Evaluation of Nutritional and Antioxidant Properties of *Cola cordifolia* Seeds

ABSTRACT

Abstract: *Cola cordifolia* is a natural substance rich in nutrients and bioactive compounds. It is important to incorporate it into the diet to prevent certain metabolic diseases and to improve the nutritional and health status of populations. This study aimed to evaluate the nutritional and antioxidant properties of *C. cordifolia* seeds for their potential use in the dietary field. The seeds were fermented for 6 days and then sun-dried for 15 days. Nutritional and antioxidant properties were determined using referenced methods. Nutritional analysis showed that the seeds are rich in calcium (880 mg/100g), magnesium (600 mg/100g), iron (50 mg/100g), proteins (17.93%), and lipids (10.85%). Seeds exhibited significant levels of polyphenols (705.15 mg/100g), tannins (267.52 mg/100g), and flavonoids (20.17 mg/100g), with an antioxidant activity of 62.45% inhibition of DPPH. This study suggests that C. cordifolia seeds could be used as a dietary supplement to prevent metabolic diseases.

Keywords: Cola cordifolia, nutritional, antioxidant, dietary

1. INTRODUCTION

African populations are increasingly facing a resurgence of metabolic diseases such as cardiovascular diseases, cancer, and diabetes due to changes in dietary habits [1]. In response to this situation, there is a search for new sources of bioactive compounds in unconventional resources such as medicinal plants and fruits [2]. These unconventional resources serve as ingredients in diets and remedies for diseases [3, 4], and are used therapeutically by approximately 80% of the population in developing countries [5]. Among these unconventional resources is Cola cordifolia, a fruit species native to West Africa [6]. It contributes to meeting the primary needs of populations by providing food and medicinal products. Medicinally, the bark and leaves are used to treat pain, fever, diarrhea, and wounds [7, 8]. The leaf sap is used in the treatment of leprosy and ocular conditions [9]. In terms of diet, fresh leaves and small branches are consumed as a diuretic [9], and the fruit pulp is highly valued for its sweet taste and high vitamin C content [10]. Despite existing research on the use of leaves and bark in treating certain diseases, there is a lack of scientific data on the nutritional and antioxidant profile of Cola cordifolia seeds. Therefore, the objective of this study is to evaluate the nutritional and antioxidant properties of Cola cordifolia seeds with a view to their utilization in the food and dietary sectors.

2. MATERIAL AND METHODS

2.1 Material

2.1.1 Biological material

Biological material used in this study consists of Cola cordifolia fruits collected from the botanical garden of the Université Peleforo Gon Coulibaly in Korhogo.

Figure 1: *Cola cordifolia* Fruits and Seeds

2.1.2 Chemical product

Reagents and chemicals used in this study are of analytical grade. Vanillin, methanol, sodium carbonate, potassium acetate, and Folin-Ciocalteu reagent were obtained from Sigma. Hexane, tannic acid, quercetin, and phytic acid were sourced from Sharlau.

2.2 Methods

2.2.1 Sample Treatment

Sample treatment was performed according to the method described by [11]. Cola cordifolia fruits were manually opened, and the seeds were separated from the shells. Seeds were fermented for 6 days on banana leaves, with mixing occurring every 2 days. After fermentation, the seeds were sun-dried for 8 days, then hulled and ground using an electric grinder (Stainless Steel). Ground material was sieved through a 10 µm mesh, and the flour was stored in a plastic container at 4°C.

2.2.2 Determination of Nutritive Properties

2.2.2.1 Moisture

Moisture content was determined using the method described in [12]. 5 g of flour were weighed in a pre-weighed capsule. Sample was then dried at 105 ± 2°C for 24 hours until a constant weight was achieved. After 24 hours, the capsule was removed from the oven and cooled in a desiccator. Capsule and sample were weighed, and the following expression was used to determine moisture content:

$$\text{Moisture (\%)} = \frac{m_1 - m_o}{m_e} \times 100$$

m_1 : mass of capsule + sample before drying
m_2 : mass of capsule + sample after drying
m_e : mass of flour

2.2.2.2 Ash

Ash content was determined using the method described in [12]. 5 g of flour were weighed in a pre-weighed crucible. Sample was incinerated in a muffle furnace at 550 ± 15°C for 12 hours. After incineration, the crucible containing the ash was cooled in a desiccator. Crucible and ash were weighed, and the following expression was used to determine ash content:

$$\text{Ash (\%)} = \frac{m_1 - m_o}{m_e} \times 100$$

m_0 : mass of capsule
m_2 : mass of capsule + ash
m_e : mass of flour

2.2.2.3 Proteins

Protein content was determined using the method described in [12]. 1 g of flour was mineralized in a flask with 20 mL of concentrated sulfuric acid at 400°C for 2 hours, in the presence of a mineralization catalyst (potassium sulfate + selenium). After mineralization, the digest was transferred to a flask containing a small amount of water and made up to 100 mL with distilled water. To 10 mL of the diluted digest, 10 mL of 40% NaOH was added, and the mixture was distilled for 10 minutes, capturing the distillate in a flask containing 20 mL of 4% boric acid with a mixed indicator (methyl red + bromocresol green). Distillate was titrated with 0.1 N sulfuric acid until the color turned orange. The following expression was used to calculate the protein content.

$$\text{Proteins (\%)} = \frac{(V_1 - V_o) \times 14 \times 6.25 \times N}{m_e}$$

2.2.2.4 Lipids

Lipids content was assessed using the method described in [13]. 10 g of flour were weighed into a pre-weighed cellulose extraction capsule. Capsule containing the flour was plugged with cotton and placed in a Soxhlet extractor. Extraction was performed using 300 mL of hexane in reflux for 7 hours. After extraction, the hexane was evaporated using a rotary evaporator, and the pre-weighed extraction flask containing the oil was dried in an oven at 100°C for 20 minutes. The flask and oil were then cooled in a desiccator and weighed. The following expression was used to calculate the lipid content:

$$\text{Lipids (\%)} = \frac{m_1 - m_o}{m_e} \times 100$$

m_0: mass of empty flask
m_1 : mass of flask + oil
m_e : mass of flour

2.2.2.5 Carbohydrate

Carbohydrates and energy value were calculated using the method described in [14]. This method considers moisture, ash, lipid, and protein contents, as well as energy coefficients.

Carbohydrates (%) = 100 – [moisture (%) + lipids (%) + proteins (%) + ash (%)]
Energy value (kcal/100g) = 4 × proteins (%) + 9 × lipids (%) + 4 × carbohydrates (%)

2.2.2.6 Mineral

Mineral content was quantified using the method described in [15]. This method employs argon plasma source ionization mass spectrometry. 0.25 g of ash from the flour was homogenized in 10 mL of a 50% hydrochloric acid and 50% nitric acid mixture. The resulting mixture was filtered, and the volume was adjusted to 100 mL with demineralized water. Quantitative analysis was performed using standard solutions of minerals.

2.2.2.7 Oxalates

Oxalate content was determined using the method of [16]. 1 g of flour was homogenized in 75 mL of 3 M sulfuric acid. The mixture was stirred for 1 hour using a magnetic stirrer. After stirring, the mixture was filtered, and 25 mL of the filtrate were titrated hot with 0.05 M potassium permanganate solution until a pink endpoint was reached. The following expression was used to determine oxalate content:

$$\text{Oxalates (mg/100g)} = \frac{2.2 \times V}{m_e} \times 100$$

V: volume of burette discharge
me: mass of flour

2.2.2.8 Phytates

Phytate content was evaluated using the method described in [17]. 1 g of flour was homogenized in 20 mL of 0.65 N hydrochloric acid. Mixture was stirred for 12 hours and then centrifuged at 1200 rpm for 40 minutes. To 0.5 mL of the supernatant, 3 mL of Wade reagent was added, and the mixture was allowed to rest for 15 minutes. Optical density was read at 490 nm against a blank. Phytate content was determined using a standard curve of sodium phytate solution at 1 mg/mL.

2.2.3 Determination of antioxidant Properties

2.2.3.1 Extraction of Phenolic Compounds

Phenolic compounds were extracted using the method described in [18]. 1 g of flour was homogenized in 10 mL of 70% methanol. Mixture was centrifuged at 1000 rpm for 10 minutes. Supernatant was collected in a 50 mL flask, and the residue was re-extracted with 10 mL of 70% methanol and centrifuged again. The combined supernatants in the 50 mL flask were adjusted to 50 mL with distilled water.

2.2.3.2 Phenolic Compounds

Phenolic compounds were quantified using the method described in [18]. To 1 mL of phenolic extract, 1 mL of Folin-Ciocalteu reagent and 1 mL of 20% sodium carbonate were added successively. The volume of the mixture was adjusted to 10 mL with distilled water. After 30 minutes of incubation in the dark, optical density was measured at 725 nm against a blank. Total phenol content was determined using a standard curve of gallic acid solution at 1 mg/mL

2.2.3.3 Tannin

Tannins were quantified using the method described in [19]. To 1 mL of phenolic extract, 5 mL of 0.1 mg/mL vanillin reagent was added. Mixture was allowed to stand in the dark for 30 minutes. After incubation, optical density was measured at 500 nm against a blank. Tannin content was determined using a standard curve of tannic acid at 1 mg/mL.

2.2.3.4 Flavonoids

Flavonoids were determined using the method described in [20]. To 0.5 mL of phenolic extract, 0.5 mL of distilled water, 0.5 mL of 10% aluminum chloride, 0.5 mL of 1 M sodium acetate, and 2 mL of distilled water were added successively. Mixture was left at room temperature for 30 minutes, and optical density was measured at 415 nm against a blank. Flavonoid content was determined using a standard solution of quercetin at 0.1 mg/mL.

2.2.3.5 Antioxidant activity

Antioxidant activity was determined using the method described in [21]. To 2.50 mL of phenolic extract, 1 mL of 3 mM DPPH solution was added. Mixture was incubated in the dark for 30 minutes, and optical density was measured at 415 nm against a blank. A control tube (2.5 mL methanol + 1 mL DPPH) was prepared under the same conditions as the test. The following expression was used to determine antioxidant activity

$$\text{Antioxidant activity (\%)} = \frac{[\,DO_c - (DO_e - DO_b)]}{DO_c} \times 100$$

DOc: absorbance of control tube (1 mL DPPH + 2.5 mL methanol)
DOe : absorbance of test tube (1 mL DPPH + 2.5 mL phenolic extract in methanol)
DOb : absorbance of blank tube (1 mL methanol + 2.5 mL phenolic extract in methanol)

2.2.3 Statistical analyzis

All tests were performed in triplicate, and results were expressed as mean ± standard deviation. Analysis of variance (ANOVA) was performed using StatPlus 2009 software. Fisher's test at a 95% confidence level was used to determine significant differences between means.

3. RESULTS AND DISCUSSION

3.1 Nutritional properties

Figure 2: Dried, dehulled, and ground seeds of *C. cordifolia*

Table 1 presents biochemical properties of *Cola cordifolia* seeds. Biochemical parameters are statistically different at the 5% significance level. The moisture content of the seeds is 14.46 ± 0.30%. This value is higher than those recorded by [22] for shea cake (12.18%), cotton seeds (9.71%), and mango kernel seeds (9.23%), but lower than those of [23] for dried mango peels (14.55%) and dried cashew apple cake (25.33%). These observed differences may be due to methods and drying times. Low moisture content of the studied seeds could be advantageous for long-term storage, as it would reduce microbial development [24]. Regarding ash content, the value obtained is 3.38 ± 0.02%. This value is significantly higher than those found by [25] in baobab pulp (2.98 to 3.06%) but lower than those of [26] in cocoa pods from three varieties (6 to 9.40%). Seeds studied may contain appreciable amounts of minerals, as ash represents the total mineral content of the sample. For proteins, the seeds contain 17.93%, compared to [27], who reported a value of 28.60% in fermented *Parkia biglobosa* seeds. Seeds studied could be considered a significant source of protein, as their content exceeds 12% [28]. Additionally, the protein content of these seeds is similar to that of chickpeas (18%) [14]. Thus, *Cola cordifolia* seeds could be used in the food industry as supplements in the preparation of infant porridges to prevent protein-energy malnutrition in children [29]. Lipid content of the seeds is 10.85%, which is lower than that recorded by [30] for Kent (21.54%) and Keitt (18.74%) mango seed kernels but higher than that of [31] for voandzou seeds (7.77%). Seeds studied could be considered a notable source of lipids. A biochemical characterization of this fat could reveal potential uses in food or cosmetics. *Cola cordifolia* seeds (53.38%) cannot be considered a significant source of carbohydrates compared to starchy products (70%) [32]. These low total carbohydrate and lipid contents explain the lower energy value (382.69 Kcal/100g) compared to [27] and [33], who reported 503 and 471.75 Kcal/100g in *Parkia biglobosa* seeds.

Table 1. Biochemical Composition of *Cola cordifolia* Seeds

Parameters	Quantity
Moisture (%)	14.46 ± 0.30d
Ash (%)	3.38 ± 0.02f
Proteins (%)	17.93 ± 0.11c

Lipids (%)	10.85 ± 0.14e
Carbohydrates (%)	53.38 ± 0.84b
Energy value (Kcal/100g)	382.69 ± 1.32a

Values in the table are means of the tests with standard deviations. Statistical differences between these means at a 95% confidence level are indicated in the column by different letters a, b, c, d, e, and f.

Mineral composition is presented in Figure 2. Seeds contain significant amounts of calcium (880 mg/100g), magnesium (600 mg/100g), phosphorus (254 mg/100g), potassium (1233 mg/100g), and iron (50 mg/100g). Calcium, magnesium, and phosphorus contents of the studied seeds are considerably higher than those of [27] in soumbara, with values of 15.45 and 32.35 mg/100g for calcium and magnesium, respectively, and [22] in shea cake (Ca: 154 mg; Mg: 67 mg; P: 24 mg). Consumption of 100 g of *C. cordifolia* seeds could cover the daily requirements for calcium and magnesium, estimated at 800 mg and 400 mg, respectively, but not phosphorus (800 mg) [34, 35]. These minerals are involved in bone and tooth formation, muscle contraction, cellular energy production, and blood pressure regulation [36, 37]. Seeds studied could be used as an ingredient in infant formula. Potassium is the predominant mineral. Its presence could be beneficial to consumers, as it plays a role in regulating blood pressure, the proper functioning of the nervous system, and muscle activity [38, 39]. Iron content of the seeds (50 mg/100g) could largely cover the daily iron requirement estimated at 8 mg [34]. This richness in iron could be used in food formulations in Africa to prevent anemia caused by malaria and immune deficiencies [40].

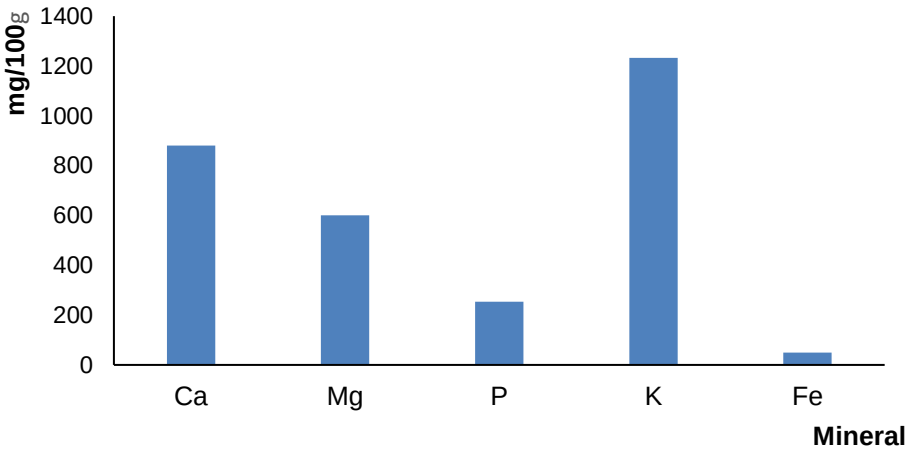

Figure 3: Mineral Composition of *Cola cordifolia* Seeds

Table 2 presents the anti-nutritional factors and the ratios of anti-nutritional factors to minerals. Oxalate and phytate contents of the studied seeds are 332.50 mg/100g and 20.78 mg/100g, respectively. These oxalate and phytate levels are significantly lower than those reported by [41] for dried *C. sesamoides* leaves (oxalates: 480 mg/100g; phytates: 27 mg/100g) and *L. hastata* (oxalates: 750 mg/100g; phytates: 24 mg/100g). Oxalates and phytates are anti-nutritional factors that can reduce the bioavailability of essential minerals such as calcium and iron [42]. To predict the bioavailability of calcium and magnesium, the oxalate/Ca, phytate/Ca, and phytate/Fe ratios were calculated. Oxalate/Ca ratio (0.37) is well below the threshold of 2.5, suggesting that oxalates may not significantly impact calcium bioavailability. Similarly, the phytate/Ca ratio (0.02) is below the threshold of 0.5 [42]. However, the phytate/Fe ratio (0.41) exceeds the norm of 0.4, which could affect iron bioavailability. Thermal treatments of the seeds may be beneficial to reduce phytate levels and improve iron bioavailability [43].

Table 2. Anti-Nutritional Factors in *C. cordifolia* Seeds

Parameters	Values
Oxalates (mg/100 g)	332.50 ±3.53a
Phytates (mg/100g)	20.78 ±0.47b
Oxalates / Ca	0.37
Phytates / Ca	0.02
Phytates / Fe	0.41

Values in the table are means of the tests with standard deviations. Statistical differences between these means at a 95% confidence level are indicated in the column by different letters a and b.

3.2 Antioxidant properties

Table 3 shows the antioxidant properties of *C. cordifolia* seeds. Levels of polyphenols, tannins, and flavonoids are statistically different ($p < 0.05$). Contents are 705.15 mg/100g for polyphenols, 267.52 mg/100g for tannins, and 20.17 mg/100g for flavonoids. Seeds studied exhibit a DPPH inhibition percentage of 62.45%. Polyphenol and tannin levels in the seeds are significantly higher than those reported by [26], who recorded polyphenol values ranging from 176.90 to 301.40 mg/100g and tannin values between 5.90 and 21.80 mg/100g in the placenta of three cocoa varieties. However, the polyphenol and flavonoid levels are lower than those found by [44] in dried *C. sesamoides* leaves (1100 mg/100g and 81.12 mg/100g). Consumption of *C. cordifolia* seeds could be beneficial to consumers, as polyphenols protect the body against free radicals responsible for cellular aging and cardiovascular diseases [45]. Additionally, flavonoids are powerful antioxidants that combat oxidative stress [46]. Tannins present in the seeds could also protect consumers against free radicals, as tannins have antioxidant activity [47].

Table 3. Antioxidant Compounds in *C. cordifolia* Seeds

Parameters	Values
Polyphenols (mg/100g)	705.15 ± 0.19a
Tanins (mg/100g)	267.52 ± 0.78b
Flavonoids (mg/100g)	20.17 ± 0.29c
Antioxidant activity (%)	62.45 ± 0.45

Values in the table are means of the tests with standard deviations. Statistical differences between these means at a 95% confidence level are indicated in the column by different letters a, b, and c.

4. CONCLUSION

This study was conducted to evaluate the nutritional and antioxidant properties of Cola cordifolia seeds. The results indicate that the studied seeds are significant sources of proteins, lipids, and minerals. Additionally, the study revealed that these seeds are rich in polyphenols and possess a noteworthy DPPH inhibition percentage. Cola cordifolia seeds could be utilized in food formulations to contribute to food security and to prevent certain metabolic diseases.

REFERENCES

[1] Aseervatham GS, Sivasudha T, Jeyadevi R, Arul AD. Environmental factors and unhealthy lifestyle influence oxidative stress in humans—an overview. Environmental Science and Pollution Research. 2013: 20(7): 4356-4369.

[2] Liu Z, Mo K, Fei S, Zu Y, Yang L. Efficient approach for the extraction of proanthocyanidins from Cinnamomum longepaniculatum leaves using ultrasonic irradiation and an evaluation of their inhibition activity on digestive enzymes and antioxidant activity in vitro. Journal of Separation Science. 2017: 40(15): 3100-3113.

[3] Goly C, Soro Y, Kassi B, Dadié A, Soro S, Djé M. Antifungal activities of the essential oil extracted from the tea of savanna (Lippia multiflora) in Côte d'Ivoire. International Journal of Biological and Chemical Sciences. 2015: 9(1): 24-34.

[4] Coulibaly O, Ira B, Soro Y, Dosso M, Touré A, Yapo-Crezoit C. Antifungal activities of hydroalcoholic extract fractions of Hugonia platysepala on opportunistic pathogens of HIV/AIDS. Phytotherapy. 2019: 1-7.

[5] WHO. Essential medicines and pharmaceutical policies: supporting countries to reduce medicine access shortages. Annual Report. (2003): Geneva, 20 p.

[6] AFTD (2021). Available at: http://www.worldagroforestry.org/treeDBS/AFT/Speciesinfo.cfm?spID=17999, 2021 (accessed April 15, 2024).

[7] Diallo D, Sogn C, Samake FB, Paulsen BS, Michaelsen TE, Keita A. Wound Healing Plants in Mali, the Bamako Region. An Ethnobotanical Survey and Complement Fixation of Water Extracts from Selected Plants. Pharmaceutical Biology. 2002: 40: 117-128.

[8] Togola A, Naess KH, Diallo D, Barsett H, Michaelsen TE, Berit SP. A polysaccharide with 40% mono-O-methylated monosaccharides from the bark of Cola cordifolia (Sterculiaceae), a medicinal tree from Mali (West Africa). Carbohydrate Polymers. 2008: 73: 280-288.

[9] Tom EG, Silje G, Mona S, Ngolo B, Sekou B, Drissa D, Berit SP. Ethnopharmacological survey of six medicinal plants from Mali, West Africa. Journal of Ethnobiology and Ethnomedicine. 2008: 4(26): 1-11.

[10] Diop PA, Franck D, Grimm P, Hasselmann C. High-performance liquid chromatographic determination of vitamin C in fresh fruits from West Africa. Journal of Food Composition and Analysis. 1988: 1: 265-269.

[11] Gbrogbri GF. Impact of fermentation on antioxidant, anti-inflammatory, and immunomodulatory properties of cocoa. PhD Thesis. 2019: 210 p.

[12] AOAC. Official Methods of Analysis. Association of Official Analytical Chemists Ed., Washington DC. 1990: 684 p.

[13] AFNOR. Recueil de Norme Française, fats, oilseeds, derived products. AFNOR Ed., Paris. 1986: 527 p.

[14] FAO. Food energy-methods of analysis and conversion factors. FAO Ed., Rome. 2002: 97 p.

[15] CEAEQ. Mineral determination. Argon plasma spectrometry method, MA 200 – Met 1.2, Rev 4. Quebec. 2013: 24 p.

[16] Day RA, Underwood AL. Quantitative Analysis (5th ed.). Prentice Hall. 1986: 701 p.

[17] Latta M, Eskin M. A simple method for phytate determination. Journal of Agricultural and Food Chemistry. 1980: 28: 1313-1315.

[18] Singleton VL, Orthofer R, Lamuela-Raventos RM. Analysis of total phenols and other oxidant substrates and antioxidants by means of Folin-Ciocalteu reagent. Methods in Enzymology. 1999: 299: 152-178.

[19] Bainbridge Z, Tomlins K, Westby A. Analysis of condensed tannins using acidified vanillin. Journal of the Science of Food and Agriculture. 1996: 29: 77-79.

[20] Meda A, Lamien CE, Romito M, Millogo J, Nacoulma OG. Determination of total phenolic, flavonoid, and proline contents in Burkina Faso honeys and their radical scavenging activity. Food Chemistry. 2005: 91: 571-577.

[21] Choi CW, Kim SC, Hwang SS, Choi BK, Ahn HJ, Lee MZ, Park SH, Kim SK. Antioxidant activity and free radical scavenging capacity between Korean medicinal plants and flavonoids by assay-guided comparison. Plant Science. 2002: 163: 1161-1168.

[22] Bamba, R., Toure, N., Kone, F.M.T., & Toure, A. (2023). Biochemical characteristics of some agricultural by-products from Côte d'Ivoire for poultry feed utilization. Journal of Animal & Plant Sciences. 2023 : 58(2) : 10701 -10712.

[23] Guehi MS, Toure A, Zoro AF, Boni AP, N'guessan KR, Toure N, Kabran AF, Kablan ALC, Coulibaly A. Physicochemical and nutritional characterization of flours from cashew apple, Kent mango peelings and kernel almonds collected in Korhogo city (Northern Ivory Coast). GSC Biological and Pharmaceutical Sciences. 2023: 22(1): 048–055.

[24] Ates S, Dingil N, Bayraktar E, Mehmetoglu U. Enhancement of citric acid production by immobilized and freely suspended Aspergillus niger using silicone oil. Process Biochem. 2002: 38: 433–436.

[25] Kodjo NF, Silué PA, Zoro AF. Variabilités des caractères morphologiques et biochimiques des fruits de Adansonia digitata L., issus des zones agroclimatiques en Côte d'Ivoire. International Journal of Innovation and Applied Studies.2022: 37(3): 650-658.

[26] Zoro AF, Oussou KF, Touré A. Nutritive and Antioxidant Properties of Cocoa Placenta Obtained from Cocoa Varieties Grown in Lodjiboua (Côte d'Ivoire). Asian Journal of Advances in Agricultural Research. 2023: 22(1): 38-45.

[27] Cissé I, Koffi NE, Niamketchi GL, Dembélé S, Kouadio KB, Anin AL. Composition phytochimique et nutritionnelle des graines fermentées de Parkia biglobosa issues du Nord de la Côte d'Ivoire. Journal of Applied Biosciences. 2021: 168: 17507 – 17519.

[28] Pearson D. Chemical Analysis of Foods, 7è Ed., Churchill Livingstone Publication. 1976: 422-511.

[29] Hsairi M, Gargouri L, Safi F, Elleuch A, Mahfoudh E. Dénutrition protéino- énergétique chez l'enfant. Journal de l'information médical de SFAX.2021 : 37 : 10-16.

[30] Boni AP, Toure A, Kablan ALC, Zoro AF, Zoue LYT. Sensory, Micrographic and Physico-chemical Characterization of Kernel Almond Flour of Two Varieties of Mangoes Grown in Northern Côte d'Ivoire. European Journal of Agriculture and Food Sciences. 2022: 4(5): 48–53.

[31] Diallo KS, Soro D, Kone KY, Assidjo NE, Yao KB, Gnakri D. Fortification et substitution de la farine de blé par la farine de Voandzou (Vigna subterranea L. verdc) dans la production des produits de boulangerie. International Journal of Innovation and Scientific Research. 2015: 18(2): 434-443.

[32] Cheftel JC, Cheftel H. Introduction à la biochimie et à la technologie des aliments. Technique et Documentation Ed., Paris. 1984 : 380 p.

[33] Ndamitso MM, Musah M, Mathew JT, Bissala VT. Comparative nutritional analysis of Daddawa made from fermented Parkia biglobosa and Glycine max seeds. Communication in Physical Sciences. 2020: 5(3): 263-269.

[34] FAO. Human vitamin and mineral requirements. FAO Ed. Rome, Italy. 2004.

[35] Rude RK, Singer FR, Gruber HE. 2009. Skeletal and hormonal effects of magnesium deficiency. Journal of the American College of Nutrition. 2009 : 28(2) : 131-141.

[36] Depezay L. Les légumes dans l'alimentation: leurs effets nutritionnels. Fondation Louis Bonduelle Ed. 2006 : 7 p.

[37] Baudet M, Daugareil C, Ferrieres J. Prévention des maladies cardiovasculaires et règles hygiénodiététiques. Annales de Cardiologie et d'Angéiologie. 2012 : 61(2) : 93-98.

[38] Houston MC. The importance of potassium in managing hypertension. Current Hypertension Report. 2011 : 13 : 309-317.

[39] Besnier F. Modulation du système nerveux autonome et de l'architecture cardiaque par l'activité physique dans le traitement de l'insuffisance cardiaque chronique. Thèse de Doctorat. 2018 : 268 p.

[40] Akindahunsi AA, Salawu SO. Phytochemical screening and nutrientantinutrient composition of selected tropical green leafy vegetables. Afr. J. Biotechnol. 2005: 4: 497-501.

[41] Coulibaly TA, Touré A, Zoro AF, Kablan ALC, Méité S, Coulibaly A. Effect of Three Drying Modes on Nutritive and Antinutritive Properties of Leafy Vegetables Consumed in Northern Côte d'Ivoire. EAS Journal of Nutrition and Food Sciences. 2022 : 4(4) : 102-111.

[42] Hassan LG, Umar KJ, Dangoggo SM, Maigandi AS. Antinutrient composition and bioavailability prediction as exemplified by calcium, iron and zinc in Melocia corchorifolia leaves. Pak. J. Nutr. 2011: 10: 23-24.

[43] Bhandari MR, Kawabata J. Assessment of antinutritional factors and bioavailability of calcium and zinc in wild yam (Dioscorea spp.) tubers of Nepal. Food Chem. 2004: 85: 281 – 287.

[44] Coulibaly TA, Méité S, Touré A, Zoro AF, Kablan ALC, Coulibaly A, Djaman AJ. Effect of different drying methods on the antioxidant properties of 4 leafy vegetables consumed in Northern Côte d'Ivoire. European Journal of Pharmaceutical and Medical Research. 2023: 10(1): 23-30.

[45] Deghal L, Derradji S. Étude de l'effet antioxydant des polyphénols extraits de la tomate commerciale. Mémoire de Master en Agronomie. 2018 : 66 P.

[46] Adriouch S, Kesse-Guyot E, Hercberg S, Touvier M, Fezeu LK. Association entre les apports en polyphénols et le risque de maladies cardiovasculaires : résultats d'une étude prospective sur 84 000 adultes français. Nutrition Clinique et Métabolisme. 2017 : 31(3) : 238p.

[47] Haddouchi F, Chaouche TM, Halla N. 2016. Screening phytochimique, activités antioxydantes et pouvoir hémolytique de quatre plantes subsahariennes d'Algérie. Phytothérapie. 2016 : 16 : S254-S262.