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Physical, chemical, and nutritional characterization of false Kinkeliba seeds (*Senna occidentalis* L.) from Korhogo (Côte d'Ivoire)

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Abstract

False kinkeliba is a wild plant with numerous pharmacological properties, whose seeds can be processed into a coffee substitute. The aim of this study was to promote Ivorian agricultural resources by characterizing *Senna occidentalis* L. seeds. To this end, the physical, chemical, and nutritional parameters of the seeds were determined using conventional methods. Results showed that *Senna* seeds were rich in minerals such as calcium (4110.72 mg/kg), potassium (953.657 mg/kg), magnesium (286.538 mg/kg), phosphorus (209.902 mg/kg), sodium (197.701 mg/kg), zinc (56.252 mg/kg), and iron (12.236 mg/kg). The macronutrients present were total carbohydrates (79.57%), crude fiber (23.11 ± 0.68%), lipids (3.28 ± 0.09%), and proteins (3.09 ± 0.21%). Seeds had an energy value of 360.16 kcal, an ash content of (7.31 ± 0.04%), titratable acidity of 7.14 ± 0.12 g/100 mL with a slightly acidic pH (6.20 ± 0.005), water content of 6.75 ± 0.2%, and dry matter content of 93.25 ± 0.2%. The sizes were 11.06 ± 1.64 cm for the pods and 0.3 ± 0.1 cm for the seeds. Given the high nutrient content of the seeds, consuming them could be beneficial for the body.

Keywords: False kinkeliba; *Senna occidentalis*; Physical; Chemical; Nutritional Characteristics; Korhogo

1. Introduction

Plant resources form an important part of the biological biodiversity of many African countries. There is a wide variety of wild plants [1, 2] used for therapeutic, food, cosmetic, economic, or social purposes. Among these plants is the false kinkeliba (*Senna occidentalis* L. (syn. *Cassia occidentalis* L.)), also known as coffee grass, which is an herbaceous or shrubby perennial plant that can grow up to 1.5 meters tall. The plant produces yellow flowers grouped in clusters, followed by flat, elongated pods. It is considered a common weed in many regions, particularly tropical and subtropical areas [3].

Senna occidentalis L. is native to the humid and warm regions of America and has become naturalized in Australia, the southern and eastern United States, and East Africa [4].

It is known by various common names, such as negro coffee, stinking herb, false kinkeliba, coffee 'senna' etc. [5, 6]. In Côte d'Ivoire, it is found under various names such as: gbébé n'dé (Abbey); m'bêchilê gnilêté (Attié); badja (Malinké); alouklou-sêrê-sêrê, sango-sêrê-sêrê (Baoulé); sêrê-noumbrou (Orodougou) [6].

Senna occidentalis L. contains secondary metabolites such as polyphenols, flavonoids, tannins, terpenes, glycosides, and alkaloids, which have antioxidant, antihyperglycemic, and antimicrobial properties [7, 8, 9] that are beneficial to health. Its leaves, stems, and roots are widely used in traditional medicine to treat urinary tract and liver disorders and

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influenza. They are also used as a laxative, analgesic, and vermifuge. Sometimes the seeds are roasted and used to prepare coffee-like beverages (coffee substitute) [10, 11].

Several studies highlighting the physicochemical, phytochemical, nutritional, and pharmacological properties of false kinkeliba (*Senna occidentalis* L.) have been conducted in several countries [10, 12, 13], particularly in Côte d'Ivoire [14, 6]. However, little data exists on the characterization of *Senna occidentalis* L. seeds in Côte d'Ivoire, which justifies the choice of topic for this study.

This work, carried out in the city of Korhogo, contributes to the promotion of agricultural resources in Côte d'Ivoire. In particular, it aims to highlight the physical, chemical, and nutritional characteristics of *Senna occidentalis* L. seeds.

2. Material and methods

2.1. Plant material

The material used consists of the seeds of the false kinkeliba (*Senna occidentalis* L.) (Figure A). The pods (Figure B) containing the seeds (Figure C) were harvested dry and ripe in the town of Korhogo, located in northern Côte d'Ivoire, at 9° 27′ 41″ north and 5° 38′ 19″ west. The seeds, stripped of their husks, were left to dry in the sun (at an average temperature of 35°C) for a whole day and then stored in hermetically sealed containers away from moisture. For analysis, the seeds were ground into powder using an AGIZSTAR AG-06 grinder (made in South Africa) and then passed through a 1 mm diameter sieve.

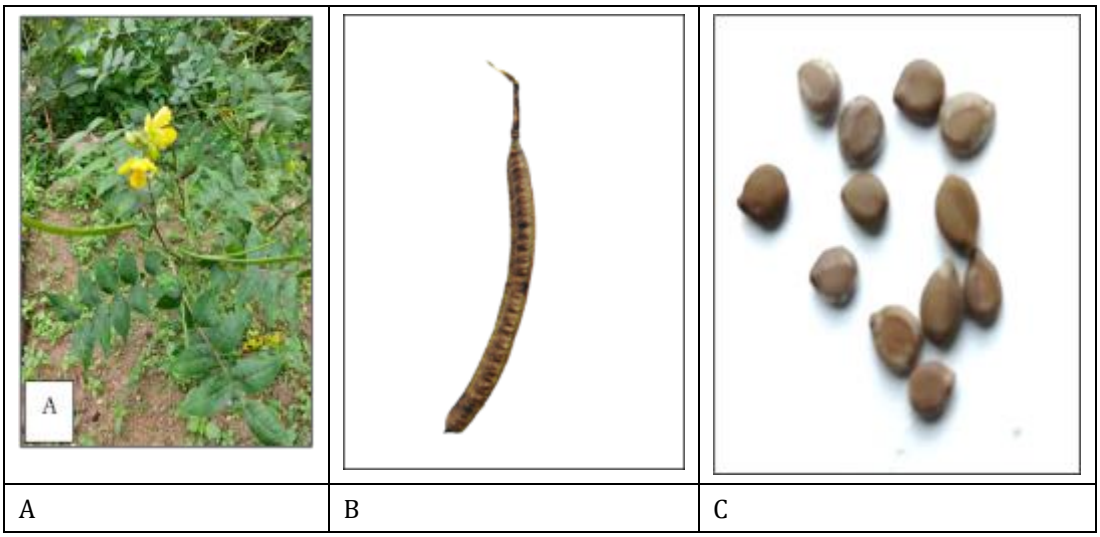

Figure 1 A-plant, B-pod, and C-seeds of *Senna occidentalis* L.

2.2. Methods

2.2.1. . Determination of physical and chemical characteristics (pods and seeds size, moisture content, dry matter, titratable acidity, pH)

The size of the pods and seeds of false kinkeliba was determined using a ruler. Due to their curvature, the pods were first measured using a string whose length was determined with the ruler. The seeds were measured directly with the ruler from the pointed end to the opposite end. Eighty pods and eighty seeds were used for this purpose.

The moisture and dry matter content of the seeds was determined by weight loss according to the method described in French standard [15]. A dry porcelain crucible of mass M_0 containing a mass M_1 of sample was placed in an oven at 105°±5°C for 24 hours. The crucible was then removed, allowed to cool in a desiccator, and weighed to give mass M_2.

The dry matter (% DM) was obtained using following equation:

$$\%DM = \frac{M2-M0}{M1} \times 100 \quad (1)$$

The moisture content (% H) was obtained using following expression :

$$\%H = \frac{M0+M1-M2}{M1} \times 100 \quad (2)$$

The titratable acidity was determined by an acid-base titration according to the method described by [16]. In the presence of phenolphthalein, 10 mL of aqueous sample extract contained in the Erlenmeyer flask was titrated with a sodium hydroxide solution (0.1 N). The solution's change to pink allowed the volume of soda required to neutralize the titratable acidity in the sample to be determined. The titratable acidity level was obtained in g.100 mL^{-1} according to formula (3) :

$$\text{titratable acidity} = \frac{N\ NaOH \times V\ NaOH \times 0,9}{V} \times 100 \quad (3)$$

V NaOH = volume of sodium hydroxide required for titration in mL
N NaOH = normality of the sodium hydroxide solution in meq-g/L
V = volume of the test sample in mL
0.9 = milliequivalent gram of lactic acid

The pH was determined using the potentiometric method with a pH meter (METTLER TOLEDO). Ten milliliters (10 mL) of the supernatant previously obtained from the aqueous extract was used to measure the pH. After calibration, the pH value was read directly on the pH meter display.

2.2.2. Determination of macronutrients (protein, fat, ash, crude fiber, total carbohydrates) and calculation of energy value

The crude fiber content of the samples was determined according to the method described in [17]. This method consists of treating 2 g of sample by boiling for 30 min with 50 mL of 0.25 N sulfuric acid and then with 50 mL of 0.31 N soda. The residue obtained was dried at 105°C for 8 hours and weighed (M_1), then calcined at 550°C in a muffle furnace (Nabertherm, Germany), preheated to 550°C for 3 hours, and the ashes were weighed (M_2).
The crude fiber content was given by the following equation :

$$F\ (g/100\ g\ of\ DM) = \frac{M_1-M_2}{P} \times 100 \quad (4)$$

F: crude fiber content
M_1: mass of the sample after 8 hours in the oven
M_2: dry residue after incineration at 550°C for 3 hours
P: test sample

The protein content was determined by measuring total nitrogen using the Kjeldahl method [17]. The nitrogen in the dry matter is mineralized using sulfuric acid in the presence of a catalyst. The mineral nitrogen formed is distilled in the presence of soda and then titrated with hydrochloric acid. The nitrogen content was multiplied by 6.25 (nitrogen-to-protein conversion factor) to determine the protein content.

Fat content was measured using the Soxhlet method [17]. The fat content of the sample was extracted using an organic solvent by reflux heating, then weighed after evaporation of the solvent. To do this, the fat content of 10 g of sample placed in a Whatman cartridge was extracted with 300 ml of hexane contained in a flask for 6 hours. After this extraction time, the flask containing the extract was placed in a rotary evaporator to separate the fat and the solvent. The mixture (flask + fat) was then dried in an oven and cooled in a desiccator for 15 minutes, then weighed.

$$MG\ (\%) = \frac{(M_2-M_1)}{P} \times 100 \quad (5)$$

MG: fat content
M_1: mass of empty flask
M_2: mass of flask and oil after extraction
P: test sample

The ash content was determined using the method described in the French standard for the analysis of growing media [18]. A crucible containing the dry sample M_1 was placed in an oven (Nabertherm, Germany) at 600°C for 4 hours. The

crucible was then removed from the oven, placed in a desiccator, and left to cool for at least 1 hour. The crucible containing the calcined sample (M_2) was weighed.
The ash content (%MM) was determined as follows:

$$\% \text{ MM} = \frac{M2-Mo}{M1-Mo} \; X100 \quad (6)$$

M_0: empty crucible mass
M_1: crucible mass + dry sample
M_2: crucible mass + calcined sample

The total carbohydrate content was estimated by difference according to method [19]. It was calculated by subtracting the sum of the moisture, lipid, protein, and ash contents of the sample from 100.

$$\% \text{ carbohydrates} = 100 - (\text{Moisture} + \% \text{ lipids} + \% \text{ proteins} + \text{Ash}) \quad (7)$$

The energy value of the sample was calculated according to the method described in [20] using the following formula :

$$\text{Energy value (kcal)} = (\% \text{ carbohydrates x } 4) + (\% \text{ lipids x } 9) + (\% \text{ proteins x } 4) \quad (8)$$

2.2.3. Micronutrients analysis (vitamin C, macroelements, trace elements)

The method used to analyze vitamin C in the samples was that described by [21], based on the reduction of 2,6 DCPIP (2,6 dichlorophenol-indophenol) by vitamin C.

A quantity of 10 g of ground sample was solubilized in 40 ml of metaphosphoric acid-acetic acid (2%; w/v). The mixture obtained was centrifuged at 3000 rpm for 20 min. The supernatant was transferred to a 50 ml volumetric flask and adjusted with distilled water boiled and cooled in the absence of air. A 10 ml test sample was placed in an Erlenmeyer flask and titrated with 2,6 DCPIP at 0.5 g/l until a persistent pink color appeared. The vitamin C content of the sample was calculated as :

$$\text{Vitamin C (mg/100 g)} = \frac{C_{2,6DCPIP} \times Ve \times 5}{P_e} \times 100 \quad (9)$$

Ve: volume of 2,6-dichlorophenol indophenol obtained by titration of the filtrate

C2,6DCPIP: concentration of dichlorophenol indophenol (0.5 g/L)

Pe: test sample

The macro and micro elements contents were determined by ICP-OES analysis. A mass of 0.3 g of dry sample a was calcined at 600°C for 5 hours in an oven until white ash was obtained. After cooling, 5 ml of 1N nitric acid was added and then evaporated to dryness on a sand bath. To the residue, 5 ml of 1N hydrochloric acid was added and the mixture was placed back in the oven at 400°C for 30 minutes. After calcination, 10 ml of 0.1N hydrochloric acid was added to the residue. The mixture obtained was transferred to a 50 ml volumetric flask. The crucible was washed three times in succession with 10 ml of 0.1 N HCl and the flask was filled to the mark. The mixture was left to settle and the supernatant was filtered through 0.45 µ Wattman paper.

The elements contained in the solution were then measured by ICP OES.

3. Results and discussion

3.1. Physical and chemical characteristics

Table 1 shows the morphological, physical and chemical characteristics of the seeds and pods of *Senna occidentalis* L. The average sizes of the pods and seeds are 11.06 ± 1.64 cm and 0.3 ± 0.1 cm, respectively. The pods of false kinkeliba are short compared to those of the cowpea cultivars studied by [22] in Tchad. Similarly, the seeds are small compared to those of *Parkia biglobosa* (néré), which ranged from 7.51 to 8.90 mm in the study conducted by [23] in Benin. The seeds of Senna occidentalis L. are slightly acidic with a pH of 6.20 ± 0.005 and a titratable acidity of 7.14 ± 0.12 g/100 ml. The pH is roughly equal to that found by [24] for rice grains in Madagascar and by [25] for durum wheat grains in

Algeria. The dry matter and moisture content observed were 93.25 ± 0.2% and 6.75 ± 0.2%, respectively. The low moisture content would be an advantage for grain storage. Indeed, for proper storage, this content should not exceed 15% according to [26] or 11% according to [27].

Table 1 Physical and chemical characteristics of *Senna occidentalis* L. seeds.

	Parameters	**Values**
Physical and chemical characteristic	Pods size (cm)	11.06 ± 1.64
	Seeds size (cm)	0.3 ± 0.1
	Moisture (%)	6.75 ± 0.2
	Dry matter (%)	93.25 ± 0.2
	Titratable acidity (g / 100 mL)	7.14 ± 0.12
	pH	6.20 ± 0.005

3.2. Macronutrient content

The macronutrient content and energy value are shown in Figure 2. *Senna occidentalis* L. seeds are rich in total carbohydrates, with a content of 79.57%. Crude fiber content is 23.11 ± 0.68%, which is significantly higher than that obtained by [12] for the aerial parts of *Senna occidentalis* L. in India. The recommended nutritional intake of dietary fiber for children, adults, and pregnant or lactating women is 19 to 25 g/day, 21 to 38 g/day, and 28 to 29 g/day, respectively [12]. Therefore, *Senna* seeds would be a good source of fiber to meet nutritional needs. The lipid, protein, ash, and energy content are 3.28 ± 0.09%, 3.09 ± 0.21%, 7.31 ± 0.04%, and 360.16 kcal, respectively. The low lipid content is advantageous in that a *Senna* seed-based drink could accompany meals to aid digestion. According to [28], the lipid consumption of many Africans, including Ivorians, is already too high compared to recommendations. The protein content is significantly lower than that found by [29] for false kinkeliba seeds in Cameroon. However, the ash content found is higher than that of Robusta coffee beans from three terroirs in Côte d'Ivoire, studied by [30] with an average of 3.88 ± 0.34%, and that of néré beans collected in northern Benin [23]. This ash content could indicate a significant presence of minerals useful for human nutrition. The energy value recorded for *Senna* seeds is higher than that found by [28] for baobab powder in Côte d'Ivoire. This suggests that a drink made from these seeds could provide energy to consumers in the same way as baobab juice.

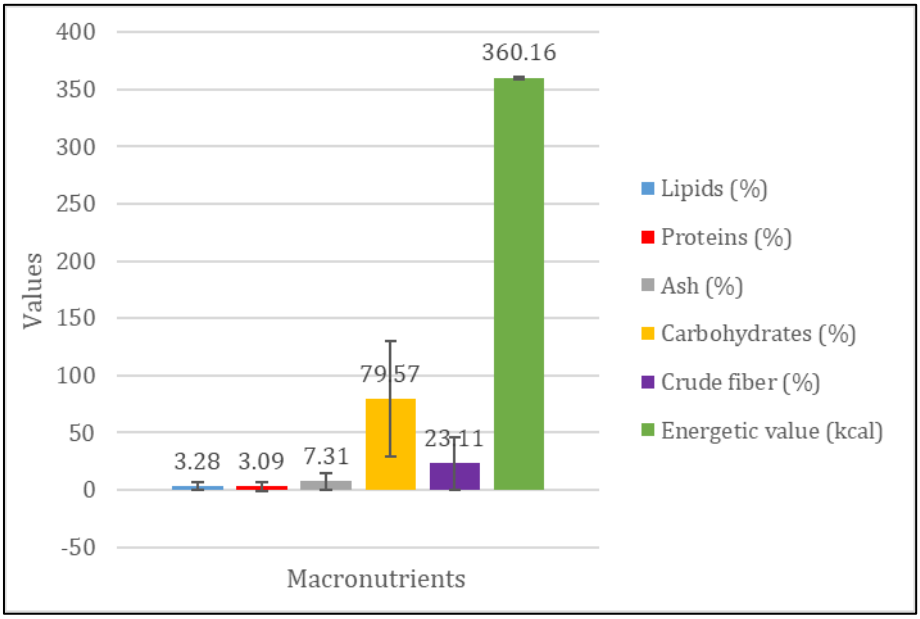

Figure 2 Macronutrient contained in *Senna occidentalis* L. seeds

3.2. Micronutrient content

The micronutrient content is shown in Table 2. *Senna occidentalis* L. seeds have a vitamin C content of around 14.16 ± 0.03 mg/100 g. This value is close to those found by [31] in his study on black plums in Côte d'Ivoire, but much lower than those of *Parkia biglibosa* (néré) powders analyzed by [32]. However, as vitamin C is an antioxidant, its presence could help fight free radicals. Senna seeds are rich in minerals, including calcium, which has the highest content at 4110.72 mg/kg, followed by potassium at 953.657 mg/kg, magnesium at 286.538 mg/kg, phosphorus (209.902 mg/kg), sodium (197.701 mg/kg), zinc, and iron. This richness could help meet individuals' daily mineral requirements.

Table 2 Micronutrients in *Senna occidentalis* L. seeds

	Parameters	**Values**
Vitamin (mg/100 g)	Vitamin C	14.16 ± 0.03
Macroelements (mg/kg)	Calcium (Ca)	4110.72
	Potassium (K)	953.657
	Magnesium (Mg)	286.538
	Phosphorus (P)	209.902
	Sodium (Na)	197.701
Microelements (mg/kg)	Zinc (Zn)	56.252
	Iron (Fe)	12.236
	Manganese (Mn)	4.584
	Copper (Cu)	1.248
	Molybdenum (Mo)	0.005

4. Conclusion

This study determined the physical, chemical and nutritional characteristics of *Senna occidentalis* L. seeds from Korhogo. These seeds are slightly acidic with low moisture content, making them suitable for long-term storage. They are small in size, low in lipids and proteins but rich in carbohydrates and fiber, which could be used to improve digestion. The seeds of the false kinkeliba are a good source of minerals with a significant ash content. They have considerable energy value. Given the significant characteristics of *Senna* seeds, the development of food products incorporating these seeds would help to increase consumer interest.

Compliance with ethical standards

Disclosure of Conflict of interest

Authors have declared that no competing interests exist.

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