

Determination of the content of polyphenols, flavonoids, tannins, mineral elements and antioxidant activity of *Anacardium occidentale* (Anacardiaceae) almonds from central Côte d'Ivoire

ABSTRACT

Anacardium occidentale from the Anacardiaceae family, is a plant whose almonds have been widely consumed in Côte d'Ivoire in recent years. In addition, almonds are a matrix containing approximately 22-24% fat; which gives it great interest in terms of valorizing its nutritional properties. This is how the nuts were harvested at the beginning of 2023 in Sessenouan, a village in Bouaké, in central Côte d'Ivoire. The quantification of total polyphenols, total flavonoids, condensed tannins and mineral elements was done by classical dosage methods; As for the antioxidant activity of the almond extract, it was evaluated with respect to DPPH using vitamin C as a control. This study showed that the almonds of *Anacardium occidentale* (Anacardiaceae) from central Côte d'Ivoire contain appreciable levels of total polyphenols ($21,000 \pm 1,330 \mu\text{g EAG/g}$), total flavonoids ($36,000 \pm 2,660 \mu\text{g EQ/g}$), condensed tannins ($19.813 \pm 0.02 \mu\text{g EAT/g}$) and minerals: K ($458.61 \pm 1.01 \text{ mg/100g}$), Mg ($300.72 \pm 0.57 \text{ mg/100g}$), P ($142.51 \pm 0.15 \text{ mg/100g}$), Ca ($31.73 \pm 0.32 \text{ mg/100g}$). The analysis of these results indicates that the almonds of *Anacardium occidentale* from Côte d'Ivoire are a source of micronutrients and can therefore be used in both herbal medicine and human nutrition in our developing countries. Future work will focus on the chemical and physical properties of the fat extracted from the almonds.

Keywords: Anacardium occidentale, almond, micronutrients, mineral elements, Côte d'Ivoire.

1. INTRODUCTION

At all times and in all latitudes, agricultural practices have been the most important factor in spatial dynamics in rural areas [1]. The development of agro-industrial plantations coupled with its processing units consume space; which is not the case for the Western cashew tree. The cashew tree, *Anacardium Occidentale*, belongs to the Anacardiaceae family. It is native to the tropical regions of Brazil. The name cashew is said to be derived from the Tupi-Guarani (Indian tribe of Northeast Brazil) "acá-yu" which means yellow apple [2]. Its cultivation has developed in West Africa because of its great hardiness and its multiple products. The cashew tree was introduced in Côte d'Ivoire in response to the very advanced degradation of land due to deforestation [3]. Since 2008, the country has become the leading African exporter of raw cashew nuts [4]. And exports of raw cashew nuts represent 33.4% of total exports in 2012 [5]. In addition to the multiple uses of the fruits that are the cashew nut and apple, the plant provides a range of secondary products. Thus, the leaves are used as condiments and have certain therapeutic properties (fight against burns). The bark rich in tannin is used in tanning; it is used to prepare indelible inks and black powder. The wood, yellow to red in color, is used in cabinetmaking and the manufacture of boxes [2].

However, we note very little research work on *Anacardium occidentale* from Côte d'Ivoire, especially on the almonds of the plant. The objective of this work is part of the growing interest given to non-timber forest products by scientific research in recent years, with a view to their valorization. This study of the almonds of *Anacardium occidentale* from central Côte d'Ivoire highlights its richness in micronutrients, mineral elements and its antioxidant activity.

2. MATERIALS AND METHODS

2.1. Plant material

Cashew nuts were collected from fruits harvested in Bouaké, in central Côte d'Ivoire, precisely in the village of Sessenouan. After the nuts were collected in April 2023, they were then shelled and the almonds dried in an air-conditioned room (18°C) for 21 days, then stored in an oven (50°C) for 7 days in the laboratory of the Water and Natural Substances Chemistry Unit, Houphouët-Boigny National Polytechnic Institute (INPHB) in Yamoussoukro (Côte d'Ivoire).



Fig. 1. Nuts (A) and dried almonds (B) of *Anacardium occidentale* from Bouaké (Côte d'Ivoire) [Photos taken by Katou in 2023]

2.2 Analytical methods

2.2.1 Determination of mineral elements

2.2.1.1 Ash content

Seeds (mass $m = 0.4$ g) were incinerated for 8 h in an oven at 600°C until a constant mass (m') of white ash was obtained [6]. The ash content is calculated according to the equation.

$$\text{Teneurcendre} = \frac{m'}{m} \times 100$$

2.2.1.2 Mineral determination

The determination of mineral elements was carried out according to the IITA method [7,8]. To the plant ash obtained (0.4 g), 2 mL of concentrated hydrochloric acid (HCl) diluted by half were added. The whole was heated on a hot plate until dry, then placed in an oven (60°C) for 1 h. The dry residue was taken up in 2 mL of the same solvent, then filtered into a graduated flask (100 mL). Distilled water was added to the filtrate up to the gauge mark to constitute the standard solution. In a graduated flask (50 mL), to this solution (5 mL), 2 mL of lanthanum chloride (LaCl_3) were added, and the whole was made up to the gauge mark with distilled water. Minerals were assayed using an atomic absorption spectrophotometer (AAS 20, VARIAN type), at different wavelengths: 285.2 nm for K (Potassium); 213.9 nm for Ca (Calcium); 279.5 nm for Mg (Magnesium); 327.4 nm for P (Phosphorus); 248.3 nm for Fe (Iron).

2.2.2. Determination of total phenols

The amount of total phenols in the extracts is determined by the Folin-Ciocalteu colorimetric method. It is based on the oxidation of phenolic compounds by the Folin-Ciocalteu reagent in a basic medium [9,10]. The reduced blue products absorb at 760 nm, the intensity of which is proportional to the amount of total phenols present in the sample. To 1 mL of hydromethanolic extract diluted 1/10 with distilled water, 1.5 mL of Na_2CO_3 (17%, m/V) and 0.5 mL of Folin-Ciocalteu reagent (0.5N) are added. The whole is incubated at 37°C for 30 minutes. The absorbance is read at 720 nm against a blank without extract taken as a reference. Quantification of total phenols is performed based on the calibration line of gallic acid at different concentrations (0 to 1000 $\mu\text{g/mL}$) prepared under the same conditions. The results are expressed in microgram equivalent of gallic acid dry matter ($\mu\text{g EAG/g DM}$). The total phenol content (Q) is calculated according to the formula:

$$Q = \frac{(V \times C \times d)}{m} \text{ (en } \mu\text{g EAG/g MS)}$$

V: final volume of extract; C: concentration of extract ($\mu\text{g/mL}$); d: dilution; m: mass of dry hydrolyzed plant material (g).

2.2.3 Total flavonoids determination

The quantification of flavonoids was carried out according to the aluminum trichloride (AlCl_3) method described by Marinova et al., (2005) [11]. The principle of the method is based on the formation of a brownish complex between flavonoids and AlCl_3 ; this complex absorbs at 510 nm. Comparison of the observed absorbance with that of quercetin (standard) allows the total flavonoid content to be assessed. 1500 μL of distilled water and 150 μL of 5% NaNO_3 were added to 150 μL of hydro-ethanolic extract. After 5 min of rest in the dark, 150 μL of 10% AlCl_3 were added. The mixture was kept in the dark again for 11 min, then 500 μL of NaOH (1 M) was added. After stirring, the absorbance was read by UV-Visible spectrophotometer at 510 nm. A calibration line made from solutions of different concentrations of quercetin (0 to 50 $\mu\text{g/L}$) and carried out under the same operating conditions was used to quantify flavonoids. The results are expressed in micrograms of quercetin equivalent per gram of extract ($\mu\text{g EQ/g}$).

2.2.4 Determination of condensed tannins

The determination of condensed tannins was carried out according to the method described by Julkunen-Titto (1985) [12] slightly modified. To 400 μL of each sample, 3 mL of vanillin solution (4% in methanol) and 1.5 mL of concentrated HCl were added. The mixture was incubated for 15 min and the absorbance was read at 500 nm. The concentrations of condensed tannins were deduced from the calibration ranges established with catechin (0 – 300 $\mu\text{g/mL}$), and were expressed in micrograms of catechin equivalent per gram ($\mu\text{g CE/g}$) of extract.

2.2.5 Evaluation of antioxidant activity against DPPH.

The method used is that described by Wood et al., (2002) [13] which was modified in terms of concentrations for the determination of the antioxidant activity of plant extracts against DPPH (1,1-Diphenyl-2-picrylhydrazyl). DPPH is solubilized in absolute ethanol at 0.3 mg/mL , and the extracts are prepared in ethanol (EtOH) at concentrations 8; 4; 2; 1; 0.5; 0.25; 0.125 mg/mL . The reaction mixture used for the test, consisting of the extract (1 mL) and the DPPH dilution (2 mL) after shaking, is placed away from light for 30 min. The reaction mixture introduced into the tank of the UV-Visible spectrophotometer, the absorbance of which is read at 517 nm against a blank (prepared under the same conditions without DPPH). Vitamin C served as a reference. The percentage reduction of the DPPH radical is calculated according to the formula:

$$\% \text{ Réduction} = \frac{A_b - A_e}{A_b} \times 100$$

% Red: percentage reduction; A_b : absorbance of the blank; A_e : absorbance of the sample.

3. RESULTS AND DISCUSSION

3.1 Mineral content

Table 1 presents the mineral composition of *Anacardium occidentale* almonds from nuts harvested in the city of Bouaké, in central Côte d'Ivoire. Mineral elements are not synthesized by the body, so they must be provided regularly through our diet. They are irreplaceable micronutrients; in fact, their insufficient presence or excess leads to the appearance of specific pathologies [14].

Table 1. Mineral content of *Anacardium occidentale* kernels

Mineralelements	Almonds (Concentration in mg/100g)
Na	2,45 ± 0,12
K	458,61 ± 1,05
P	142,51 ± 0,15
Ca	31,73 ± 0,32
Mg	300,72 ± 0,57
Cu	1,83 ± 0,08
Fe	1,94 ± 0,09
Mn	0,51 ± 0,02
Zn	4,85 ± 0,26

Mean ± S.E.M = Mean values ± Standard error of means of three experiments

The values obtained in Table 1 clearly indicate the presence of essential minerals in the almonds of *Anacardium occidentale* from Bouaké, in central Côte d'Ivoire.

At the same time, when analyzing Table 2, which presents the comparative mineral composition of some oilseeds, it should be noted that the seeds of *Anacardium occidentale* from Côte d'Ivoire are an excellent source of potassium (458.61 ± 1.05 mg/100g); magnesium (300.72 ± 0.57 mg/100g) and phosphorus (142.51 ± 0.15 mg/100g). However, they are an average source of sodium (2.45 ± 0.12 mg/100g) and calcium (31.73 ± 0.32 mg/100g).

Table 2. Mineral composition of some oilseeds

Seeds	Mineral composition in mg/100g								
	Na	Ca	K	Mg	P	Zn	Fe	Mn	Cu
Anacardium occidentaleB ouaké (CI)	2,45±0,12	31,73±0,32	458,61±1,05	300,72±0,57	142,51±0,15	4,85±0,26	1,94±0,09	0,51±0,02	1,83±0,08
Anacardium occidentale Togo [15]	3,39-7,56	44,34-80,43	145,47-182,15	103,81- 249,80	139,61-164,00	4,39- 6,99	7,05-7,76	1,23-1,67	2,46-3,27

Parkiabioglobosa [16]	4,47	1,545	6,24	3,285	-	0,003	0,022	0,031	0,02
Griffoniasimplificifolia [17]	1,26	1,63	25,02	1,15	13,80	0,005	0,06	0,003	0,02
Myrianthus arboreus [8]	-	412-520	900-1031	287-350	290-430	0,72-1,03	1,73-2,9	0,55-1,3	-

3.2 Total phenol content

The polyphenol content of *Anacardium occidentale* from central Côte d'Ivoire is given in Table 3; its value is $21000 \pm 1330 \mu\text{g EAG/g}$ of DM. The total polyphenol content of the seeds is ($960 \mu\text{g EAG/g}$ of DM). Note that this family of secondary metabolites, widely distributed in the plant kingdom [18], provides the seeds with antioxidant power [19]. This rate could explain the anti-inflammatory and antioxidant power of the seeds. By comparing this value with that obtained for certain plants or plant organs recognized for their richness in phenolic compounds, including dates ($5660 \mu\text{g EAG/g}$) [20] and grape seeds ($7500 \mu\text{g EAG/g}$) [21], it is possible to affirm that *Anacardium occidentale* almonds from the center of Ivory Coast are very rich in phenolic compounds.

Table 3. Total polyphenol content of *Anacardium occidentale* from CI

	Value
experiment1	0,19
experiment 2	0,22
experiment 3	0,22
Mean	$0,21 \pm 0,0133$
Total polyphenols (g EAG/g)	$0,021 \pm 0,00133$
Total polyphenols ($\mu\text{g EAG/g}$)	21000 ± 1330

3.3 Total flavonoid content

Flavonoids occupy a prominent place in the group of phenols; they are secondary metabolites present in almost all organs of the plant (leaves, flowers, seeds, roots, etc.). And until recently, more than 4000 natural flavonoids have been described [22]. The average value of total flavonoids obtained after tests, presented in Table 4 is $36000 \pm 2660 \mu\text{g EQ/g}$ of dry matter.

Table 4. Total flavonoid content of *Anacardium occidentale* from CI

	Value
experiment 1	0,35
experiment 2	0,4
experiment 3	0,33
Mean	$0,36 \pm 0,0266$
Total flavonoids (g EQ/g)	$0,036 \pm 0,00266$
Total flavonoids ($\mu\text{g EQ/g}$)	36000 ± 2660

3.4 Condensed tannin content

The condensed tannin content is $19.83166 \pm 0.02444 \mu\text{g EAT/g DM}$ (Table 5). It is good to know that tannins exhibit the properties of vitamin P. They strengthen blood vessels and contribute to the

accumulation of vitamin C in the body. They are also anti-infectious [23, 24], prevent cardiovascular risks and are anticancer [25, 26].

Table 5. Total tannin content of *Anacardium occidentale* from CI

3.5 Antioxidant activity

The anti-radical capacity of the extracts of *Anacardium occidentale* almonds is indicated in Table 6. The studied extract presents an antioxidant profile; this antioxidant potential could be justified by the presence of several secondary metabolites in the almonds of *Anacardium occidentale* from Ivory Coast, because Silviya et al., (2010) [27] showed that the richer an extract is in polyphenols, its antioxidant power is high.

Table 6. Value of antioxidant activity of *Anacardium occidentale* of CI

	Value
experiment 1	0,5409
experiment 2	0,5394
experiment 3	0,5393
Mean	0,539866667
Inhibition (%)	21,96203142
Antioxidant Concentrations or Activity (μM eqTrolox)	2,20060435

However, the antioxidant activity of the almond extract which is 2.2 μM eqTrolox is low compared to the activity of the vitamin C control which is $A_o = 0.6918 \mu\text{M}$ eqTrolox.

4. CONCLUSION

This study showed that the almonds of *Anacardium occidentale* from the center of Ivory Coast are an excellent source of micronutrients, especially in view of the data obtained in polyphenols, flavonoids, tannins, macroelements and trace elements. In view of the mineral composition, the antioxidant activity, the almonds of *Anacardium occidentale* could be exploited both in therapeutics and in human nutrition.

DISCLAIMER

The authors hereby declare that NO generative artificial intelligence technology was used in the writing or editing of the manuscript.

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DEFINITIONS, ACRONYMS, ABBREVIATIONS

g: gram
mL: milliliter
MS: dry matter
DPPH: 1,1-diphenyl-2-picrylhydrazine
NaOH: sodium hydroxide
CI: Côte d'Ivoire