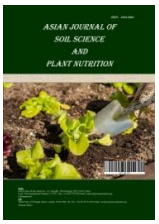

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Physicochemical and Nutritional Properties of Date (*Phoenix reclinata*) from Dabou (Côte d'Ivoire)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The date, Phoenix dactylifera is known for its richness in nutrients. Given the high selling price and its scarcity, some rural populations in Côte d'Ivoire consume the Phoenix reclinata date without knowing the functional properties for their well-being. The highlighting of the nutritional value of these fruits is necessary to promote its valorization and its consumption in the form of bioformulated foods. Thus, the physicochemical and antioxidant properties as well as the mineral richness contained in the pulps and the cores were determined using the Association of Official Analytical Chemists and spectrophotometric methods The analyzes were carried out on ripe fruits dried at 20°C in the laboratory of agrovalorization of the Department of Biochemistry and Microbiology, University Jean Lorougnon Guédé between March and May 2019. The results reveal that the pulps and the cores are weakly acidic with respectively pH values of 6.37 ± 0.13 and 5.74 ± 0.06. The pulps and the cores contain respectively dry matter contents (90.39 ± 0.14 against 92.1 ± 0.02), in fibers (10.40 ± 0.17 against 88.7 ± 0.48), in energy values (335.2 ± 0.44 kcal against 378.7 ± 1.07 kcal), in total

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polyphenols (2.63 ± 0.19 against 3.69 ± 0.18) and in minerals. The pulp and the cores have, for 100 g of solids, sodium contents (3.22 ± 0.12 mg against 3.69 ± 0.18 mg), potassium (0.71 ± 0.07 mg against 2.52 ± 0.08 mg), in phosphorus (3.00 ± 0.02 mg against 2.52 ± 0.08 mg), in calcium (0.16 ± 0.04 mg against 0.65 ± 0.03 mg), zinc (3.30 ± 0.05 mg vs. 3.08 ± 0.03 mg), iron (3.09 ± 0.01 mg vs. 3.26 ± 0.01 mg) and copper (2.93 ± 0.06 mg vs 3.08 ± 0.03 mg). These nutritious potentialities could be recommended in the formulation of foods for the malnourished.

Keywords: Phoenix reclinata; physicochemical; nutritional properties; antioxidant nutrients.

1. INTRODUCTION

In Africa, the survival of 60 to 80 percent of the poor depends directly on natural resources [1]. The production and consumption of the *Phoenix dactylifera* date is of great interest in the world and in most Arab countries because of the awareness of the causal relationship between food quality and health [2,3,4]. Nehdi et al. [5] noted the considerable nutritional importance of date-like cores itself in animal nutrition Olapeju et al. [6] have clearly shown great nutritional potential for industrial exploitation through the study of the physicochemical composition of *P. dactylifera* and *P. reclinata* dates from Nigeria. The nutritional composition of a fruit may vary according to the origin, soil composition in each region, climatic conditions and genetic evolution of trees in each region, and relatively from one species to another [7,8]. In Côte d'Ivoire, consumers are increasingly interested in this agricultural product. However, given the high selling price and the scarcity of *P. dactylifera*, some rural populations consume the *P. reclinata*, which grows in many marshy areas but does not know the nutritional properties for their well-being. The present study aims to evaluate the nutritional potential of this fruit in order to promote its valorization in the form of bioformulated foods and its consumption. More specifically, it will be necessary to determine the physico-chemical and antioxidant properties as well as the mineral richness contained in the pulps and the cores.

2. MATERIALS AND METHODS

2.1 Sample Preparation

The fruits of *Phoenix reclinata* at maturity were harvested in the locality of Dabou in February 2019. These fruits were separated from the stems, then kernels to be kept at room temperature (20°C) for two weeks to avoid all proliferation of microorganisms. The cores and the dried pulp were made into powder by means of a moulinex. And, the biochemical analyzes were carried out on the samples crushed in the laboratory of agrovalorization of the department of Biochemistry and Microbiology, between March and May 2019.

2.2 Methods

2.2.1 Physicochemical analysis of the date

The pH of the sample was measured with a digital pH meter (Consort P107, Belgium). The pH was measured directly from a pulp mill (pulps or cores) according to the Association of Official Analytical Chemists "AOAC" method [9]. Ten (10) g of sample were weighed into a beaker and then 20 mL of distilled water were 68 added. The pH was measured by immersing the electrode and the pH value was read on the pH meter screen.

The dry matter (DM) is determined after drying in a ventilated oven of the sample according to AOAC [10]. To do this 0.5 g (m_0) of date (pulp or cores) was crushed in a porcelain mortar and placed in a pre-weighed aluminum can (m_1). The whole is then placed in an oven at 105°C for 24 hours; after cooling in a desiccator, the whole was weighed again (m_2). The dry matter content (DM) is obtained according to formula No.1.

$$\% \text{ DM } = \frac{M_2 - M_1}{M_0} X\ 100 \quad (1)$$

Where, DM = Dry matter content

Ash levels were determined using the AOAC method [10]. Two (2) grams of samples were placed in a dried porcelain crucible of mass m1. The crucible containing the sample of total mass m2 was placed in a self-regulating muffle furnace and then incinerated at 550 ± 15°C for 12 h. The ash content is expressed as a percentage of mass according to equation 4. The tests were performed in triplicate and the average of the three tests was selected for each sample.

The determination of sodium (Na) and potassium (K) was carried out by flame emission spectrophotometry (Eppendorf, Hamburg, Germany) at 589 and 766.5 nm, respectively. The phosphorus content was determined by the colorimetric method based on the properties of molybdates which in acidic medium and in the presence of phosphorus, give a phosphomolybdate complex which after its reduction turns into a blue color measured spectrophotometer at 820 nm. Calcium, magnesium, iron and zinc were separately assayed by atomic absorption spectrophotometry (285.2 nm: Mg, 248.3 nm: Fe and 213.9 nm: Zn) (Thermo Elmentar AA, England); These minerals were determined according to the method using strong acids [10]. More precisely 0.5 g of sample was taken and dissolved in 31 ml of a mixture consisting of perchloric acid (11.80 mol / l), nitric acid (14.44 mol / l) and sulfuric acid (18.01 mol / L), then the mixture was well stirred under the hood. Then everything was heated on a hot plate until the appearance of thick white smoke. The mixture was cooled on the bench for 10 minutes and then diluted in 50 mL of distilled water, boiled again for 30 minutes using the same hot plate and then cooled again under the same conditions. The resulting mixture is filtered through WHATMAN No. 42 filter paper; distilled water was added to the filtrate thus obtained up to the gauge line of the flask. The content of mineral matter is determined by flame atomic spectrophotometer (SHIMADZUS 5, type A.A-6200), at a specific wavelength compared to the standard solutions. The content of the mineral considered from formula 2 is obtained

$$\mathrm{A\ (mg/g)} = \frac{Co}{E} \times\ 100 \qquad (2)$$

Where, A = Quantity of the mineral, Co = Concentration of the mineral, E = Sample

The determination of the lipid content of the sample is performed by Soxhlet extraction [11]. To do this, 10 g of the sample (pulps or cores) were taken and introduced into an extraction cartridge (Wattman cartridge), then the cartridge was inserted into the extraction ampoule. A pre-weighed round bottom flask (P1) containing 300 ml of hexane is heated to 70°C. This flask is scoured to the rest of the refrigerant system and the lipid is extracted for 4 hours. After the extraction, the hexane was recovered using a rotary evaporator at 40°C under vacuum, then the extracts obtained were dried at 130°C. for 30 minutes in an oven and then cooled in a desiccator and weighed. to obtain the weight (P_2). The lipid content is calculated from formula No. 3.

$$\%\ \text{lipid} = \frac{\mathrm{P2-P1}}{\mathrm{PE\times MS}}\times 100 \qquad (3)$$

Avec, P_2 = Weight of the balloon + Mass of lipid (g), P_1 = Weight of the empty balloon (g), P_E = Weight of the sample (g), MS = Dry matter

The determination of the total nitrogen of the samples is carried out by the method of Kjeldahl [12] and the amount of crude protein contained in a product is estimated from said assay. For this study, 1 g of each sample (pulps or cores) was introduced into a Kjeldahl flask tube followed by 20 mL of concentrated sulfuric acid (H_2SO_4) and a pinch of mineralization catalyst (copper sulfate (Cu_2SO_4) and potassium sulphate (K_2SO_4)) were added thereafter, the samples were mineralized for 2 hours at a temperature of 400°C. Appearance of a white smoke showing that the evaporation of water was completed and the resulting liquor had a light green color is ammonium sulfate. The tubes were cooled, the mineralized material was transferred to a 100 mL flask and adjusted with distilled water to prevent crystal formation; 10 mL of the above mixture was removed and 10 mL of 40% NaOH solution was added thereto. The whole was distilled for 10 min, taking care to trap the distillate in a flask containing 20 ml of boric acid plus a mixed indicator (methyl red + bromocresol green). The ammonia was finally titrated with hydrochloric acid (0.1 N) in the presence of a colored indicator (methyl red). The titration is complete when turning from blue to pink and the percentage of nitrogen is calculated by equation 4.

$$\%\ \mathrm{N} = \frac{(\mathrm{V_{HCl}-V_0})\ \mathrm{X\ N_{HCl}\ X\ 14{,}01}}{\mathrm{P\ X\ MS}}\ \mathrm{X}\ 100 \qquad (4)$$

Where, VHCl = Volume of hydrochloric acid for the sample (ml), V0 = Volume of hydrochloric acid poured into the white (ml), P = Test sample of the sample, MS = dry matter

The calculation of the crude protein content (P) is obtained by multiplying the nitrogen content (N) obtained by a factor which corresponds to the inverse of the average nitrogen content in the proteins. The conversion factor changes depending on the material studied. However, when the nature of the proteins is not known, a conventional factor of 6.25 is adopted. Then the protein content is calculated according to formula No. 5.

$$\% P = \% N \times 6.25 \quad (5)$$

The glucid content (expressed as a% of the dry matter) was estimated by FAO / WHO / UNU [13] according to formula No. 6.

$$\% \text{ glucide} = 100 - (\% \text{ de protein} + \% \text{ lipid} + \% \text{ fiber} + \% \text{ Ash}) \quad (6)$$

Total oses were determined by the phenol-sulfuric method [14]. Quantification of total sugars was done by destroying the glycosidic bonds of complex sugars (polysaccharides), converted into simple sugars (monosaccharides). First, 0.5 ml of the sample was taken and placed in a test tube, then 1 ml of 5% phenol (w / v) and 5 ml of concentrated sulfuric acid were added thereto. Then the mixture was homogenized and allowed to stand until completely cooled to room temperature. In the end the reading was done against a blank. The glucose standard solution at 1 mg / mL was prepared as well as a range of standard prepared with a series of five (5) tubes, the first of which represents white. In the other 4 tubes were respectively 0.2; 0.4; 0.6 and 0.8 mL of solution. The test tube contains 1 mL glucose solution, 1 mL phenol 5% (w / v) and 5 mL concentrated sulfuric acid. The mixture was homogenized and allowed to stand until completely cooled to room temperature. Finally, the reading was done. For each test, the total sugar content was calculated from a calibration curve whose regression equation is: D O.= 9.525Q with R^2 = 0.9923. The total sugar contents were determined according to formula No. 7 with reference to a standard range of glucose (1 mg / ml).

$$\% \text{ Total sugars (g / 100 g)} = \frac{Q \times F}{Me} \times 100 \quad (7)$$

Where, Me = Mass of the sample, Q = Quantity of total sugars in each tube (mg), F = Dilution factor

This assay method is based on the reducing properties of glucids [15]. It consists of dosing all the so-called reducing glucids (glucose and fructose). Fructose is measured by colorimetry according to the method using DNS and described by Bernfeld [16]. The intensity of this coloration is proportional to the fructose content. The reading of the optical density at the wavelength of 540 nm allows the determination of the fructose contents of the different samples (expressed in%) with reference to a standard range of glucose (2 mg / ml).

The raw fiber contents were determined according to the method of Wolf [17]. Two (2) g of sample (me) were homogenized in 50 mL of sulfuric acid (0.25 N). The whole is boiled for 30 minutes under reflux condenser. 50 ml of sodium hydroxide (0.31 N) are added to the contents and the whole is heated to boiling for 30 minutes under reflux condenser. The resulting extract is filtered on Whatman filter paper. The residue is washed several times with hot water until complete elimination of the alkalis. The residue is dried in an oven at 105°C for 8 h and cooled in a desiccator and weighed (m1). The resulting residue is incinerated in the oven at 550°C for 3 h, cool to the desiccator and weighed again (m^2). Finally, the percentage of crude fiber based on dry matter (DM) is calculated from formula No. 8.

$$\text{Fiber } (\%) = \frac{(m_1 - m_2) \times 100}{m_e} \quad (8)$$

Where, m_1 = mass (g) of the dried residue; m_2: = Mass (g) of ash obtained; m_e = Mass (g) of the sample

The determination of the crude cellulose was carried out by the method of Henneberg & Stohmann [18] also called the Weende method. It consists of successively treating the sample with an acid and alkaline solution while hot. One (1) g of each sample (pulp or cores) was removed and placed in a flask, 50 mL of H_2SO_4 was added and the mixture was boiled for 30 min. The solution obtained is cooled and then filtered and the residue is rinsed with distilled water. To the residue obtained, 25 ml of NaOH are added and the mixture is boiled for 30 minutes. After cooling and filtration of the solution, the residue is rinsed successively with distilled water, HCl, distilled water and finally acetone. The residue thus obtained is dried in an oven at 105°C for 1 hour, cooled and weighed before being incinerated at 700°C in the oven for 1 hour. The product obtained is reweighed and the crude fiber content in% is determined according to formula 9

$$\% \text{ Crude cellulose } = \frac{P_1 - P_2}{P_0} X \frac{100}{100 - H} \quad (9)$$

Where, P_0 = Weight in g of the test sample, P_1 = Weight in g of the crucible + residue before incineration, P_2 = Weight in g of the crucible + residue after incineration, H = Humidity content of the sample

The starch level was determined according to formula No. 10 by difference from the

percentages of total glucids and total sugars according to the method of Dubois et al. [14].

$$\%Starch = (\% GT - \% ST) \times 0.9 \quad (10)$$

Where, GT = Total Glucide, ST = Total Sugars, 0.9 = Starch / glucose ratio = $C_6 H_{10} O_5$ / $C_6 H_{12} O_6$

The energy value (VE) of food comes from 3 macronutrients (glucide, lipid and protein). It is calculated using Formula N° 11, multiplying the mean glucid, lipid and protein values by at water factors of 4, 9 and 4, respectively [19]. It is expressed in kilocalorie (kcal).

$$VE = (4\times \text{ glucide}) + (9\times \text{ lipid}) + (4 \times \text{ protein}) \quad (11)$$

2.2.2 Nutriments antioxydants

The extraction of the polyphenols was carried out with hot water according to the protocol described by Dominique & Qian [20]. Ten (10) g of the crushed plant material (pulps or cores), 200 mL of water is added thereto, then shake manually and gently, then heat the mixture in a water bath at 77°C for 30 min. Allow the mixture to cool to room temperature and filter through a wathman filter paper. Then repeat the procedure 3 times (fraction retained by the filter in 200 mL of hot distilled water), finally the 3 filtrates obtained are placed in a single container, which is the phenolic extract. For the determination of total phenolic contents, the method of Wood et al. [21] was used. To do this 2.5 ml of diluted Folin-Ciocalteu reagent (1/10) was added to 30 µl of extract, the mixture was kept for 5 minutes in the dark at room temperature. Then 2 mL of calcium carbonate solution (75 $g.L^{-1}$) was added thereto; then, the mixture was placed for 15 minutes in a water bath at 50°C and then cooled rapidly. Absorbance was measured at 760 nm with distilled water as white. Finally a calibration line was made with gallic acid at different concentrations. The results were expressed as mg of gallic acid equivalent per 100 g dry matter (mg GAE/ 100 g DM).

The method used for the determination of vitamin C (volumetric assay) of the samples is that described by Pongracz et al. [22] whose principle is based on the reduction of 2,6-dichlorophenol-indophenol (2,6 DCPIP) by vitamin C. More specifically, 1 g of the mash of the sample was taken and then 5 mL of 1% oxalic acid was added; the whole thing was shaken for 15 minutes in the dark and filtered and filtered on a filter paper. The filtrate was taken for a second extraction (according to the previous protocol), 0.5 mL of filtrate is added to 2.5 mL of the DCPIP at (0.004%) and the whole is left standing for 10 min; finally, the reading of the absorbance at 515 nm on the spectrophotometer against a control consisting of 2.5 mL of DCPIP and 0.5 mL of oxalic acid was carried out. The concentration of vitamin C is determined using the calibration curve established by ascorbic acid.

2.2.3 Reproductibility of analyses

The assays carried out to determine the physicochemical composition (pH, dry matter, total glucid, starch, sugars, lipid, fiber, ash), the polyphenol, vitamin C and mineral composition of the samples taken, were carried out three times over for each sample. The values presented in the results are the averages of the three measures followed by the standard deviations.

3. RESULTS AND DISCUSSION

3.1 Results

3.1.1 Physicochemical properties of pulps and cores

Table 1 presents the contents of physicochemical elements of pulps and cores. The pH contents are respectively 6.37 ± 0.13 and 5.74 ± 0.06. Pulps and cores contain respectively dry matter content (90.39 ± 0.14 against 92.12 ± 0.02), lipid content (1.69 ± 0.01 against 3.32 ± 0.17), in fibers (10.4 ± 0.17 against 88.7 ± 0.48), in protein (11.1 ± 0.05 against 5.62 ± 0.32), in energy values (335.2 ± 0. 44 kcal vs 378.7 ± 1.07 kcal) and ash (8.12 ± 0.04 vs. 1.57 ± 0.09) indicating mineral richness.

3.1.2 Antioxidant nutrient analysis

The results obtained and presented in Table 2 indicate that the pulps and cores contain respectively total phenolic contents (2.63 ± 0.19 mg GAE/ 100 g DM against 3.69 ± 0.18 mg GAE/ 100 g DM) and vitamin C (3.22 ± 0. 12 mg vs 3.69 ± 0.18 mg).

3.1.3 Mineral composition of cores and pulp

Table 3 shows different grades of minerals. The pulp and the cores have, for 100 g of solids,

sodium contents (3.22 ± 0.12 mg against 3.69 ± 0.18 mg), potassium (0.71 ± 0.07 mg against 2.52 ± 0.08 mg), in phosphorus (3.00 ± 0.02 mg against 2.52 ± 0.08 mg), in calcium (0.16 ± 0.04 mg against 0.65 ± 0.03 mg), zinc (3.30 ± 0.05 mg vs. 3.08 ± 0.03 mg), iron (3.09 ± 0.01 mg vs. 3.26 ± 0.01 mg) and copper (2.93 ± 0.06 mg vs 3.08 ± 0.03 mg).

Table 1. Physicochimical properties content of pulp and cores

Physicochemical properties	Contents	
	Pulpe	Cores
pH	6.37 ± 0.13	5.74 ± 0.06
Dry matter	90.4 ± 0.14	92.1 ± 0.02
lipid	1.69 ± 0.01	3.32 ± 0.17
Fiber	10.4 ± 0.17	88.7 ± 0.48
Protein	11.1 ± 0.05	5.62 ± 0.32
Total glucid	68.8 ± 0.12	81.61 ± 0.48
VE (kcal)	335.2 ± 0.44	378.7 ± 1.07
Ash	8.12 ± 0.44	1.57 ± 0.09
Total sugars	64.1 ± 0.02	4.47 ± 0.11
Crude cellulose	6.43 ± 0.08	16.9 ± 0.50
Starch	4.73 ± 0.16	69.4 ± 0.53
SR	51.4 ± 0.03	3.42 ± 0.08

DM = Dry matter, VE = Energetic value; SR= *Reducing sugars*

Table 2. Antioxidant nutrient levels in pulp and cores

Antioxidant nutrients	Content of the date	
	Pulp	cores
Vitamin C (mg/100 g DM)	0.03 ± 0.00	0.04 ± 0.00
Total phenolic (mg GAE/ 100 g DM)	2.63 ± 0.19	3.69 ±0.18

Values are means ± standard deviations of triplicate determinations

3.2 Discussion

The values obtained for the pH of the pulps and cores of *P. reclinata* show that they are acidic. Associated with certain parameters such as water activity; pH, an element characterizing the acidity or basicity of a medium, is a determining factor in the proliferation of microorganisms in a food or fruit [23]. These results are close to those obtained by EL-Hooti et al. [24] for the varieties Lulu (pH 6.5) and Shahla (pH 6.2) and by Jassim and Naji [25] for Khalas (pH 6.68) and Bunaam varieties (pH 5.72). The dry matter content of pulps and cores close to that obtained (95%) by Harfi & Kaanin [26] indicate dates can be classified in the group of seeds and cereals, they are close to those indicated by Munier [27], which obtained 89 to 93% of dry matter on the Khalas, Lulu and Fard varieties.The high energy content (between 335 kcal) allows the biotechnologist to enrich foods that are poor in sugars for diabetics for example or even those of infants, malnourished and poultry.The lipid content (1.69%) is consistent with that obtained by Benflis [28], which specified an oil content of Moreover, the amount between 0.2% and 0.5% reported by Al-Shahib and Marshall [29], proved to be lower than ours. at the origin of the samples, the processes (storage and nipulation) and methods used for lipid extraction. The total fiber content (10.40%) is higher than that (ranging between 4.09% and 6.28%) obtained by Berregui [30]. According to Jaccot and Campillo [31], the fibers, because of their hydrophilic power, facilitate intestinal transit and have a preventive role against colorectal cancers, appendicitis, diverticulosis and haemorrhoids [32]. Dietary fiber is the source of prebiotics. The ash content, indicative of mineral abundance, ranged from 1.57% (Phoenix reclinata) to 5.50% (Phoenix dactylifera). These values are higher than that found (1.12%) by Munier [27]. The amount of ash in a food product depends on the nature, degree of maturity, climatic conditions and culture of the product [33].

The presence of vitamin C and polyphenols in pulp and kernels implies that they have antioxidant properties. Their consumption would provide elements that can inhibit the oxidation of other molecules. Indeed, since oxidation is a biochemical reaction that generates free radicals to a chain reaction, it can harm cells, tissues and, ultimately, physiological functions. According to Kishore et al. [34], vitamin C is one of the antioxidants that terminate the chain reactions to protect the body from free radicals. Favier et al. [35] obtained a level of 0.02% vitamin C. This value corroborates those of our results (0.03-0.04%). The polyphenol content, meanwhile, gave the cores a value around 3.69%, which is higher than that of Besbes [36] which ranged between 0.0215% and 0.0526%. While that of the pulp was around 2.46% and 2.63%, in agreement with Benmeddour et al. [37] which obtained 2.77% and 2.25% respectively for the Mech Degla and Deglet Nour varieties. The mineral richness of dates (pulps and cores) in zinc, iron, Na, phosphorus, calcium, potassium and copper has been reported by several authors [6].

Table 3. Mineral composition of pulps and cores

Minerals composition	Content of the fruit (mg / 100 g of dry matter)	
	Pulp	cores
Phosphor (P)	3,00 ± 0,02	2,52 ±0,08
Potassium (K)	0,71 ± 0,07	2,52 ±0,08
Sodium (Na)	3,22 ± 0,12	1,28 ± 0,03
Calcium (Ca)	0,16 ± 0,04	0,65 ± 0,03
Magnesium (Mg)	0,65 ± 0,06	0,61 ± 0,01
Iro (Fe)	3,09 ±0,01	3,26 ± 0,01
Zinc (Zn)	3,30 ± 0,05	3,08 ± 0,03
Copper (Cu)	2,93 ±0,06	3,08 ± 0,03

Values are means ± standard deviations of triplicate determinations

4. CONCLUSION

The analysis of the pulp and cores of *Phoenix reclinata* has shown that this fruit has antioxidant qualities due to the presence of vitamin C, polyphenols and certain minerals (Zn and Cu). This nutritional value with antioxidant properties makes this fruit a functional food that could be used in food formulation for malnourished and infants on the one hand, and on the other hand for the nutrition of animals including poultry.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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