Chemical composition and antioxidant activity of *Dialiumguineense* fruit (Fabaceae) from Côte d'Ivoire

Abstract : This study is devoted to the phytochemical analysis of*Dialiumguineense* fruit, which is particularly popular in urban areas in Côte d'Ivoire. Despite its high consumption, there is still little information about its potential. To assess and identify the levels of various secondary metabolites, hydromethanolic extracts of the pulp, kernel, and shell of *D. guineense* fruit were analyzed via qualitative and quantitative methods (colorimetric and TLC tests) : total phenols (40.201 ± 1.8 ; 509.023 ± 14.5 and 194.368 ± 2.2 µg EAG/g dry extract), flavonoids (58.958 ± 6.1 ; 216.771 ± 21.7 and 238.385 ± 6.2 µg EC /g dry extract), condensed tannins (264.167 ± 13.9 ; 411.667 ± 25.8 and 282.500 ± 5.2 µg EC/ mg dry extract) and hydrolysable tannins (0.44 ± 0.03 %; 0.21 ± 0.02 % and 0.30 ± 0.03 %). Furthermore, the analysis of antioxidant potential (DPPH and FRAP) showed satisfactory activity overall, with special attention given to the kernel and shell. These results indicate that the fruit of *D. guineense* could be viewed as a potential source of antioxidant compounds that can help prevent or fight various pathologies associated with oxidative stress.

Key words:*Dialiumguineense, fruit, chemical composition, antioxidant activity*

1. Introduction

*Dialiumguineense*Willd, commonlyreferred to as black tamarind or velvet tamarind, is an endangered plant species that is widely used by people in Côte d'Ivoire **[1, 2]**. Despite the high level of consumption, this species has not undergone any studies. Adopo et al.**[3]**haveconductedresearch on the shell, pulp, and kernel of this fruit, whichiswhy**.** The resultsreveal the presence of various minerals, with a particularly high concentration of calcium (Ca), potassium (K) phosphorus (P) and magnesium (Mg). Despite not being factored into men's eating habits, the kernel is a significant protein source (23.58 ± 1.18%) in comparison to other parts of the fruit. In terms of energy utilization, the pulp, kernel, and shell can generate 317.01 ± 0.14 kcal/100g, 364.47 ± 0.35 kcal/100g, and 351.02 ± 0.32 kcal/100g, respectively. The kernel contained 56.79 ± 1.22 g/100 g of carbohydrates, while the pulp had 70.15 ± 0.9%, and the shell had 79.44 ± 0.7%. The hull had a significant amount of total fiber (30.14 ± 0.02%). The anti-nutritional elements were found to be only in the kernel (14.83 ± 0.07 mg/100g), and oxalates were found in all parts of the fruit through the evaluation of the anti-nutritional elements. With this information, the understanding of *D. guineense* in Côte d'Ivoire is enhanced and new opportunities for this fruit's development are opened up **[4–6]** Incorporating antioxidant-rich food supplements into our diet is essential to combat these conditions **[7].** Synthetic antioxidants have been criticized for their potential toxic risks **[8].** Many researchers are investigating antioxidant molecules that come from nature for this reason. *D. guineense* has been studied in various regions, particularly in Nigeria, and it has been found to have

phytocompoundswithinterestingpotential**[9, 10].** *D. guineense* has the potential to be a promising source of antioxidant substances. The aim of this study is to examine the shell, kernel, and pulp of the fruit of *D. guineense*from Côte d'Ivoire's chemical composition and antioxidant potential.

2. Materials and methods

2.1. Plant material

Dialiumguineense fruits (Figure 1A) were collected in March 2020 in Dimbokro (6°39‘ north, 4°42’ west), a town in the N'Zi region of central Côte d'Ivoire. They were identified by an ethnobotanist from Nangui ABROGOUA University and then certified at the Centre National de Floristique in Abidjan in accordance with existing herbariums (N°UCJ009331). After collection, the fruits were cleaned and shelled. The various resulting parts (pulp, kernel and shell) (Figure 1(B-D)) were dried in an air-conditioned room (18°C) for 21 days, then reduced to powder using an electric grinder.

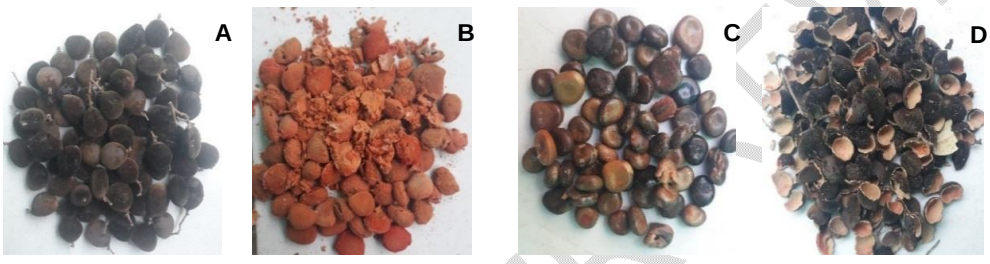

Figure 1:Unhulled fruit (A), pulp (B), kernels (C) and shells (D) of *Dialiumguineense* (Photo taken by ADOPO in 2020)

2.2. Methods

2.2.1. Preparation of samples

100 g of powder from each part of the fruit was macerated in 600 mL of 80 %methanol(MeOH, 3 × 24 h) at room temperature (25°C) with continuous stirring. After vacuum filtration, the filtrates were combined and concentrated using a rotary evaporator (Büchi RII) at 40°C. The aqueous extracts obtained were kept in a refrigerator (4°C) for 24 h, in order to precipitate the lipophilic compounds. Once the lipophilic compounds had been removed by decantation, part of the aqueous extracts were oven-dried at 45°C until the dry crude extracts were obtained, which were used for phytochemical screening using colour reactions, quantitative analysis and antioxidant potential studies. The second part of the aqueous extracts was successively exhausted in solvents of increasing polarity (3×50 mL): hexane (n-C6H14), chloroform (CHCl3), ethyl acetate (AcOEt) and n-butanol (n-BuOH). The selective extracts obtained were used for phytochemical screening by thin-layer chromatography (TLC).

2.2.2. Qualitative analysis

The chemical composition of every part of the *D. guineense* fruit was determined through qualitative analysis. To achieve this, colorimetric tests and TLC were employed **[11–18]**.

2.2.3. Quantitative analysis

The content of certain compounds in each part of the *D. guineense* fruit wasevaluated through quantitative analysis using spectrophotometry. The Folin-Ciocalteucolorimetricmethodwas used to determine the total phenols **[12, 19, 20]**. Aluminum chloride method was used to estimate the

total flavonoid levels **[21, 22]**. The vanillinhydrochlorideassaywasused to determinatecondensed tannins **[23, 24].**The method described by Dif and colleagues, based on a reaction with iron (III) chloridewasused to evaluate the level of hydrolysable tannins**[22].**

2.2.3.1.Study of antioxidant potential

DPPH test **[25-27]** and FRAP method **[28, 29]** were used to assess the free radical scavenging capacity of the various parts of *D. guineense* fruit.

2.2.4. Statistical analysis

Statistical analyses were performed using IBM SPSS Statistics version 22 software. Assay results, expressed as the mean of six trials ± standard deviation, were subjected to a one-factor ANOVA at the 5% threshold. Tukey's test (verified homoscedasticity) and Tamhane's T2 test (unverified homoscedasticity) were used as post hoc tests, when the ANOVA test led to significant differences between means. These tests make it possible to group the different means into homogeneous subsets. Finally, the Pearson test was applied to establish the correlations between the different levels obtained.

3. Results and discussions

3.1. Phytochemical screening using color tests of the different parts of the *D. guineense* fruit

Several secondary metabolites were discovered during phytochemical screening using colorimetric tests (Table I). $FeCl_3$ solution was used to identify polyphenols in all parts of *D. guineense* fruit. Kernel and pulp extracts had intense blue-black coloration, while the shell extracts had green-black coloration, suggesting a significant presence of these compounds in these parts. Different classes of flavonoids could be identified by detecting flavonoids in all three-study media using Shinoda, ammonia, and vanillin tests. According to **[17]**, flavones and flavonols can be detected by a yellow color at room temperature or a red-orange color when heated by ammonia test, which can be verified by Shinoda's test. The presence of flavonoids is confirmed by a positive result observed with vanillin. All parts of the fruit contain tannins, coumarins, sterols, and terpenes. Saponins were detected with foam indices of 100, 125 and 200 for the pulp, kernel and shell respectively. The kernel and shell showed positive results from Borntraëger reagent, which suggests that quinones are present, as well as alkaloids detected by the Dragendorff and Wagner reagents. In spite of this, cardiotonic glycosides, which are detected using Liebermann-Bürchard's reagent,were not present in all parts of the fruit.According to studies on the species in Nigeria, which **[30]**observed in ethanolic, methanolic, and aqueous extracts, these results agree with those of other studies.

Table I: Compounds detected in different parts of *D. guineense* fruit

		Pulp	Kernel	Shell
Polyphenols		**+**	**+**	**+**
	Shinoda's test	**+**	**+**	**+**
Flavonoids	*Ammonia test*	**+**	**+**	**+**
	Vanillin test	**+**	**+**	**+**
Coumarins		**+**	**+**	**+**
Tannins		**+**	**+**	**+**

	Dragendorff's test	-	-	+
Alkaloids	*Wagner's test*	-	+	+
	Picric acid test	-	-	-
Sterols and terpenes		+	+	+
Quinones		-	+	+
Saponins		+(Im = 100)	+(Im = 125)	+(Im = 200)
Cardiotonic glycosides		-	-	-

+ : Positive test; - : Negative test

In the end, the fruit of *D. guineense* has phytocompounds that have the potential to be beneficial for the body. The kernel and shell, which are often ignored by the public, could have potential uses in other fields because of their intriguing chemical composition.

3.2. TLC profiles of selective extracts

The presence of variousphytocompounds, includingsterols, terpenes, coumarins, flavonoids, tannins, and anthocyanins, wasuncoveredthrough TLC screening of *D. guineense*shell (Coq), kernel (Noy), and pulp (Pul) (Tables II and III). To study the migration of compounds, present in hexane and chloroformextracts, solvent gradients containing,respectively n-C_6H_{14}/$CHCl_3$/AcOEt (4:10:1, V/V/V) and n-C_6H_{14}/$CHCl_3$/AcOEt(6:10:6, V/V/V) were used. To determine what compounds were in the ethyl acetate and n-butanol extracts, the AcOEt/$CHCl_3$/EtOH/ (V/V/V) mixture was employed. Different developers were used to identify the compounds. Liebermann-Bürchard reagent was utilized to view sterols, which appeared brown and green to the naked eye and yellow and yellow-green under UV at 365 nm (Figure 2A). Various reagents were employed to identify the compounds present in the extracts. For instance, sterols were visualized using the Liebermann-Bürchard reagent (Figure 2A), which produced brown and green colors to the naked eye and yellow to yellow-green colors under UV light at 365 nm. The same reagent was utilized to detect terpenes (Figure 2A), particularly triterpenegenins, which manifested as blue and purple spots to the naked eye, and orange-yellow spots under UV light at 365 nm for lupane-type triterpenegenins**[18, 31]**. Additionally, a sulfuric vanillin solution was employed to indicate the presence of terpenes, which appeared purple, pink, and orange both to the naked eye and under UV light at 365 nm. This solution also confirmed the presence of sterols, which were visible as blue spots to the naked eye and under UV light at 365 nm **[31]**. Flavonoids were identified using ammonia vapor and a 1% aluminum chloride solution (Figure 2B), which rendered them yellow to the naked eye; this coloration could vary from blue to brown or yellow-green under UV light at 365 nm **[11, 31]**. In the presence of ammonia vapor, flavonoids appeared yellow and green both to the naked eye and under UV light at 365 nm **[32]**. Furthermore, the presence of anthocyanins was indicated by blue or purple colorations revealed by ammonia vapor **[11].** Yellow spots observed with the naked eye using a 5% methanolic KOH solution indicated the presence of coumarins (Figure 2B), with this yellow coloration potentially intensifying or diversifying under UV light at 365 nm. Tannins were highlighted using a 2% (m/v) aqueous solution of $FeCl_3$ (Figure 2C), resulting in gray or brown colorations **[31, 33]**.

Table II: Compounds identified in the hexanolic and chloroform extracts of the different parts of the *D. guineense* fruit.

Solvents	Extracts	Possible compounds : [Rf], Colour, Developer
Hexane	Pul	**Sterols :** [0.3],Br[e] ; [0.32 ; 0.64],B[a] ;[0.81],Ve[e] , B[a] **Terpenes :** [0.08],J-Or[e], Ve[d], Vi[a] ; [0.2],J-Or[e], [0.3],J-Or[e], Vi[a] ; [0.41],J-Or[e], Or[a] ; [0.5],J-Or[e], Ve[a] ; [0.54],R[e] ; [0.56],R[e], Ro[a] ;[0.64],J-Or[e], Or[a] ; [0.7],J-Or[e] ; [0.8],Ro[a] ;[0.9],J-Or[e]
	Noy	**Sterols :** [0.32 ; 0.6 ; 0.92],Br[e] ; [0.27 ; 0.8], B[a] **Terpenes :** [0.08],J-Or[e], Vi[a] ; [0.14],J-Or[e] ; [0.2],J-Or[e] ; [0.27],Vi[a] ; [0.32 ; 0.45],J-Or[e] ; [0.5],Vi[a] ; [0.6],J-Or[e], Vi[a] ; [0.7],Vi[e, a] ; [0.81],J-Or[e] ; [0.92],J-Or[a]
	Coq	**Sterols :** [0.34], Br[e] ; [0.21 ; 0.62 ; 0.8],B[a] **Terpenes :** [0.08 ; 0.14 ; 0.2],J-Or[e], Vi[ea] ; [0.34 ; 0.4],J-Or[e] ; [0.46],Vi[a] ; [0.5 ; 0.6 ; 0.7],J-Or[e] ; [0.9],J-Or[e]
Chloroform	Pul	**Sterols :** [0.72 ; 0.8 ; 0.92],Br[e] ; [0.8],Br[e], B[a] **Terpenes :** [0.12], J-Or[e], B[a] ; [0.27 ; 0.35],J-Or[e] ;[0.57 ; 0.67 ; 0.72 ; 0.81 ; 0.92],B[e] ; [0.88],B[e], B[a] **Flavonoïds :** [0.12],Ve[b], J[f] ; [0.22 ; 0.29], J[f] ; [0.35],B[b], Ve[f] ; [0.47], B[b] ; [0.57],J[b] ; [0.75], Ve[f] ; [0.88], B[b], B[f] ; [0.9],J[b] **Anthocyanins :** [0.87],B[f] **Coumarins :** [0.06],Ve[C] ; [0.12 ; 0.35],J[C] ; [0.47],Ve[C] ; [0.54],B[C] ; [0.85 ; 0.9],J[C]
	Noy	**Sterols :** [0.12],J-Ve[e] **;** [0.23; 0.62],Ve[e] ; [0.84],B[a] **;** [0.88],J[e], B[a] **Terpenes :** [0.71 ; 0.88], J-Or[e] ; [0.91],B[e] ; [0.94], J-Or[e] **Flavonoïds :** [0.12],Ve[b],J[f]; [0.23],Ve[b] ; [0.25],J[f] ; [0.29],Ve[b] ; [0.4],Ve[f] ; [0.59],J[b] ; [0.82],B[b] ; [0.87],B[f] ; [0.91],B[f] **Anthocyanins :** [0.87 ; 0.91],B[f] **Coumarins :** [0.06],Ve[C] ; [0.12 ; 0.25 ; 0.5],J[C] ; [0.4],B[C] ; [0.82],Ve[C] ; [0.91],B[C]
	Coq	**Sterols :** [0.19],Br[e] **;** [0.26],Ve[e], B[a] ;[0.37 ; 0.88],B[a] ; [0.4 ; 0.8],Br[e] **Terpenes :** [0.08 ; 0.16],B[e],Or[a] ; [0.19 ; 0.22 ; 0.3 ; 0.4],B[e] ;[0.62 ; 0.71 ; 0.86], B[e], Or[a] ; [0.54 ; 0.89 ; 0.94],J-Or[e] **Flavonoïds :** [0.06],J[b,f] ; [0.17],B[b] ; [0.21],J[f] ; [0.4],B[b] ; [0.49],Ve[b,f] ; [0.54],J[b] ; [0.59],J[f] ; [0.86],J[b] ; [0.89],B[b] **Coumarins :** [0.06 ; 0.12],Ve[C] ; [0.3 ; 0.35],J[C] ; [0.47 ; 0.54 ; 0.69],J[C] ; [0.88],R[C]

a : compounds developed with sulfuric vanillin; b: compounds developed with aluminum chloride ($AlCl_3$); c: compounds developed with 5% potassium hydroxide (KOH); e: compounds developed with 1% Liebermann-Bürchard reagent ; f: compounds developed with ammonia vapour (NH_3).

B: blue, Br: brown, J: yellow, Or: orange, R: red, Ro: pink, Ve: green, Vi: violet or purplish.

Table III: Compounds identified in ethyl acetate and n-butanol extracts of different parts of *D. guineense* fruit.

Solvents	Extracts	Possible compounds : [Rf], Colour, Developer
Ethyl acetate	Pul	**Flavonoïds :** [0.08 ; 0.19],J[b] ; [0.1],J[f] ; [0.45 ; 0.56],J[f] ; [0.55],Ve[b] ; [0.66],Ve[b], P[f] ; [0.71 ; 0.77],Ve[f] ; [0.8],Ve[b] ; [0.9],Ve[b,f] **Anthocyanins :** [0.66],Vi[f] **Coumarins :** [0.08 ; 0.12 ; 0.22 ; 0.26],J[C] ; [0.71],P[C] ; [0.82],J[C] ; [0.9],Ve[C]

		Tannins : [0.7],Gr[g]
	Noy	**Flavonoïds :** [0.12],Ve[f] ; [0.19],J[b], P[f] ; [0.29],J[b], P[f] ; [0.36],P[f] ; [0.4],P[b,f] ; [0.46],J[b] ; [0.54],P[f] ; [0.61 ;0.79],J[b] ; [0.69],Ve[f] **Anthocyanins :** [0.19 ; 0.36 ; 0.42],Vi[f] **Coumarins :** [0.06 ; 0.15 ; 0.29 ; 0.4],P[C] ; [0.5],Ve[C] ; [0.6],Gr[C] ; [0.7],Ve[C] ; [0.81],J[C] **Tannins :** [0.11 ; 0.15],Ro[g] ; [0.24 ; 0.42],Gr[g]
	Coq	**Flavonoïds :** [0.07 ; 0.17],J[f] ; [0.1],J[b] ; [0.19 ; 0.27],Ve[b] ; [0.22],B[f] ; [0.34],Ve[b,f] ; [0.42],J[b] ; [0.56],B[b] ; [0.49 ; 0.62],J[f]; [0.6],Ve[b] ; [0.66 : 0.75],P[f] ; [0.7],J[b] ; [0.79],B[b] ; [0.86],B[f] **Coumarins :** [0.14 ; 0.19 ; 0.22],J[C] ; [0.31],Ve[C] ; [0.41 ; 0.51 ; 0.6],J[C] ; [0.69 ; 0.71],P[C] ; [0.8 ; 0.9],J[C] **Anthocyanins :** [0.22 ; 0.86],B[f] **Tannins :** [0.08 ; 0.19 ; 0.22 ; 0.3 ; 0.71],Gr[g] ; [0.29 ; 0.36],Ro[g] ; [0.4],B[g] ; [0.5 ; 0.6]Ro[g]
n-butanol	**Pul**	**Flavonoïds : [0.1],**B[b,f] ; [0.15 ; 0.2],Ve[b] ; [0.6],B[b] ; [0.75],J[f] ; [0.89],Vi[f] **Anthocyanins :** [0.12],B[i] ; [0.89],Vi[f] **Coumarins :** [0.07 ; 0.29 ; 0.4],Ve[C] ; [0.2 ; 0.47 ; 0.62],Be[C]
	Noy	**Flavonoïds :** [0.06 ; 0.08 ; 0.14],P[f] ; [0.17],J[b] ; [0.19],Ve[f] ; [0.27],P[f] ; [0.3],J[b] ; [0.41],Ve[b], J[f] ; [0.49],J[b] ; [0.5],Ve[f] ; [0.6],J[f] **Anthocyanins :** [0.06 ; 0.08 ; 0.14 ; 0.27],Vi[f] **Coumarins :** [0.08],P[f] ; [0,1]J[C,f] ; [0,14],P[f] ; [0,2],J[C], Ve[f] ; [0,27],J[C], P[f] ; [0,4],Ve[f], J-Ve[f] ; [0,47],J[C] ; [0,61],Ve[C] ; [0,81],J[f] **Tannins :** [0,27 ; 0,4],Gr[g] ; [0,47],B[g] ; [0,55],Or[g]
	Coq	**Flavonoïds :** [0,06],J[b], B[f] ; [0.12],B[b,f] ; [0.16],Ve[b,f] ; [0.2],B[b,f] ; [0.31 ; 0.5],J[f] ; [0.25 ; 0.31 ;0.45 ; 0.59],Ve[b] ; [0.67],J[b] ; [0.75],Ve[b,f] ; [0.8],B[b] **Anthocyanins :** [0.07 ; 0.12 ; 0.21],B[f] **Coumarins :** [0.07],Ve[C] ; [0.2],B[C] ; [0.29 ; 0.4],Ve[C] ; [0.47 ; 0.62],B[C] ; [0.76],J[C] **Tannins :** [0.16 ; 0.25],Gr[g] ; [0.69],Be[g]

b: compounds developed with aluminium chloride ($AlCl_3$); c: compounds developed with 5% potassium hydroxide (KOH); f: compounds developed with ammonia vapour (NH_3); g: compounds developed with 2% iron chloride ($FeCl_3$).

B: blue, Gr: grey, J: yellow, Or: orange, P: purple, Ro: pink, Ve: green, Vi: violet or purplish.

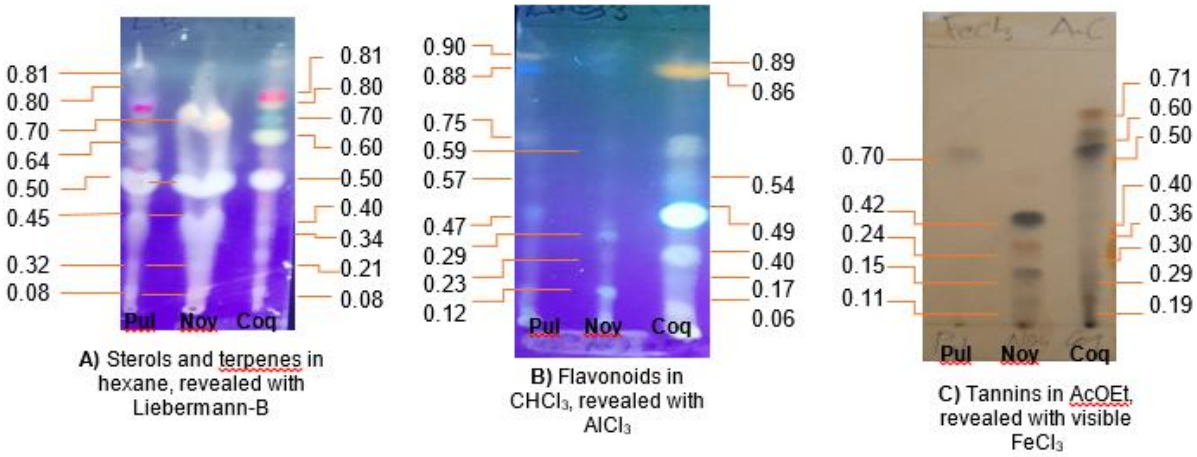

Figure 2: Some chromatographic profiles of the different parts of the *D. guineense* fruit.

The presence of various phytocompounds was discovered through phytochemical screening, such as sterols, terpenes, flavonoids, anthocyanins, coumarins and tannins, in the various parts of the *D. guineense* fruit. These results show the wide diversity of bioactive compounds present in this fruit. The presence of flavonoids, anthocyanins, coumarins, and tannins has been observed in other Dialium species, including *D. gossweileri* and *D. corbisieri***[34].**

3.3. Quantitative analysis

3.3.1. Total phenol content

The levels of total phenols in the different parts of the *D. guineense* fruit (pulp, kernel and shell) (Figure 3) were measured using a calibration curve with gallic acid, the equation of which is y = 0.0232x + 0.0002.

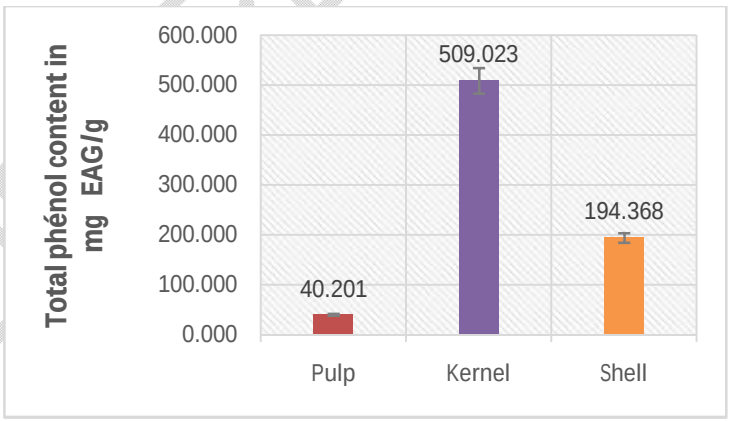

Figure 3: Total phenol content of the different parts of *D. guineense* fruit

The concentrations of phenols obtained variated from 40.201 ± 0.718 to 509.022 ± 5.912 µg EAG/g in samples. The kernel (509.022 ± 5.912 µg EAG/g) had the highest content, while the pulp showed the lowest content (40.201 ± 0.718 µg EAG/g. The total phenol content of the different parts of the *D. guineense* fruit was significantly different ($p < 0.05$) in the analysis of variance at the 5% level. Due to the variability of the variances, the Tamhane test was used as a post-hoc test. This indicated that the total phenol content of the different parts of the fruit differed

significantly from one organ to another. Consequently, they are not comparable. This observation would suggest an uneven distribution of natural compounds in the different organs and physiological tissues of plants. This phenomenon has also been observed by other authors **[22, 35, 36]**. In addition, the phenol content of the kernel is 12.7 times higher than that of the pulp and around 2.6 times higher than that of the shell. This high concentration of phenols in the kernel suggests that it could be considered a reservoir of phenolic compounds, which could be attributed to the presence of flavonoids, coumarins and tannins detected during phytochemical screening. Similar studies conducted on the different parts of the fruit of *Tamarindusindica* (Fabaceae) revealed levels of 152 ± 2.2 µg EAG/g for the pulp, 94 ± 2.1 µg EAG/g for the shell and 66 ± 0.7 µg EAG/g for the kernel **[37].**These results contrast with those obtained for *D. genus*, where the tamarind pulp contains more phenolic compounds than the shell, which is itself richer than the kernel. These observations suggest that there is an unequal distribution of phenolic compounds in the organs of a plant species, despite their belonging to the same family.

3.3.2. Total flavonoid content

The figure 4 shows that the flavonoid levels in different parts of the *D. guineense* fruit varied from 58.958 ± 2.476 to 238.385 ± 2.533 EC/g dry matter. The catechin calibration curve was used to obtain the latter, with the formula y = 0.0004x - 0.0026.

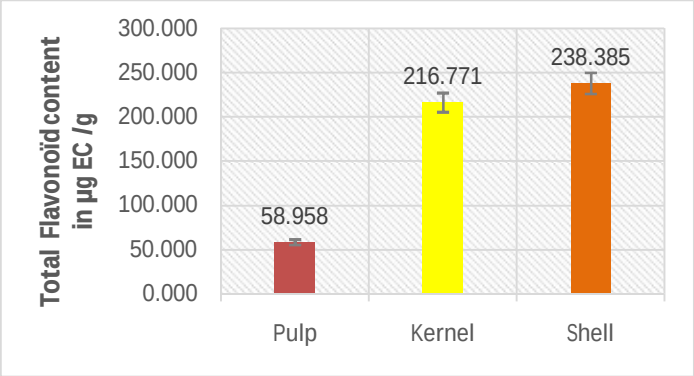

Figure 4: Total flavonoid content of different parts of *D. guineense* fruit

The total flavonoid content of different parts of *D. guineense* fruit was significantly different ($p < 0.05$) according to analysis of variance at the 5% level. According to the Tamhane test, the flavonoids content in the shell (238.385 ± 2.533 µg EC/g) and kernel (217.71 ± 8.863 µg EC/g) of *D. guineense* is comparable. *D. guineense* shell and kernel may have similar pharmacological properties, including antioxidant potential. Flavonoids are recognized in the literature as powerful antioxidants, beneficial for the body **[38]**. It would therefore be wise to consume all parts of the fruit in order to maximize its many benefits. A Comparison of the proportions of total flavonoids of black tamarind and *Tamarindusindica* reveals that the latter contains fewer flavonoids (pulp (24 ± 1.4 µg EC/g); shell (27 ± 1.0 µg EC/g) and kernel (21 ± 0.7 µg EC/g)) **[37]**. Furthermore, Pearson's test indicated a mean positive correlation (r = 0.672) between total phenol and total flavonoid levels. This could indicate an average contribution of flavonoids to the estimation of phenolic compound levels.

3.3.3. Condensed and hydrolysable tannin content

The catechin calibration line (y = 0.004x + 0.006) was utilized to calculate condensed tannin levels, and hydrolysable tannin levels were measured using a 660 nm spectrometer. The results obtained are shown in figure 5.

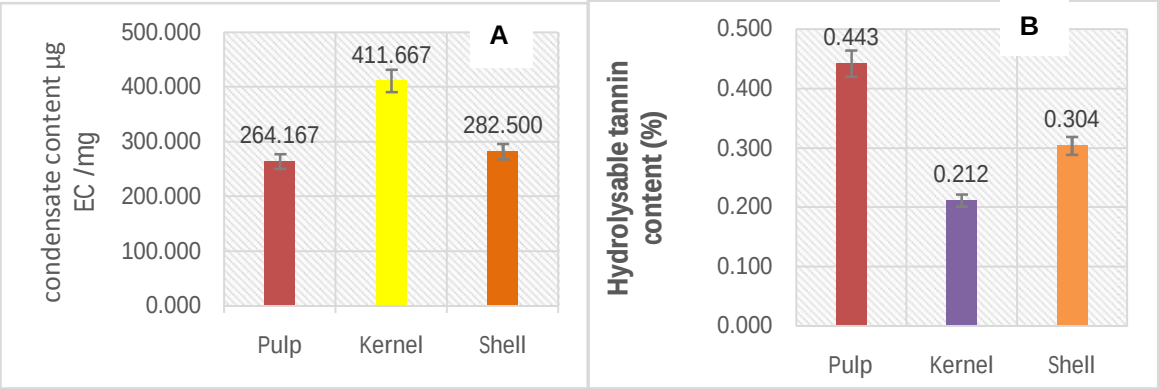

Figure 5: Condensed (A) and hydrolysable (B) tannin content of the various parts of the fruit of *D. guineense*

The percentage of condensed tannins in the different parts of *D. guineense* fruit was significantly different ($p < 0.05$) in the analysis of variance at the 5% level. The Tamhane test revealed that the shell (282.5 ± 2.141 µg EC/g) and pulp (264.167 ± 5.689 µg EC/g) of *D. guineense* have comparable condensed tannin contents (Figure 5A) but are different from that of the kernel. The kernel (411.667 ± 10.541 µg EC/mg) thus remains the part richest in condensed tannins. In addition, a strong positive correlation ($r = 0.942$) was observed between condensed tannin content and total phenol content, indicating the significant contribution of condensed tannins to the quantification of phenolic compounds. In general, the analysis of variance applied to the hydrolysable tannin content showed a significant difference ($p < 0.05$) between the different averages. The Tukey test showed that the hydrolysable tannin contents of the different parts were not comparable (Figure 5B). The presence of tannins in the fruit of *D. guineense* fruit could explain several properties attributed to it, in particular the astringent flavor felt when the pulp is eaten. This sensation arises from the interaction between the tannins of the consumed matrix and salivary proteins, particularly those rich in proline**[39].**

3.4. Antioxidant activity

3.4.1. Antioxidant capacity by DPPH test

The figure 6 shows the results of the DPPH test.

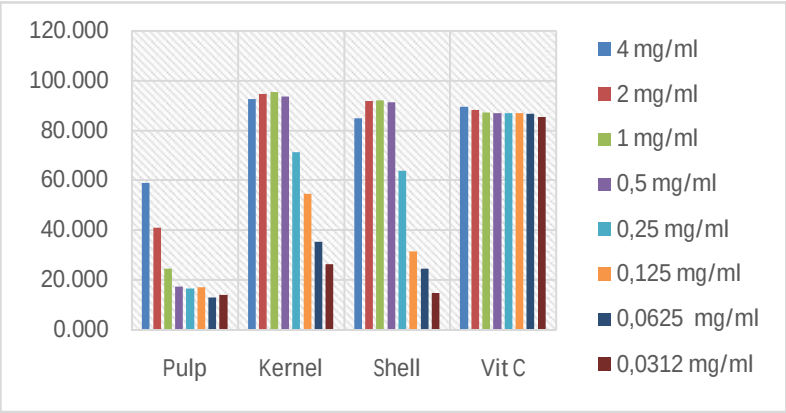

Figure 6: Antioxidant profiles of different *D. guineense* extracts

Overall, the extracts tested had an anti-radical effect on the DPPH. Extracts from the kernel and shell showed significantly greater reduction capacity than those from the pulp. For concentrations of 4 to 0.0312 mg/mL, the reduction percentages (PR) for the kernel range from 92.728 to 26.380% and for the shell, it ranges from 84.873 to 14.756%. They are greater than 50% for concentrations between 0.125 and 4 mg/mL (Figure 6). In addition, for concentrations between 0.5 and 4 mg/mL, PR above 90% were observed for most extracts, except for the shell at 4 mg/mL with a PR of 84.873%. These results suggest that the kernel and shell are potential sources of antioxidant compounds. For the pulp, the highest PR (59.023%) was observed at 4 mg/mL, indicating a reduced capacity to neutralize DPPH compared to other organs. The Table IV presents the different CR50 values, designating the concentrations that cause the loss of 50% of the DPPH. These values were determined graphically.

Table IV: CR_{50} (mg/mL) of crude extracts of *D. guineense* and vitamin C

Extract	Pulp	Kernel	Shell	Vitamin C
CR_{50}	3.102	0.110	0.193	0.008

According to the literature, the lower the CR_{50}, the greater the antioxidant activity and vice versa. On the basis of this principle, it can be stated that the kernel extract has a greater antioxidant capacity, followed by the shell. On the other hand, compared to vitamin C, the different parts of *D. guineense* exhibit much lower activity. The antioxidant properties of the kernel and shell of *D. guineense* are much stronger than those of the fruits of *D. gossweileri*. (CR_{50} = 500 µg/mL). Conversely, their activity is less than that of *D. corbisieri*(CR_{50} = 14.44 µg/mL) **[34].** Consumption of these three parts of the fruit could therefore be beneficial for the body.

3.4.2. Antioxidant activity by FRAP test

The concentrations of ferric ions (Fe^{3+}) to ferrous ions (Fe^{2+}) were varied from 2115.91 to 51101.52 µg EFS/g DM in the different parts of *D. guineense* fruit. (Figure 7). These values were obtained after projection onto the calibration line of equation y = 0.0197x - 0.0187 with R^2 = 0.9991, performed with iron (II) sulfate, prepared under the same conditions as the samples.

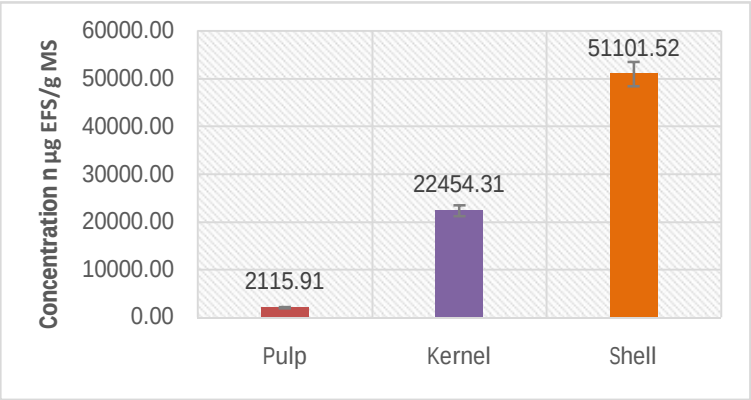

Figure 7: Reduction concentrations of Fe^{3+} to Fe^{2+} in the FRAP test

The shell signed the highest reduction concentration (51101.52 µg EFS/g DM), while the pulp presented the lowest (2115.91 µg EFS/g DM). This could be explained by the presence of phytocompounds such as flavonoids in the shell of *D. guineense*, which are capable of providing electrons to reduce the ferric ion. This hypothesis was confirmed by a strong positive correlation (r = 0.999) between the FRAP test and the total flavonoid content (238.385 ± 6.2 µg EC /g). **[40]**report that most flavonoids possess the ferric ion's reducing properties. However, those which have in their structure, the O-dihydroxy group in the ring B and the 3-hydroxy group and a double bond at the 2,3 positions in the ring C are the most active during the FRAP test **[40]**. The pulp was the least active part of *D. guineense* fruit, regardless of the method used to evaluate its antioxidant potential. Consequently, incorporating the other parts of the fruit (shell and kernel) into dietary habits and other uses could be beneficial.

4. CONCLUSION

This study focused on improving the value of *D. guineense* fruit from Côte d'Ivoire by analyzing its chemical composition and evaluating the antioxidant potential of its various components (shell, pulp, and kernel). Phytochemical screening revealed the coexistence of several phytoconstituents (flavonoids, coumarins, tannins, sterols, terpenes, alkaloids and saponins) and the absence of cardiotonic glycosides in all parts of the fruit. Furthermore, quinones and alkaloids were not visible in the pulp. Quantitative analysis revealed significant levels of total phenols (509.023 ± 14.5 µg EAG/g) and condensed tannins (411.667 ± 8.7 µg EC/ mg) in the kernel. Flavonoids are most abundant in the shell (238.385 ± 25.8 µg EC /g). The study of antioxidant potential using DPPH and FRAP methods revealed interesting antioxidant compounds in the various parts of the *D. guineense* fruit. These compounds could help to promote *D. guineense* fruit as a health food, offering an effective response to certain chronic diseases. We therefore encourage people to consume the whole fruit of *D. guineense* to reap its full benefits.

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