly, the flask was removed from the agitator-heater, and the overall set was left for 15 additional min for cooling. To end, the solution was filtered.

2.3. Total Polyphenols Determination

The total polyphenols' extractions were performed regarding [4], and [17] approaches. So, a 2.5 mL of Folin-Ciocalteu reagent diluted to one-tenth was added to 30 μ L of an extract. Then, the mixture was kept for 2 minutes in the dark at room temperature. Thereafter, 2 mL sodium carbonate solution with a concentration of 75 g/L was added. Finally, the mixture was kept for 15 minutes in a water bath at 50°C, and then quickly cooled. The absorbance was read at 760 nm, using a UV-visible spectrophotometer (Shimadzu UV-1601 PC, Kyoto, Japan), with distilled water as a blank. Through the lectures, the results were given in mg gallic acid equivalent per liter (mg GAE/L). Then, they were converted into mg GAE/g by multiplying by 9.06 (4.53 mL/0.5mg).

2.4. Total Flavonoids Determination

In a 25 mL Erlenmeyer flask, 0.75 mL of sodium nitrite (NaNO_2) at 5% (w/v) was added to 2.5 mL of extract. To the mixture, 0.75 mL of aluminium chloride (AlCl_3) at 10% (w/v) was added, and then the mixture was incubated for 6 minutes in the dark. Then, 5 mL of sodium hydroxide (1 N, NaOH) were added, and the volume was completed to 25 mL. The preparation was vortexed, and total flavonoids evaluation content was assessed at 510 nm UV-visible spectrophotometer (Shimadzu UV-1601 PC, Kyoto, Japan). The given results in mg quercetin equivalent per liter (mg QE/L) have been converted to mg QE/g of matter by multiplying by 0.6 [25 mL/(125/3) mg] [17].

2.5. Antioxidant Activity

A 2,20-azino-bis (3-ethylbenzothiazoline-6-sulfonic acid (ABTS^{*+}) radical cation was produced [17]. This ABTS^{*+} solution was diluted with methanol to obtain a solution whose absorbance was 0.7 ± 0.02 at 734 nm. For the readings, 3.9 mL of diluted ABTS^{*+} solution was added to 100 μ L of the extract. After a vortex shaking, the mixture was incubated for 6 minutes in the dark ($T = 30^\circ\text{C} \pm 2^\circ\text{C}$). The radical ABTS^{*+} residual absorbance was then measured at 734 nm by visible-UV spectrophotometer (Shimadzu UV-1601 PC, Kyoto, Japan). The antioxidant activity was computed with Equations (1) and (2).

$$I(\%) = \frac{\text{Abscontrol} - \text{AbsExtract}}{\text{Abscontrol}} * 100 \quad (1)$$

where: I (%), is the inhibition rate, (Abs) Control is the diluted ABTS absorbance, (Abs) Extract is the diluted ABTS + Sample absorbance.

$$\text{Extract_Concentration} = \frac{I(\%) * DF}{4.9901} \quad (2)$$

The number 4.9901 stands for the slope of the standard Trolox line, and DF is the dilution factor.

The results were expressed in micromole Trolox equivalent per liter ($\mu\text{mol T.E/L}$) of extract. These results were converted into micromole Trolox equivalent

lent per gram ($\mu\text{mol T.E/g}$) of sample extract by multiplying by a factor of 2.4 [4 mL/(5/3) mg]. The 4 mL was the final medium volume used for the analysis, and 5/3 mg was the weight of the sample in this solution.

2.6. Statistical Analyses

During the tests, the results were generated in triplicate. Thereafter, for the statistical tests, the results were submitted to factorial analysis of variance (Two-ways, ANOVA), using XLSTAT 2014. The least-squares mean was separated according to Newman-Keuls' (SNK) multiple range tests in a confidence interval of 95% ($\alpha = 5\%$). After looking at the one-factor effect on the extracts, the results were given in terms of interaction between the plants' organs and the extractions modes.

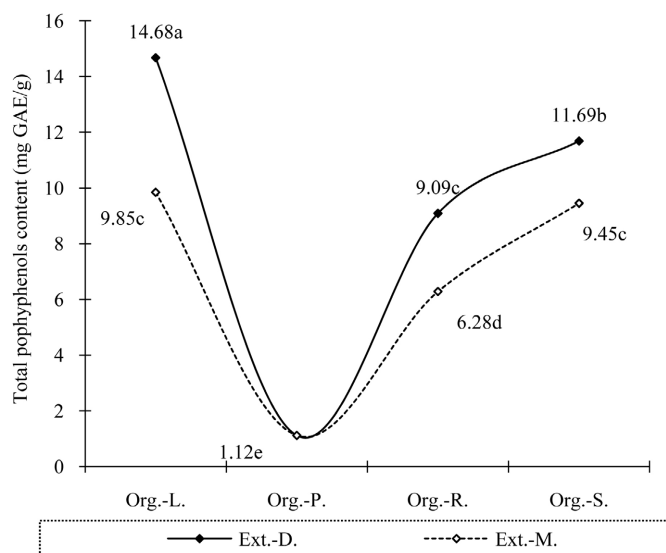
3. Results and Discussion

3.1. Total Polyphenols Content

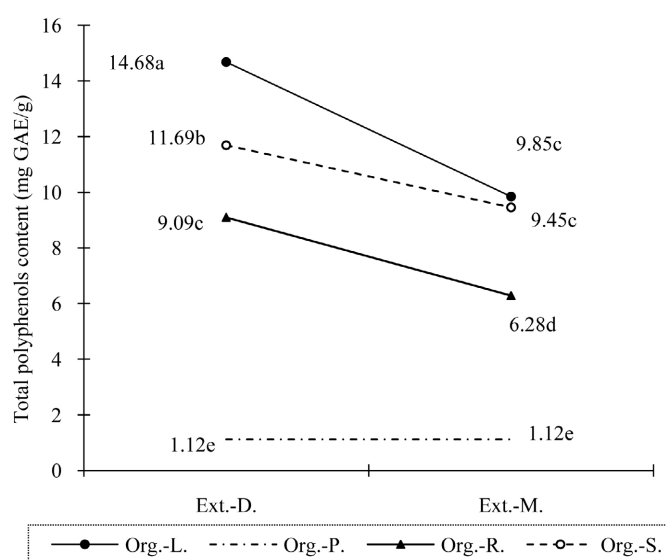
In West Africa's rural areas, many traditional medicine practitioners are boiling their plants' parts for bioactive compounds extraction [5] [6]. Herein outcome is in accordance with this ancient knowledge (Figure 1). In fact, the decoction improves the bioactive compounds extractions. Looking only at the medicinal parts, which are leaves, root bark, and stem bark; all the extracts were improved from maceration to decoction. Firstly, on leaves level, total polyphenols extractions were improved by 49.03%, from 9.85 ± 0.43 to 14.68 ± 0.43 mg GAE/g. Secondly, the root bark total phenols extraction was improved by 44.74%, from 6.28 ± 0.43 to 9.09 ± 0.43 mg GAE/g. Thirdly, stem bark extracts were also improved by 23.70%, from 9.45 ± 0.43 to 11.69 ± 0.43 mg GAE/g (Figure 1(a); Figure 1(b)). Importantly, stem bark total polyphenols extracts did not overcome those from leaves. While leaves decoction extract exhibited 14.68 ± 0.43 mg GAE/g, stem barks extract results were 11.69 ± 0.43 mg GAE/g. This 2.99 ± 0.43 mg GAE/g gap was highly significant ($0.0001 \leq p \leq 0.0002$).

Singularly, leaves and stem bark maceration led to similar results, 9.85 ± 0.43 mg GAE/g and 9.45 ± 0.43 mg GAE/g ($p = 0.4510$). Again, the group made by leaves and stem bark extracts through the maceration was like root bark extracts in decoction which allowed 9.09 ± 0.43 mg GAE/g ($0.4510 \leq p \leq 0.5618$). The difference got higher when comparing leaves extract to those of roots' bark, in decoction. Keeping the analysis with decoction extraction mode, the roots' bark extract of 9.09 ± 0.43 mg GAE/g was improved by 61.50% to reach 14.68 ± 0.43 mg GAE/g. So, leaves decoction total polyphenols extract was tremendously higher than that of roots' bark ($p < 0.0001$). On an overall look, the fruits' pulp was not a good source of phytochemicals. Globally, from maceration or decoction, the fruits' pulp total polyphenols extract got 1.12 ± 0.43 mg GAE/g.

Singularly, the extraction mode (maceration or decoction) had no effect on these poor outputs. However, [8] announced that the pulp is used to overcome fever, diuretic, and mild purgative matters. When [18] investigated *Parkia*



(a)



(b)

Figure 1. Total polyphenols' content according to plants' part and extraction mode. (a): Total polyphenols content according to the extraction mode; (b): Total polyphenols content according to plant parts. **Notes:** Values are the least square means of three data \pm standard error. In **Figure 1(a)**, **Figure 1(b)**, the values followed by different letters differ significantly ($p < 0.05$), according to Newman-Keuls' (SNK) multiple range test. Org.: Organ; L.: leaves; P.: pulp; R.: root; S.: stem; Ext.: extraction; D.: decoction; M.: maceration; mg GAE/g.: mg Gallic Acid Equivalent per gram of product.

biglobosa seed phytochemicals extract contents, total polyphenols results were 1.32 ± 0.02 mg GAE/g in a solution of 70% ethanol, and 1.89 ± 0.08 mg GAE/g in a medium of 80% acetone. Even though he used some alcohol, his results were like herein outputs. Enujiugha's [18] results could have been better with distilled water as solvent. Of course, [15] got better extracts with distilled water than 70% methanol solution for total polyphenols extraction.

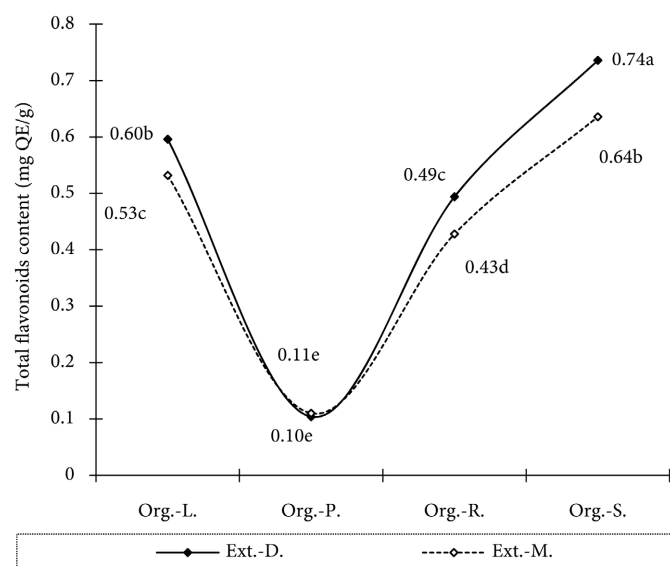
As an example, with *Morus alba* var. *alba* leaves, [15] extracted 560 ± 97.23 , and 759 ± 74 mg GAE/100g, respectively with 70% methanol solution and distilled water. So, moving from the alcohol solution to distilled water, the extracts were improved by 35.53%. Likewise, Lezoul *et al.* [4] demonstrated that water is a very good extractor for phytochemicals extractions. Particularly, fruits seeds and fruits pulp are not good sources of total polyphenols.

When considering the maceration, the pulp results were 8.80 (9.85/1.12), 5.61 (6.28/1.12), and 8.44 (9.45/1.12) folds inferior to those of leaves, root bark, and stem bark ($p < 0.0001$). Fortunately, fruits seeds are very rich in protein, which content fluctuate between 26.3 and 47.4% [9]. Moreover, they contain important minerals such as Ca (321 - 880 mg/100g), P (550 - 584 mg/100g), Fe (36.2 - 51 mg/100g) [9]. *Parkia biglobosa* phytochemicals may be linked with photosynthesis products transportation. During photosynthesis, the phytochemicals are synthesized at the leaves level. Thereafter, they are transported through the stem bark to the root bark. Because of the plant growing action, fruiting, and the synthesis of defense metabolites such as total flavonoids, the total polyphenols contents decrease alongside the transit. This may be the reason why, the traditional doctors use preferentially the leaves, the stem bark, and roots. According to [13], traditional healers mainly use *Parkia biglobosa* leaves, stem barks, and roots. Likewise, [5] observed that *Zanthoxylum chalybeum* most collected parts were stem and root bark. Many other trees, such as *Betula utilis*, *Acer pictum*, and *Quercus ilex* stem bark and roots are collected for medicinal uses [6].

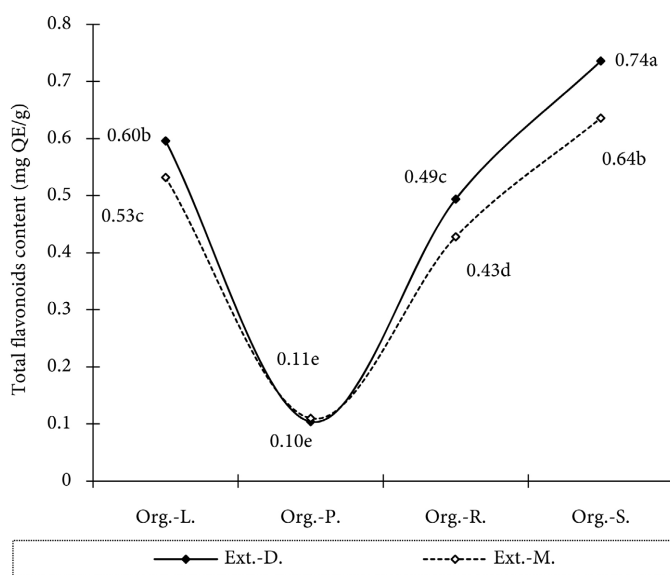
So, stem bark, roots, and leaves may be the most efficient in treating diseases [5] [6]. When [19] checked *Mallotus philippinensis* stem bark, *Trichosanthes bracteata* stem and *Syzygium operculatus* stem bark for total polyphenols contents, they got 284.12 ± 0.60 , 63.20 ± 0.10 , and 155.21 ± 0.60 mg GAE/g in dry extracts, respectively. Similarly, [20] reported that medicinal plant parts displayed important content of total polyphenols. As an illustration, the assessment of *Olea europaea* leaves revealed that they contain about 23.52 ± 0.3 mg GAE/g [20]. In fact, *Oleuropein* oil from the leaves exhibits an antioxidant, antihypertensive, hypoglycaemic, hypocholesterolaemia and cardioprotective activity [19]. Also, *Punica granatum* leaves, roots and stem bark delivered 199.26 ± 1.16 mg GAE/g [20]. Thus, these plants (*Mallotus philippinensis*, *Trichosanthes bracteata*, *Syzygium operculatus*, *Olea europaea* and *Punica granatum*) parts exhibit more total polyphenols than *Parkia biglobosa* ones. On the contrary, when [21] screened *Cerasus mahaleb*, *Rosa canina*, *Rosa rubiginosa*, *Laurocerasus officinalis* and *Cotoneaster horizontalis* leaves for total polyphenols extractions, the results were 0.928 ± 0.042 , 4.09 ± 0.634 , 4.93 ± 0.960 , 1.30 ± 0.340 and 2.35 ± 0.641 mg GAE/g, respectively. It appears that *Parkia biglobosa* leaves are richer in total polyphenols than these plants' ones because their contents were above 9.85 ± 0.43 mg GAE/g. These total polyphenols' content largely results from its abundant phenolic acid, flavonoids, tannins, amino acids, and alkaloids allowing important health benefits [19] [20] [21].

3.2. Total Flavonoids Content

In a review, [22] recalled the anti-oxidative, anti-inflammatory, anti-mutagenic and anti-carcinogenic properties of flavonoids. Because of flavonoids' health benefits, when screening phytochemicals in natural products, total flavonoids assessment is primordial. **Figure 2** displays total flavonoids extracts. It appears



(a)



(b)

Figure 2. Total flavonoids content. (a): Total flavonoids content according to the extraction mode; (b): Total flavonoids content according to plant parts. **Notes:** Values are the least square means of three data \pm standard error. In **Figure 2(a)**, **Figure 2(b)**, the values followed by different letters differ significantly ($p < 0.05$), according to Newman-Keuls' (SNK) multiple range test. Org.: Organ; L.: leaves; P.: pulp; R.: root; S.: stem; Ext.: extraction; D.: decoction; M.: maceration; mg QE/g.: mg Quercetin Equivalent per gram of product.

that, likewise total polyphenols contents tendencies, the decoction delivered better total flavonoids extracts than the maceration. Looking respectively at leaves, root bark and stem bark, from maceration to decoction, the extracts were improved by 13.21% (from 0.53 ± 0.02 to 0.6 ± 0.02 mg QE/g), 13.95% (from 0.43 ± 0.02 to 0.49 ± 0.02 mg QE/g), and 15.62% (from 0.64 ± 0.02 to 0.74 ± 0.02 mg QE/g). The derived gaps were 0.07 ± 0.02 mg QE/g ($p = 0.02$), 0.06 ± 0.02 mg QE/g ($p = 0.0169$), and 0.1 ± 0.02 mg QE/g ($p = 0.001$), respectively for leaves, root bark, and stem bark. Thus, these gaps were all significant, making decoction more efficient than maceration for total flavonoids extractions.

Looking at plants' parts extracts, globally leaves were not anymore, the leader in the deliveries (**Figure 2(b)**). Through the decoction, while the leaves' total flavonoids extracts were 0.6 ± 0.02 mg QE/g, the stem bark exhibited 0.74 ± 0.02 mg QE/g. Thus, from leaves to stem bark, total flavonoids extracts were improved by 0.14 ± 0.02 mg QE/g, which means an increase of 23.33%, and this increase was highly significant ($p = 0.0001$). But, on the way going down to the roots, total flavonoids content lessened by dropping from 0.60 ± 0.02 mg QE/g to 0.49 ± 0.02 mg QE/g. This reduction of 0.11 ± 0.02 mg QE/g, representing a loss of 18.33% was significant ($p = 0.0022$). Finally, following the total polyphenols extracts, the mature fruits' pulp total flavonoids extracts were few, 0.10 and 0.11 ± 0.02 mg QE/g, in decoction and maceration, respectively. Anyhow, compared to the fruits' pulp, the leaves, the stem bark and the root bark are greater sources of total flavonoids. It's proved that medicinal plant parts exhibit important total flavonoids extracts.

The important extracts of total polyphenols from *Mallotus philippinensis* stem bark, *Trichosanthes bracteata* stem and *Syzygium operculatus* stem bark were backed by important total flavonoids contents [19]. Of course, these trees respective parts delivered 879.48 ± 24.75 , 657.26 ± 18.01 , and 134.25 ± 8.78 mg QE/g in dry extracts [18]. Comparatively, [21] found that wood resources such as *Cerasus mahaleb*, *Rosa canina*, *Rosa rubiginosa*, *Laurocerasus officinalis* and *Cotoneaster horizontalis* total flavonoids extracts from leaves fluctuated from 2.80 ± 0.002 (the highest) to 1.30 ± 0.004 mg QE/mg of dried weight (the lowest).

So, looking at total flavonoids' extracts, *Parkia biglobosa* leaves are richer than these trees for more than 10 times. But one reason for this difference could be the solvent used for the extraction. In fact, with some trees, distilled water is a better solvent than alcohols for phytochemicals extractions [4] [14]. Furthermore, stem bark, leaves and roots of woody plants surely contain different amounts of total flavonoids contents. As an illustration, [14] extracted 283.13 ± 4.10 and 717 ± 45 mg RE/100g (rutin equivalent) from *Morus alba* var. *alba* leaves, respectively with 70% methanol aqueous solution and distilled water. Thus, the distilled water extracts were 2.53 times those of 70% methanol medium.

Thereafter, when they checked the stem bark, they extracted 173 ± 0.74 and 450 ± 234 mg RE/100g, respectively, with 70% methanol solution and distilled water. Again, the distilled water improved the extraction of total flavonoids by 35.26% (from the lowest). This tendency was reported by [14], when they re-

ported some extractions rates amelioration with leaves from 12.5% to 37.5%, and from 12.94% to 34.12% with stem bark, respectively with alcohols and distilled water. On contrary, [23] got better phytochemical extracts with alcohols solutions than pure water. For example, from *Anisophyllea laurina* leaves, the extracts were 104.41 ± 0.02 and 346.14 ± 0.03 TFC QE mg/100g, respectively with distilled water and ethanol aqueous solutions [22]. Again, from the stem bark they had 292.98 ± 0.03 and 385.79 ± 0.07 TFC QE mg/100g, with the respective solutions. In both cases, distilled water total flavonoids results represented 30.16% and 75.94% those of ethanol aqueous solution. Nonetheless, looking at the plant parts, these results indicate that the stem bark is mainly richer than leaves for total flavonoids [22]. Likewise, Karou *et al.* [24] found that stem bark, roots and leaves are the most used for medicinal purposes. Looking at distilled water extracts from leaves to stem bark, *Morus alba* var. *alba* total flavonoids extracts went from 717 ± 45 to 450 ± 234 mg RE/100g [13]. Henceforth, high decrease of 37.24% in total flavonoids extracts was observed.

Herein *Parkia biglobosa* extracts showed an increase of 20.75% from 0.53 to 0.64 ± 0.02 mg QE/g, respectively from leaves to stem barks. Likewise, when [25] assessed the contents of the identified flavonoids in *Zanthoxylum zanthoxyloides* plant parts, they concluded that Neodiosmin, Neohesperidin, Hesperidin, and Quercetin are more concentrated in stem bark and root bark, than leaves. While Hyperoxide, Quercetin-3-O-glucopyranoside and Quercitrin are mostly in the leaves [25]. *Parkia biglobosa* total flavonoid extracts tend to be like [25] results because they observed that stem bark contains more total flavonoids than leaves and roots.

3.3. Antioxidant Activity

Generally, important total polyphenol contents allow important antioxidant activity. In **Table 1**, the antioxidant activities' importance followed the total flavonoids contents order. The outputs were 2.89, 2.58 and 2.37 ± 0.07 $\mu\text{mol T.E/g}$, respectively for stem barks, leaves and root barks ($0.0001 \leq p \leq 0.0444$). The reductions were 10.73% (from 2.89 to 2.58 ± 0.07 $\mu\text{mol T.E/g}$), and 8.14% (from 2.58 to 2.37 ± 0.07 $\mu\text{mol T.E/g}$). Finally, the fruit pulp had the poorest antioxidant activity for 1.14 ± 0.07 $\mu\text{mol T.E/g}$.

While considering the combination with organs and extraction modes, it appeared that the stem bark in decoction, leaves in decoction, and stem in maceration had similar results, respectively 3.07, 2.86, and 2.71 ± 0.1 $\mu\text{mol T.E/g}$ ($0.0532 \leq p \leq 0.2883$). These *Parkia biglobosa* results are like those of *Zanthoxylum zanthoxyloides*. Comparatively, after demonstrating that the stem bark, and root bark had higher total flavonoids contents than leaves, [24] found that high total flavonoids contents led to high antioxidant activity. Notably, while stem bark and root bark exhibited 33.32 ± 0.88 and 71.53 ± 0.85 mg/mL, respectively; the leaves delivered 24.96 ± 0.32 mg/mL [24]. These findings are widely supported by traditional medicine knowledge. Singularly, [5] reported that leaves, roots, or

Table 1. Maceration and decoction impact on *Parkia biglobosa* plant parts antioxidant activities ($\mu\text{mol T.E/g}$).

Organ	Mean \pm Standard Error	p-value	Organ*Extraction	Mean \pm Standard Error	p-value
			Stem bark*Decoction (S.D)	3.07 \pm 0.10a	
Stem bark (S)	2.89 \pm 0.07a		Leaves*Decoction (L.D)	2.86 \pm 0.10a	S.D vs L.D; 0.0532
			Stem bark*Maceration (S.M)	2.71 \pm 0.10ab	S.M vs L.D; 0.2883
Leaves (L)	2.58 \pm 0.07b	L vs S; 0.0069	Root bark*Maceration (R.M)	2.49 \pm 0.10bc	R.M vs S.M; 0.1385
			Leaves*Maceration (L.M)	2.30 \pm 0.10c	L.M vs R.M; 0.0201
Root bark (R)	2.37 \pm 0.07c	R vs L; 0.0444	Root bark*Decoction (R.D)	2.24 \pm 0.10c	R.D vs L.M; 0.6746
			Fruit pulp*Maceration (F.M)	1.45 \pm 0.10d	P.M vs R.D; <0.0001
Fruit pulp (P)	1.40 \pm 0.07d	P vs R; <0.0001	Fruit pulp*Decoction (F.D)	1.34 \pm 0.10d	P.D vs P.M; 0.4809

Notes: Values are least-square means of three data \pm standard error. In a column, the values followed by different letters differ significantly ($p < 0.05$), according to Newman-Keuls' (SNK) multiple range test. Org.: Organ; L.: leaves; P.: pulp; R.: root; S.: stem; Ext.: extraction mode; D.: decoction; M.: maceration; $\mu\text{mol T.E/g}$: $\mu\text{mol Trolox Equivalent per gram of product}$.

stem barks are regularly boiled to optimize their medicinal power. Additionally, [24] observed that when the medicinal plant extracts are orally administrated, the plant parts are generally extracted through decoction.

After a questionnaire administration, [19] discovered that for traditional medicine purposes, people use the stem bark of woody plant such as *Mallotus Philippensis* and *Syzygium operculatus*. Also, [5] discovered that, against malaria, abdominal pain, fever and body ache, people preferentially use the stem bark, the roots, and leaves, in this order. Indeed, [20] announced that high total flavonoids content in *Mentha piperita*, *Rosmarinus officinalis* and *Salvia officinalis* for 70.14 ± 1.23 , 49.14 ± 0.83 and 43.92 ± 0.05 mg CATE/g, led to high antioxidant activities, whose were 0.35 ± 0.02 , 0.27 ± 0.01 and 0.27 ± 0.01 mM Trolox/g, respectively. Accordingly, *Parkia biglobosa* stem bark which had the highest total flavonoids extracts (**Figure 2(b)**), exhibited the highest antioxidant activity. Thereafter, the leaves and the root bark followed, and the antioxidant activities kept the same order. Many works concluded that there is a good relationship between phytochemicals content and antioxidant activity. Indeed, [23] got a correlation coefficient fluctuating from 0.982 to 0.998 between phytochemicals concentrations and antioxidant activity. Herein, **Table 2** shows the correlation matrix between the different factors. Good correlation coefficients were found between total polyphenols contents (mg GAE/g), total flavonoids contents (mg QE/g) and antioxidant activity ($\mu\text{mol T.E/g}$). These correlation coefficients were 0.88 and 0.925 between total polyphenols and flavonoids, and antioxidant activity, respectively. Uniquely, *Parkia biglobosa* plant parts allow a good correlation coefficient between total polyphenols and total flavonoids contents for 0.907.

Table 2. Correlation matrix between factors.

Variables	Org.-L.	Org.-P.	Org.-R.	Org.-S.	Ext.-D.	Ext.-M.	µmol T.E/g	mg GAE/g	mg QE/g
Org.-L.	1.000								
Org.-P.	-0.333	1.000							
Org.-R.	-0.333	-0.333	1.000						
Org.-S.	-0.333	-0.333	-0.333	1.000					
Ext.-D.	0.000	0.000	0.000	0.000	1.000				
Ext.-M.	0.000	0.000	0.000	0.000	-1.000	1.000			
µmol T.E/g	0.262	-0.873	0.056	0.555	0.117	-0.117	1.000		
mg GAE/g	0.552	-0.862	-0.028	0.338	0.271	-0.271	0.880	1.000	
mg QE/g	0.287	-0.912	0.017	0.608	0.127	-0.127	0.925	0.907	1.000

Org.: Organ; L.: leaves; P.: pulp; R.: root; S.: stem; Ext.: extraction mode; D.: decoction; M.: maceration; µmol T.E/g.: µmol Trolox Equivalent per gram of product.

4. Conclusion

Traditional medicine is an important way for African and Asian healthcare systems. Alongside the herbs, many woody plants are used. Among, these woody species, *Parkia biglobosa* is an important medicinal plant in Cote d'Ivoire. Unfortunately, the plants are frequently debarked, and some plants are killed. So, *Parkia biglobosa* plants are farther and farther away from inhabitants living places. The work found that total polyphenols were more concentrated in leaves for 14.68 ± 0.43 mg GAE/g ($p < 0.0001$). But these total polyphenols' components composed of total flavonoids were more concentrated in stem bark for 0.74 ± 0.02 mg EQ/g. Thereafter, the leaves followed for 0.6 ± 0.02 mg EQ/g, and root bark for 0.49 ± 0.02 mg EQ/g ($0.0001 \leq p \leq 0.0169$). Herein work could not support the reason why rural people usually use *Parkia biglobosa* stem bark. In fact, in decoction, its stem bark and leaves delivered similar antioxidant activities, 3.07 and 2.86 ± 0.1 µmol T.E/g, respectively ($p = 0.0532$). Many other investigations should be undertaken for a better understanding of rural people's attitudes toward *Parkia biglobosa* stem bark uses. Moreover, sensitizing could help to explain to rural people that the leaves could be able to achieve the same results as stem bark for human beings and other animals' health issues. When it comes to decoction, which remains the principal extraction mode in traditional medicine by boiling, the leaves and the stem barks have similar antioxidant activity power.

Conflicts of Interest

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

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